TÜVRheinland® CERT ISO 9001

M+S HYDRAULIC

AXIAL PISTON MOTORS AND PUMPS

In cooperation with HES HYDRAULIC ELEMENTS & SYSTEMS

NEW PRODUCTS

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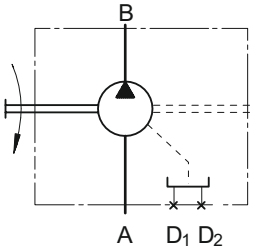
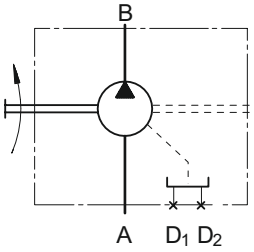
Hydraulic Pumps Type PAP50

Heavy Duty Axial Piston Pumps Fixed Displacement for open loop circuit



Symbols

B	Outlet port
A	Inlet port
D_1, D_2	Drain ports



open drain line is always required

APPLICATION

» Open loop circuit
» Agricultural machines
» Road building machines
» Mining machinery
» Food industry machines
» Special vehicles

OPTIONS

» Swash plate
» Port options
» Shaft options
» High pressure ports

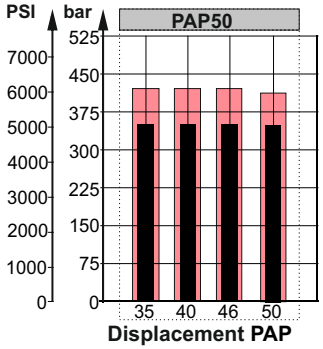
ADVANTAGES

» Low noise
» Low pulsation
» Long service life
» High power density

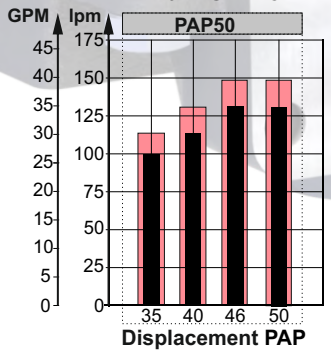
GENERAL

Displacement,	cm^3/rev [in^3/rev]	**36,16÷49.94 [2.21÷3.05]**
Max. Driving Speed,	RPM	**2800**
Max. Driving Torque,	Nm [lb-in]	**278 [2460]**
Max. Output,	kW [HP]	**54 [72.5]**
Max. Pressure,	bar [PSI]	**350 [5080]**
Max. Oil Flow,	lpm [GPM]	**132 [35]**
Min. Driving Speed,	RPM	**500**
Fluid		**Mineral based- HLP(DIN 51524) or HM(ISO 6743/4)**
Temperature Range,	°C [°F]	**-40÷82 [-40÷180]**
Optimal Viscosity Range,	mm^2/s [SUS]	**12÷68 [66÷311]**
Filtration		**ISO code 18/16/13 (Min. recommended fluid filtration of 10 micron)**

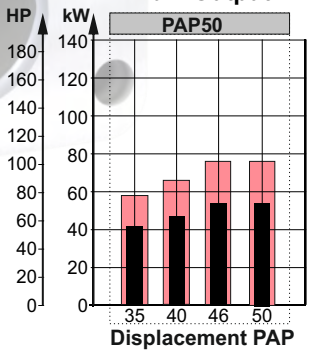
Max. Pressure



Max. Oil Flow



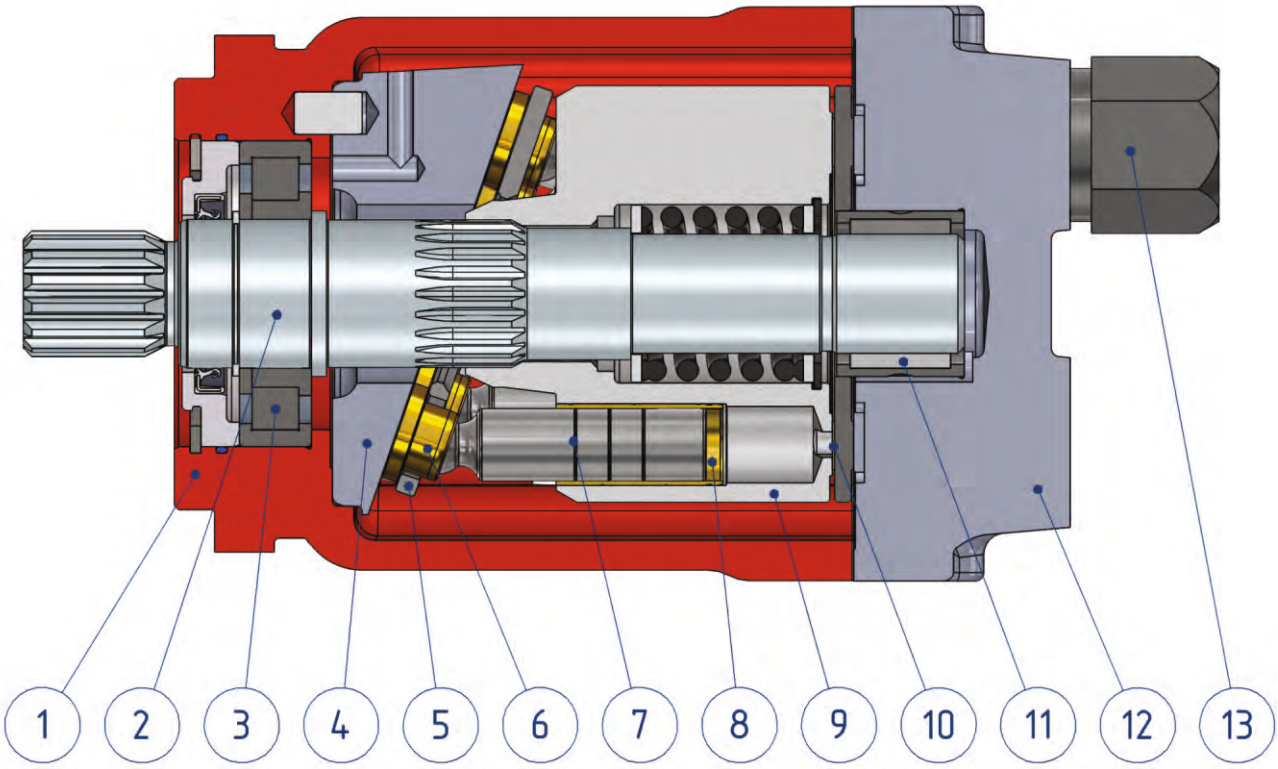
Max. Output



Intermittent values

Continuous values

SECTION VIEW



1. Cast iron body
2. Hardened shaft
3. Robust radial - axial roller bearing
4. Solid swash plate
5. Retainer plate
6. Improved piston shoes
7. Improved pistons
8. Brass bushings
9. Hardened steel cylinder block
10. Bimetal distributor
11. Needle bearing
12. Solid end cover
13. Part of hydraulic system helps reduces pump noise and vibration

The heavy duty design of PAP pumps gains big advantage over the typical swash plate pumps.
One of then is a special hydraulic system, which reduces noise and vibration created from pump.
Another big advantage of our design, which in general is typical for swash plate pumps, is that the pulsations during the operation are much less. In general the swash plate pumps are more reliable than the bent axis pumps and gear pumps.

SPECIFICATION DATA

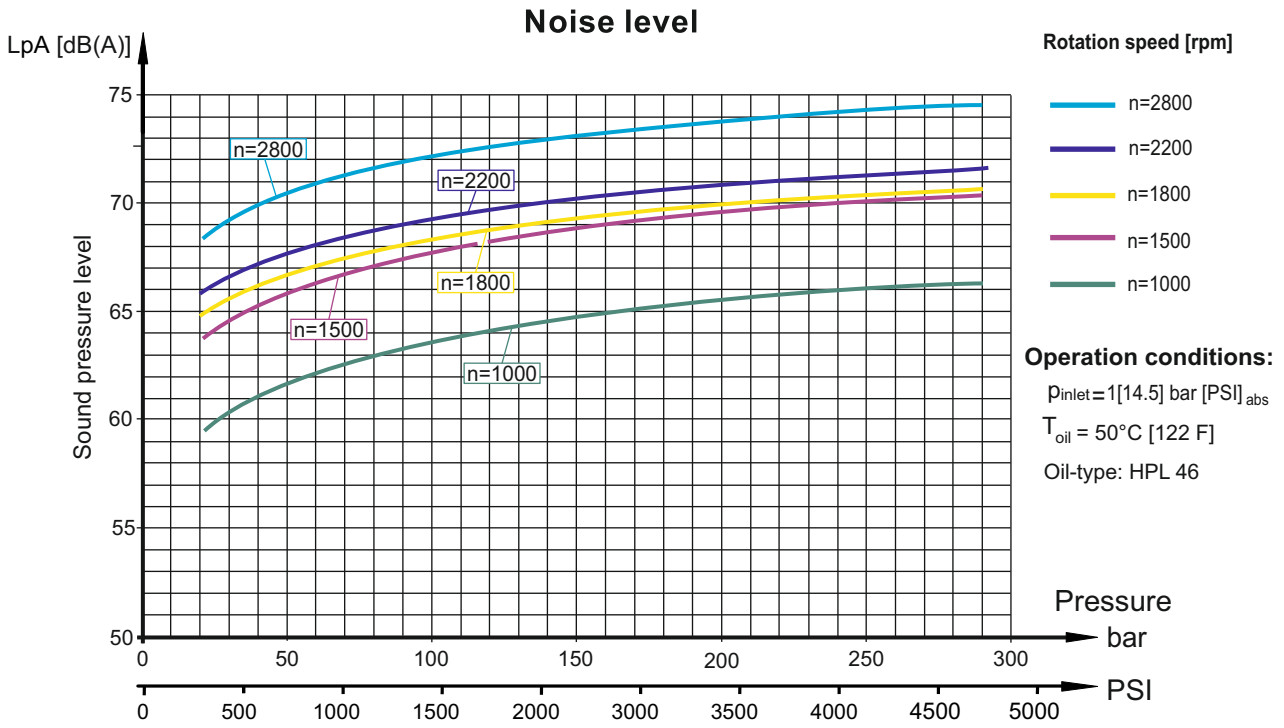
Type		PAP 35	PAP 40	PAP 46	PAP 50
Displacement, cm.^{3}/rev. [in.^{3}/rev.]		36.16 [2.21]	41.59 [2.54]	47.13 [2.88]	49.94 [3.05]
Max. Driving Speed, [RPM]	Cont.	2800	2800	2800	2500
	Int.*	3150	3150	3150	2800
Max. Driving Torque,*** Nm [lb-in]	Cont.	202 [1789]	232 [2053]	263 [2328]	278 [2460]
	Int.**	242 [2142]	278 [2460]	315 [2788]	326 [2885]
Output, kW [HP]	Cont.	41 [55]	47 [63]	54 [72.5]	54 [72.5]
	Int.**	58 [78]	67 [90]	77 [198]	77 [198]
Max. Pressure, bar [PSI]	Cont.	350 [5080]	350 [5080]	350 [5080]	350 [5080]
	Int.**	420 [6100]	420 [6100]	420 [6100]	410 [5950]
Max. Oil Flow, lpm [GPM]	Cont.	100 [26.4]	116 [30]	132 [34.9]	132 [34.9]
	Int.*	114 [30]	131 [35]	148 [39]	148 [39]
Permissible Shaft Load max Axial**** N[lb]		Fa=2000 [450]			
max Radial**** N[lb]		Fr=3600 [810]			
Min. Speed, [RPM]		500			
Max. Pressure in Drain Line, bar [PSI]		5 [70] open drain line is always required			
Weight, kg [lb]		20,5 [45]			

* Intermittent speed (flow): for pressure up to 150[2200] bar[PSI];
** Intermittent load: the permissible values may occur for max. 10% of every minute;
*** Theoretical torque;
**** The calculated max values are based on the optimal direction of the forces Fr, Fa and optimal position of the shaft.

1. The recommended output power for continuous operations should not be exceeded.
2. Recommended filtration as per ISO 4406 cleanliness code 18/16/13 or better. This filtration corresponds to SAE AS 4059 8A/7B/7C. Nominal filtration - 10 micron or better.
3. Recommended a premium quality, anti-wear type mineral based hydraulic oil, HLP(DIN51524) or HM(ISO6743/4).
4. Recommended oil viscosity - 12...68 cSt or see page 61.
5. Recommended maximum system operating temperature - 82°C [180°F].
6. To ensure optimum life of the pump, fill it up with fluid prior to load it and run with moderate load and speed for about 10-15 minutes.

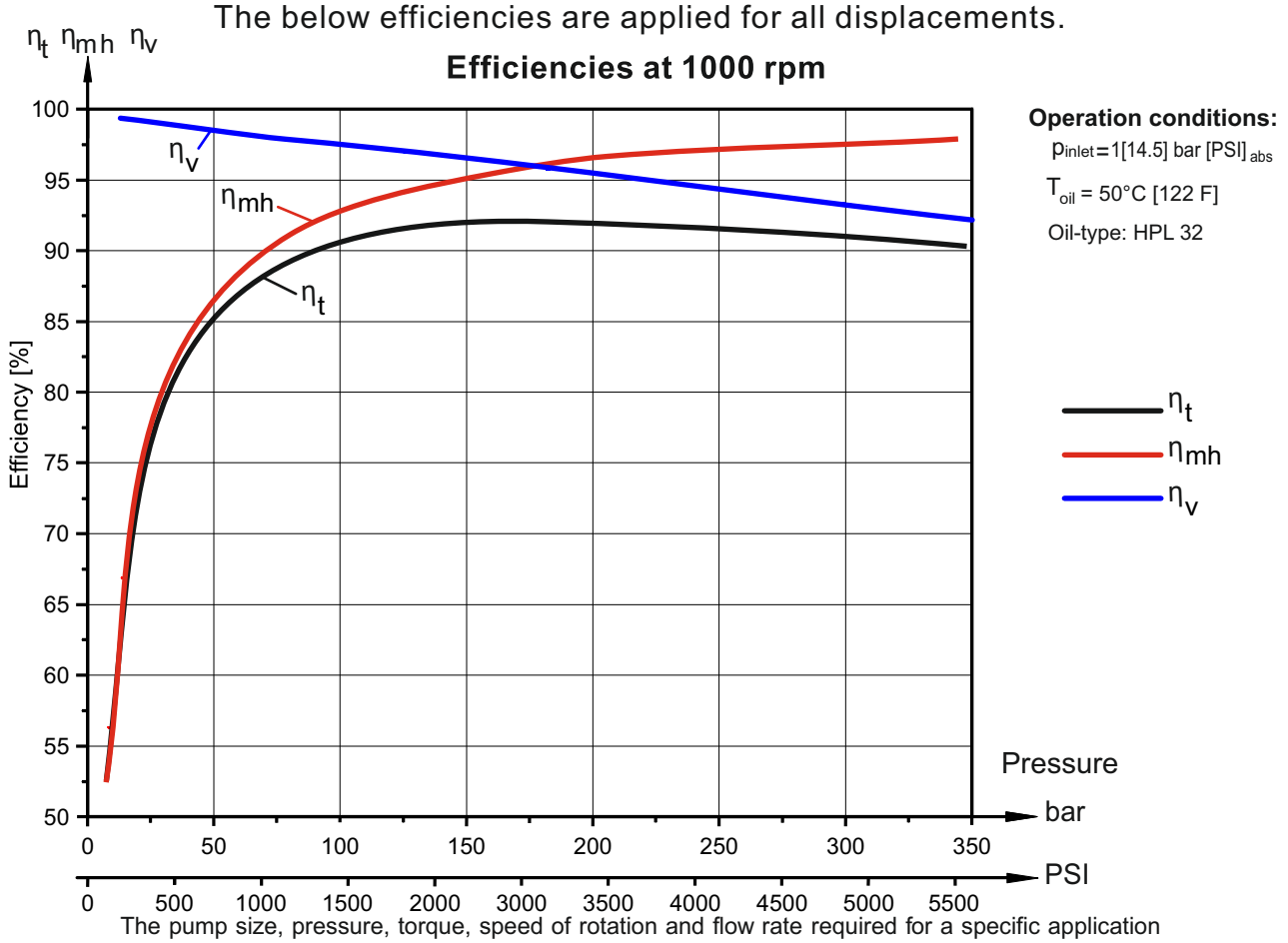
FUNCTION DIAGRAMS

Sound pressure level (noise) is measured in acoustic chamber according to DIN 45635 Part 1 and Part 26. These diagram is applied for all displacements.



The sound pressure level for a particular pump may vary ±2 dB(A) compared to what is shown in the diagram.

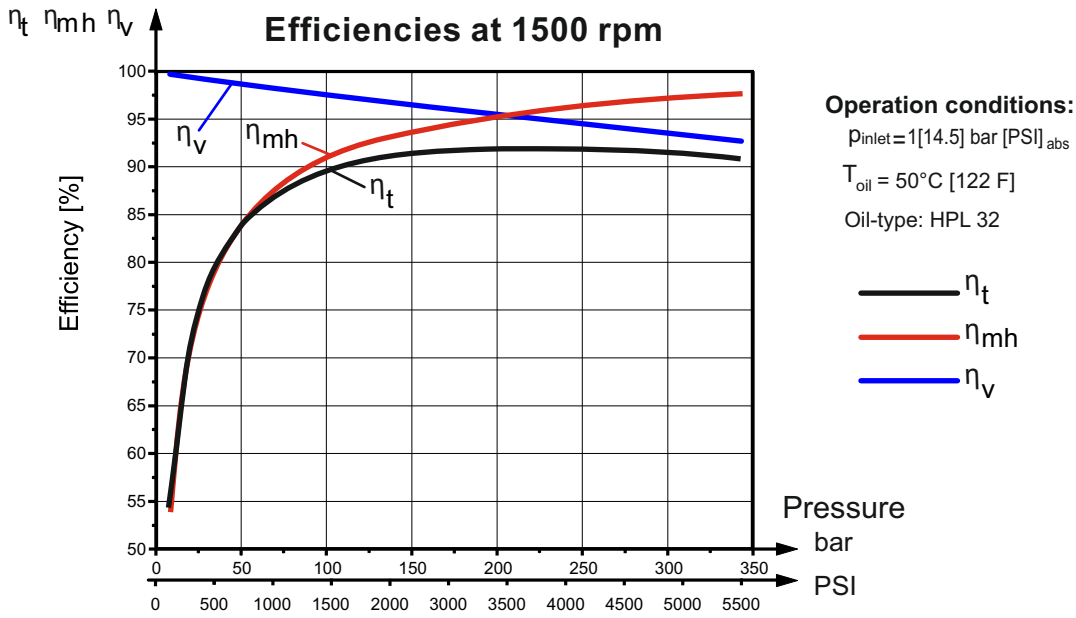
The below efficiencies are applied for all displacements.

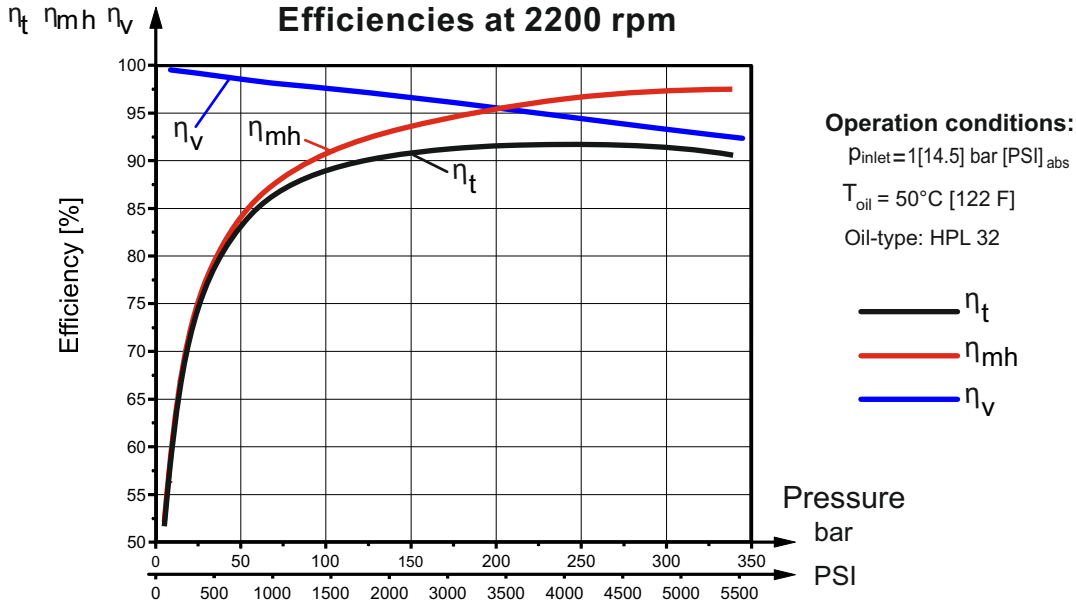


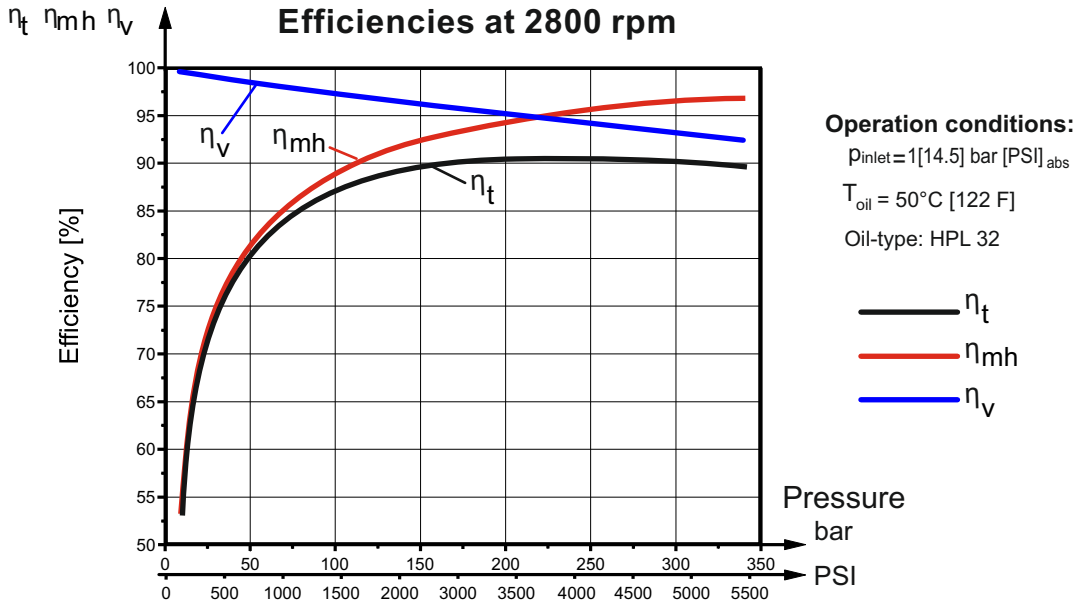
The pump size, pressure, torque, speed of rotation and flow rate required for a specific application can be calculated using the formulas on page 62

Efficiencies for a particular pump may vary from the shown in the diagram depending on the operating conditions.

FUNCTION DIAGRAMS







The pump size, pressure, torque, speed of rotation and flow rate required for a specific application can be calculated using the formulas on page 62

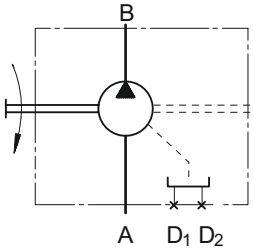
Efficiencies for a particular pump may vary from the shown in the diagram depending on the operating conditions.

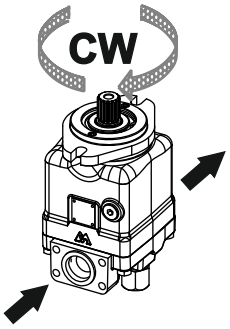
Overall Dimensions and Ports

Direction of Rotation **CW**(Right)

Port sizes **default** and **5**

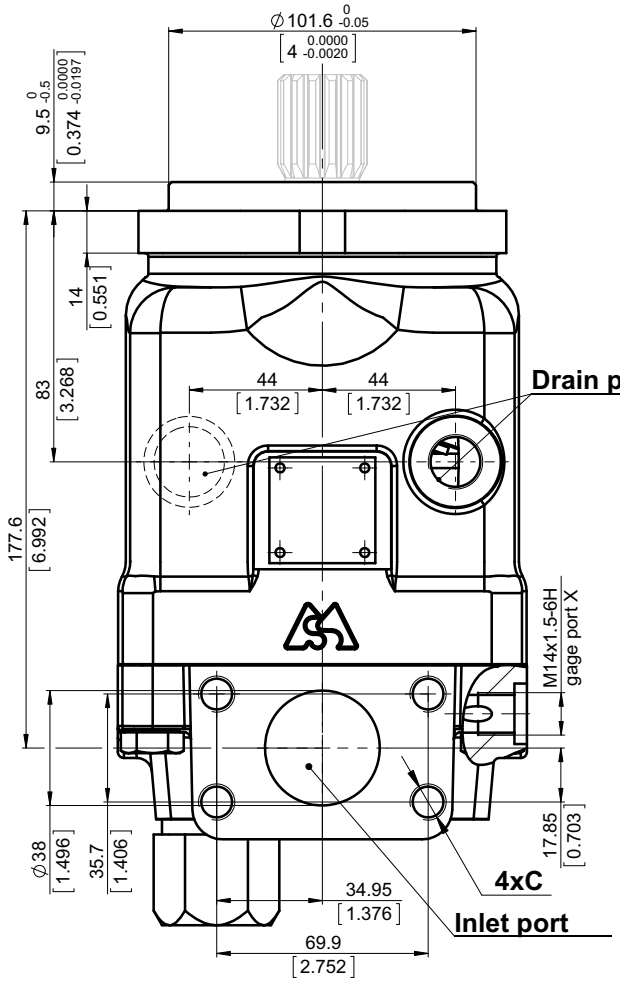
See the port sizes at the bottom of this page

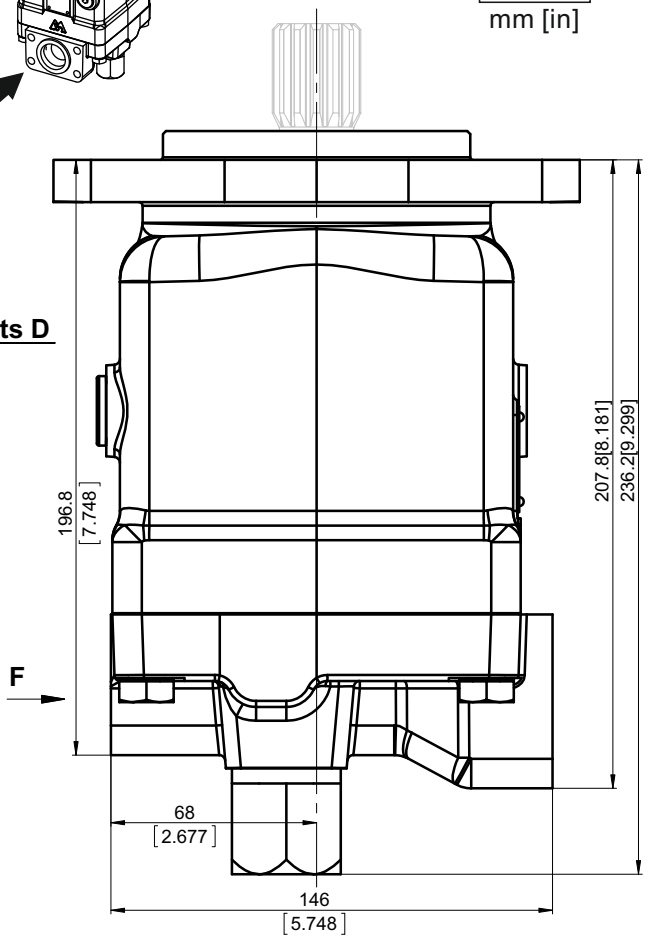


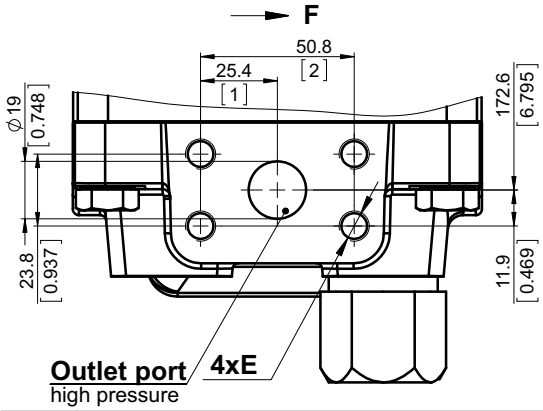


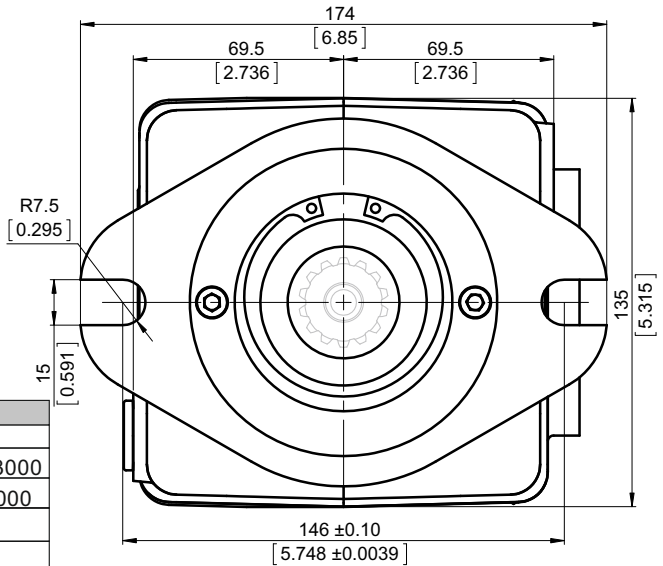
Shaft Mounting
see page 50

mm [in]









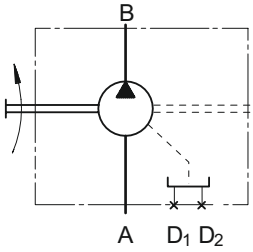
	Port Size	
	default	**5**
Inlet	ISO 6162-1 DN38	SAE J518 1-1/2 PSI3000
Outlet	ISO 6162-2 DN19	SAE J518 3/4 PSI6000
D	M18x1,5	7/8-14 UNF-2B
C	4xM12-6H	1/2-13 UNC-2B
E	4xM10-6H	3/8-16 UNC-2B

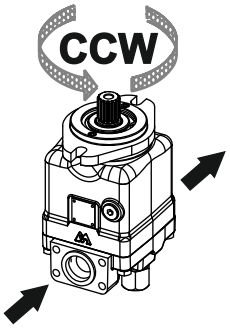
Overall Dimensions and Ports

Direction of Rotation **CCW**(Left)

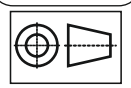
Port sizes **default** and **5**

See the port sizes at the bottom of this page

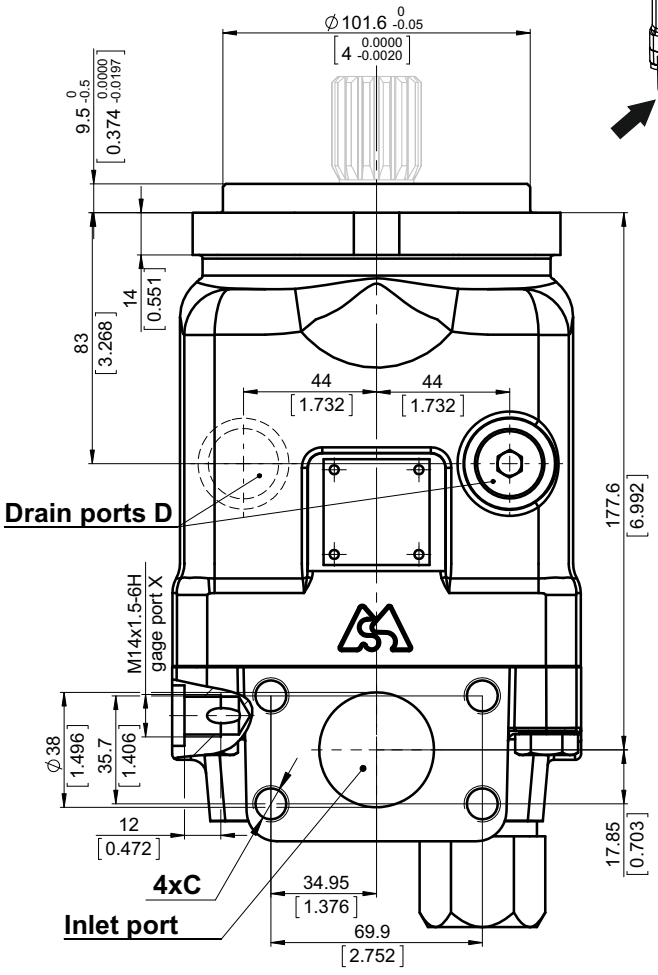


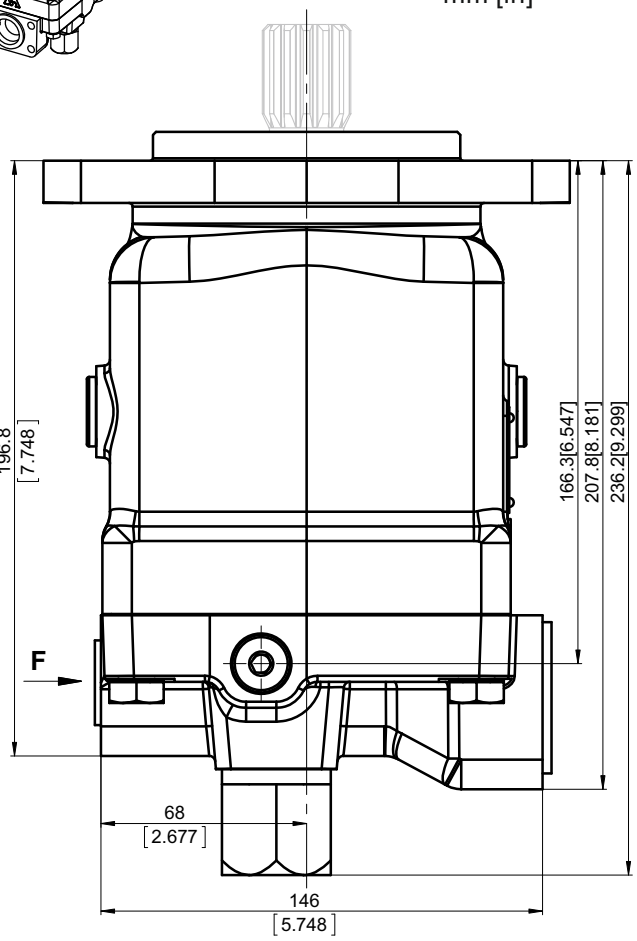


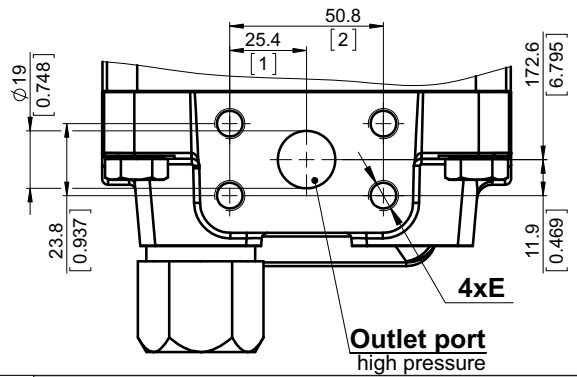
Shaft Mounting
see next page

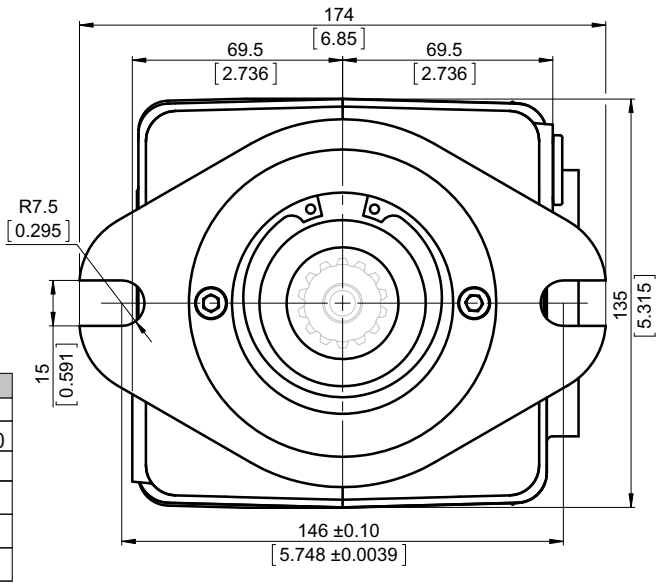


mm [in]



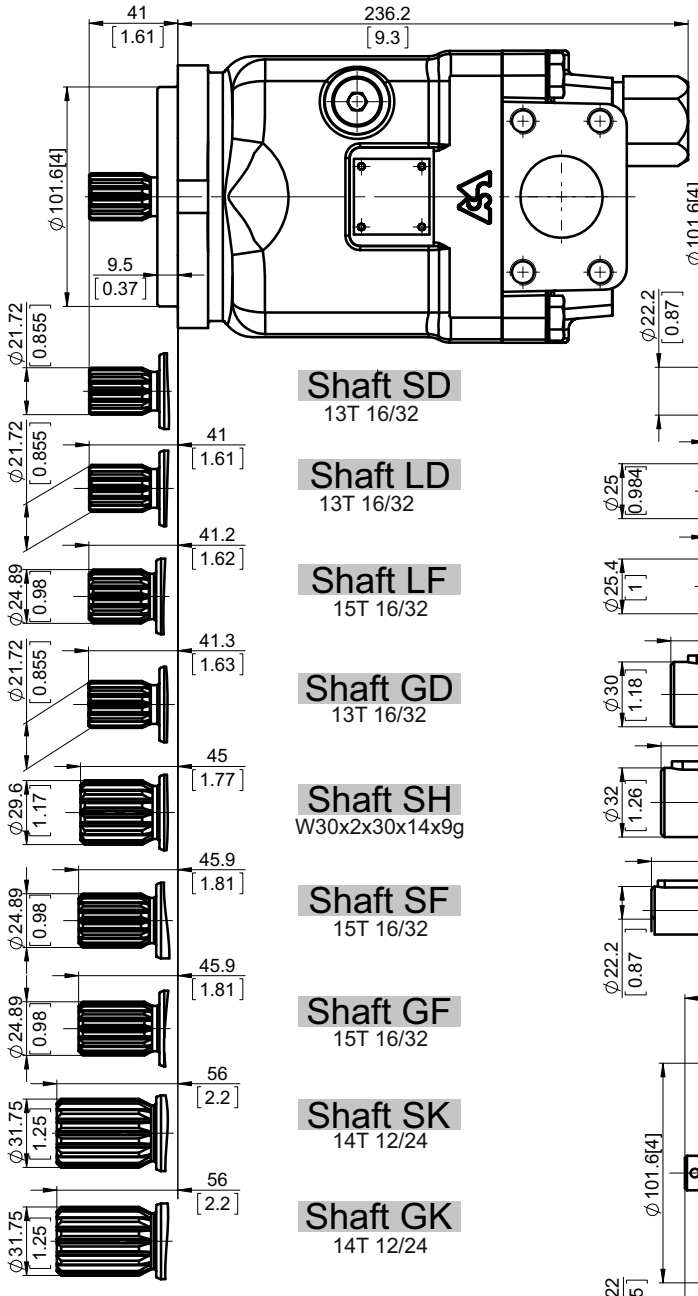






	Port Size	
	default	**5**
Inlet	ISO 6162-1 DN38	SAE J518 1-1/2 PSI3000
Outlet	ISO 6162-2 DN19	SAE J518 3/4 PSI6000
D	M18x1,5	7/8-14 UNF-2B
C	4xM12-6H	1/2-13 UNC-2B
E	4xM10-6H	3/8-16 UNC-2B

Shafts Mounting



Shaft SD
13T 16/32

Shaft LD
13T 16/32

Shaft LF
15T 16/32

Shaft GD
13T 16/32

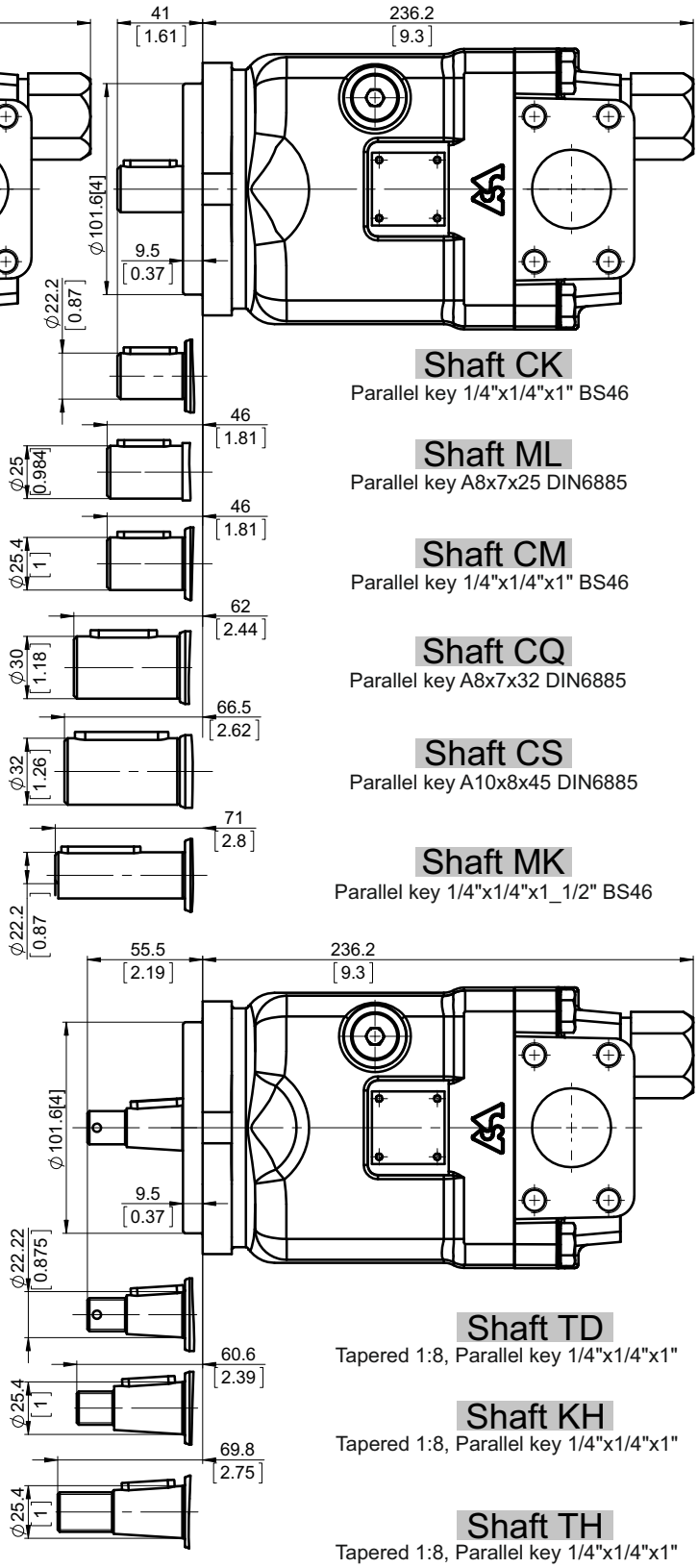
Shaft SH
W30x2x30x14x9g

Shaft SF
15T 16/32

Shaft GF
15T 16/32

Shaft SK
14T 12/24

Shaft GK
14T 12/24



Shaft CK
Parallel key 1/4"x1/4"x1" BS46

Shaft ML
Parallel key A8x7x25 DIN6885

Shaft CM
Parallel key 1/4"x1/4"x1" BS46

Shaft CQ
Parallel key A8x7x32 DIN6885

Shaft CS
Parallel key A10x8x45 DIN6885

Shaft MK
Parallel key 1/4"x1/4"x1_1/2" BS46

Shaft TD
Tapered 1:8, Parallel key 1/4"x1/4"x1"

Shaft KH
Tapered 1:8, Parallel key 1/4"x1/4"x1"

Shaft TH
Tapered 1:8, Parallel key 1/4"x1/4"x1"

Shaft Dimensions
See Page 52÷57

PERMISSIBLE SHAFT LOAD

Permissible shaft load		
max Axial	N[lb]	Fa=2000 [450]
max Radial	N[lb]	Fr=3600 [810]

The calculated max values are based on the optimal direction of the forces Fr, Fa and optimal position of the shaft (see page 58).

For more information, please, feel free to contact us.

mm [in]

ORDERING CODE

	1	2	3	4	5	6	7	8	8	8
P A P								[		]

Pos.1 - Mounting Flange

B - SAE B - 2-Bolt flange spigot diam. 101,6 mm [4"] - BC 146 mm [5.75"]

Pos.2 - Displacement Code

35 - 36.16 cm.^{3}/rev. [2.21 in.^{3}/rev.]
40 - 41.59 cm.^{3}/rev. [2.54 in.^{3}/rev.]
46 - 47.13 cm.^{3}/rev. [2.88 in.^{3}/rev.]
50 - 49.94 cm.^{3}/rev. [3.05 in.^{3}/rev.]

Pos.4 - Direction of Rotation

R - CW, Right direction
L - CCW, Left direction

Pos.4 - Shaft Extensions*

SD - ø21,72 [0.855"] spline SAE 13T 16/32 DP, M8
GD - ø21,72 [0.855"] spline SAE 13T 16/32 DP, 5/16-18 UNC-2B thread
LD - ø21,72 [0.855"] spline SAE 13T 16/32 DP, 1/4-20 UNC-2B thread
SF - ø24.9 [0.98"] spline SAE 15T 16/32, M8-6H
GF - ø24,9 [0.98"] spline SAE 15T 16/32, 3/8-16UNC-2B
LF - ø24.9 [0.98"] spline SAE 15T 16/32 DP, 1/4-20UNC-2B thread
SH - ø29.6 [1,165"] spline W30x2x30x14x9g DIN, M10-6H thread
SK - ø31,75 [1,25"] spline SAE 14T 12/24 DP, M10
GK - ø31,75 [1,25"] spline SAE 14T 12/24 DP, 7/16-14UNC-2B thread
CK - ø22.2 [ø7/8"] straight, M8-6H thread Parallel key 1/4"x1/4"x1" BS46
MK - ø22.2 [ø7/8"] straight, M8-6H thread Parallel key 1/4"x1/4"x1_1/2" Bs46
ML - ø25 [ø0.984"] straight, M8-6H thread Parallel key A8x7x25 DIN6885
CM - ø25.4 [ø1"] straight, M8-6H thread Parallel key 1/4"x1/4"x1" BS46
CQ - ø30 [ø1.181"] straight, M8-6H thread Parallel key A8x7x32 DIN6885
CS - ø32 [ø1.26"] straight, M8-6H thread Parallel key A10x8x45 DIN6885
TD - ø22.22 [7/8"] Tapered 1:8 [125:1000], Parallel key 1/4"x1/4"x1", 5/8-18 UNF-2A
TH - ø25.4 [1"] Tapered 1:8 [125:1000], Parallel key 1/4"x1/4"x1", 3/4-16 UNF-2A
KH - ø25.4 [1"] Tapered 1:8 [125:1000], Parallel key 1/4"x1/4"x1", M16x1.5

Pos.4 - Port Size

omit - Inlet ISO 6162-1 DN38,Outlet ISO 6162-2 DN19 ,metric thread, drain ports M18x1.5
5 - Inlet SAE J518 1-1/2 PSI3000, Outlet SAEJ518 3/4 PSI6000, sae thread, drain 7/8-14 UNF-2B

Pos.5 - Seal, Corrosion Resistant Seal Surface

omit - NBR seal type material
V - FKM seal type material

Pos.6 - Paint and Coating

omit - No paint or coating
PS - Painted **
PCS - Painted corrosion protected paint**

If a painting option is required, the standard color is black-Alkyd-Styrenated Enamel, Black RAL 9005.
Other color by customer's request.

Pos.7 - Special Unit

omit - None

Pos.8 - Design Series

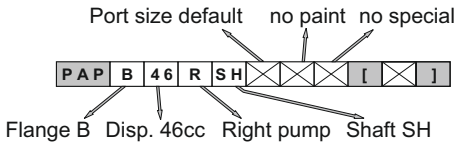
omit - Factory specified

*The permissible output torque for shafts must not be exceeded!
**Non painted feeding surface

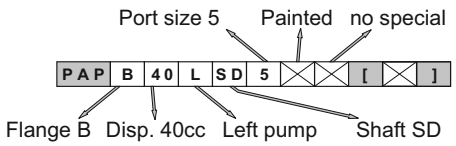
We remain open to meet your special requirements upon request.

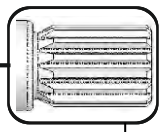
EXAMPLE

P A P B 4 6 R S H



P A P B 4 0 L S D P S

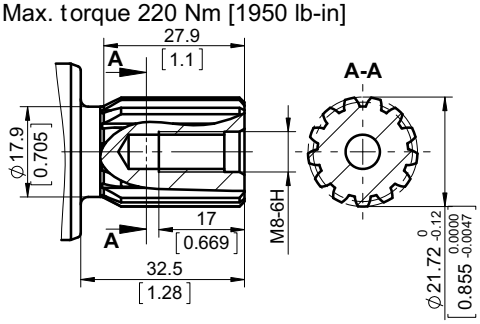




Shaft Types and Dimensions

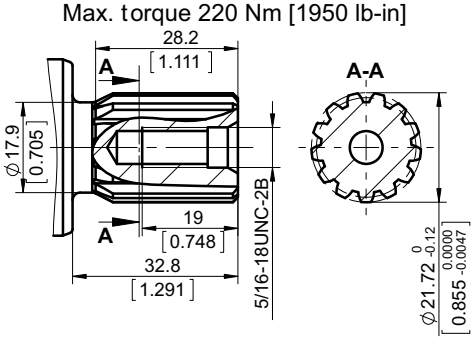
SD

ø21.72 [ø0.855“], M8-6H thread
13T 16/32 DP splined ANSI B92.1-1970
Max. torque 220 Nm [1950 lb-in]



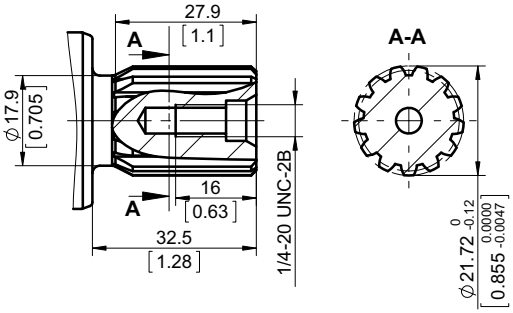
GD

ø21.72 [ø0.855“], 5/16-18 UNC-2B thread
13T 16/32 DP splined ANSI B92.1-1970
Max. torque 220 Nm [1950 lb-in]



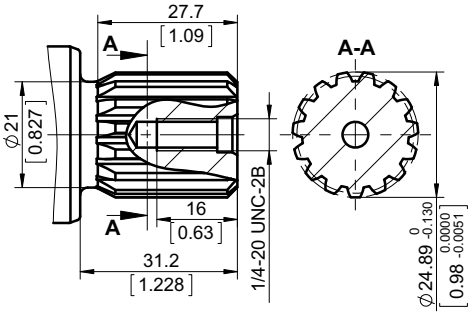
LD

ø21.72 [ø0.855“], 1/4-20 UNC-2B thread
13T 16/32 DP splined ANSI B92.1-1970
Max. torque 220 Nm [1950 lb-in]



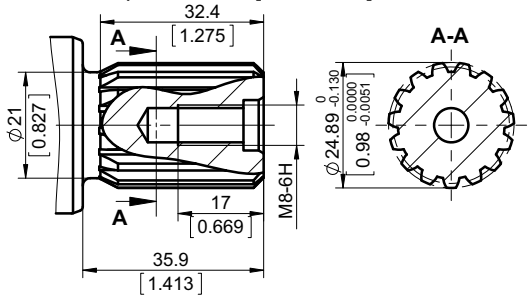
LF

ø24.89 [ø0.98“], 1/4-20 UNC-2B thread
15T 16/32 DP splined ANSI B92.1-1970
Max. torque 360 Nm [3180 lb-in]



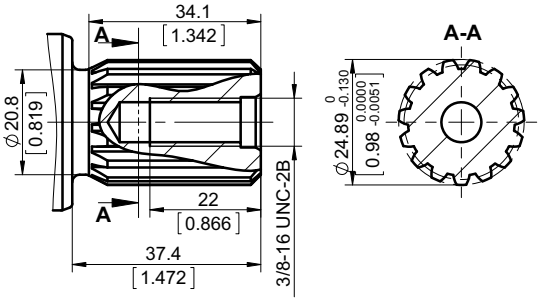
SF

ø24.89 [ø0.98“], M8-6H thread
15T 16/32 DP splined ANSI B92.1-1970
Max. torque 360 Nm [3180 lb-in]

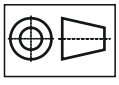


GF

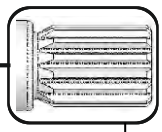
ø24.89 [ø0.98“], 3/8-16 UNC-2B thread
15T 16/32 DP splined ANSI B92.1-1970
Max. torque 360 Nm [3180 lb-in]



The required max. torque must not be exceeded



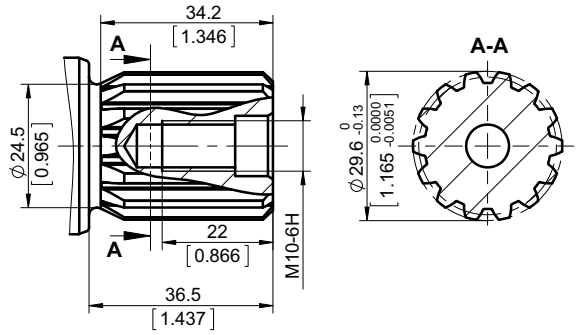
mm [in]



Shaft Types and Dimensions

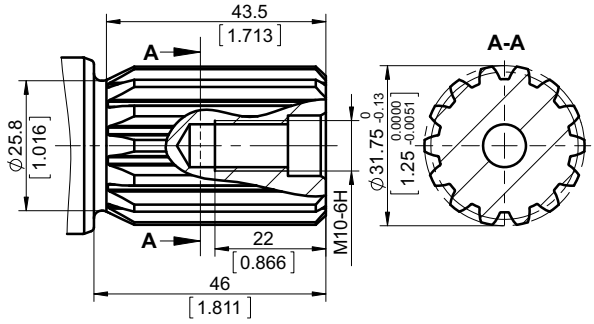
SH

ø29,6 [ø1.165“], M10-6H thread
W30x2x30x14x9g splined DIN 5480
Max. torque 600 Nm [5310 lb-in]



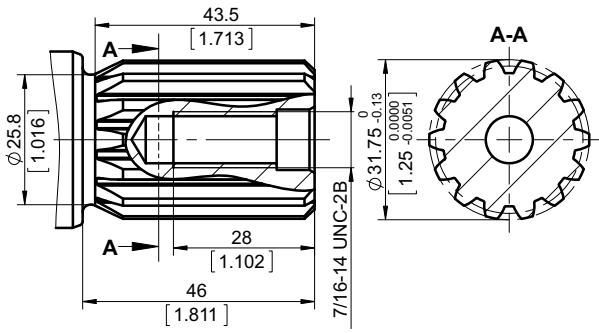
SK

ø31,75 [ø1.25“], M10-6H thread
14T 12/24 DP splined ANSI B92.1-1970
Max. torque 600 Nm [5310 lb-in]



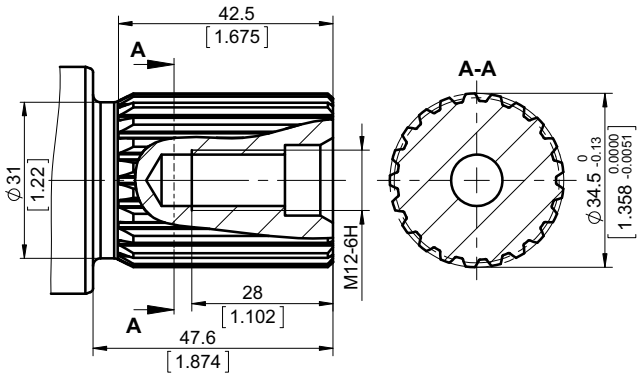
GK

ø31,75 [ø1.25“], 7/16-14 UNC-2B thread
14T 12/24 DP splined ANSI B92.1-1970
Max. torque 600 Nm [5310 lb-in]



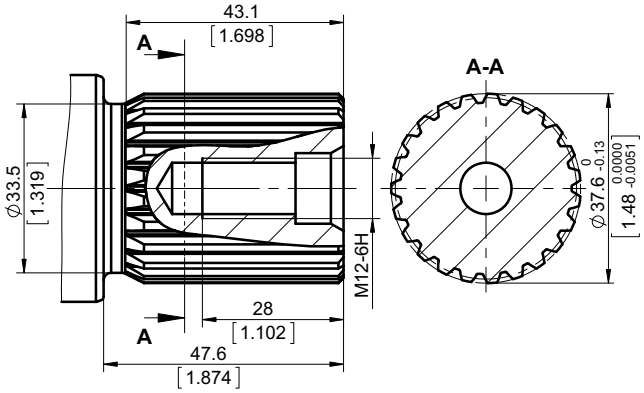
SP

ø34,5 [ø1.358“], M12-6H thread
21T 16/32 DP splined ANSI B92.1-1970
Max. torque 1085 Nm [9600 lb-in]

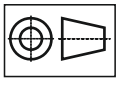


SR

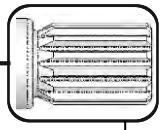
ø37,6 [ø1½“], M12-6H thread
23T 16/32 DP splined ANSI B92.1-1970
Max. torque 1300 Nm [11500 lb-in]



The required max. torque must not be exceeded



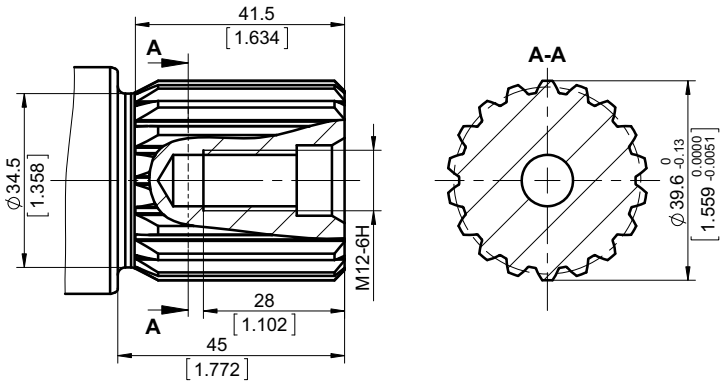
mm [in]



Shaft Types and Dimensions

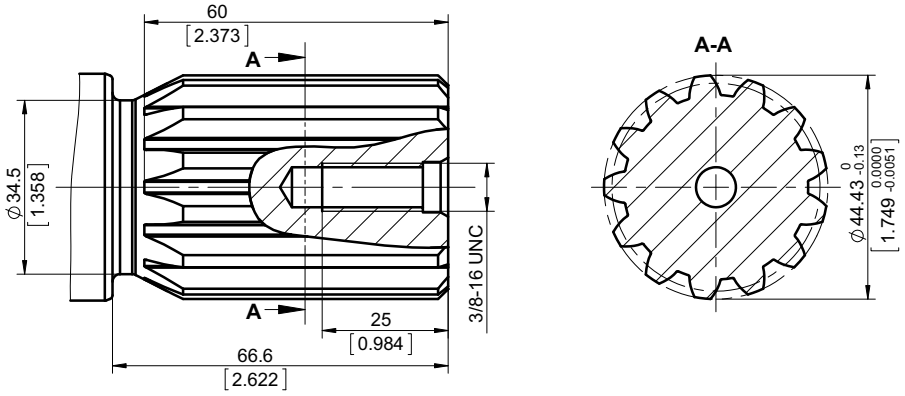
ST

ø39,6 [ø1.559"], M12-6H thread
W40x2x30x18x9g splined DIN 5480
Max. torque 1400 Nm [12400 lb-in]

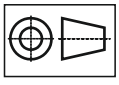


GU

ø44,43 [ø1¾"], 3/8-16 UNC-2B thread
13T 8/16 DP splined ANSI B92.1-1970
Max. torque 2000 Nm [17700 lb-in]



The required max. torque must not be exceeded

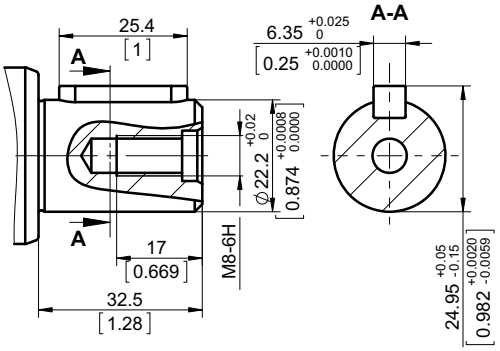


mm [in]

Shaft Types and Dimensions

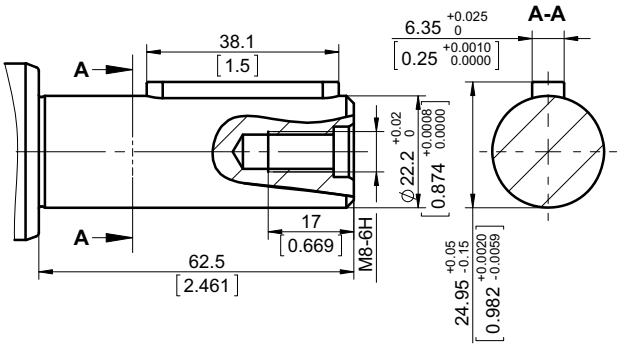
CK

ø22.2 [ø7/8“] straight, M8-6H thread
Parallel key **1/4"x1/4"x1**" BS46
Max. torque 180 Nm [1600 lb-in]



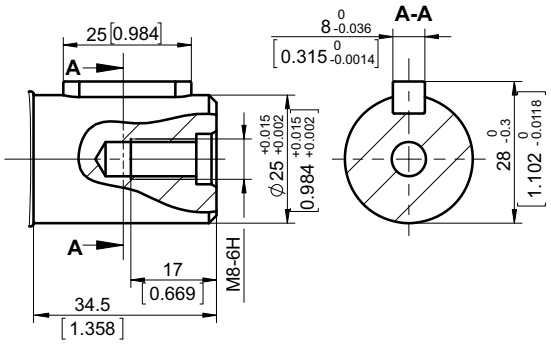
MK

ø22.2 [ø7/8“] straight, M8-6H thread
Parallel key **1/4"x1/4"x1_1/2**" BS46
Max. torque 180 Nm [1600 lb-in]



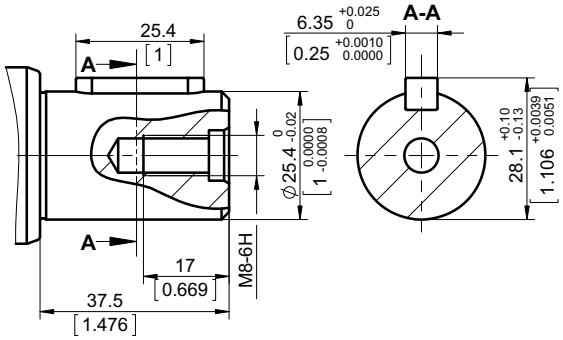
ML

ø25 [ø0.984“] straight, M8-6H thread
Parallel key **A8x7x25** DIN6885
Max. torque 250 Nm [2210 lb-in]



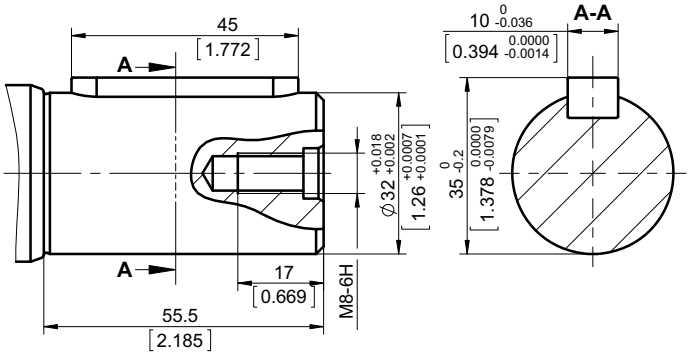
CM

ø25.4 [ø1“] straight, M8-6H thread
Parallel key **1/4"x1/4"x1**" BS46
Max. torque 250 Nm [2210 lb-in]



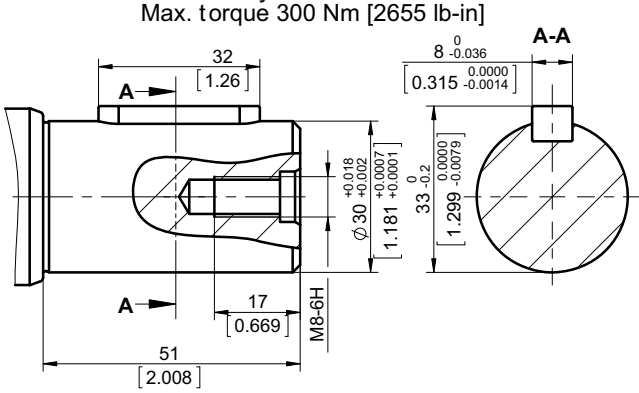
CS

ø32 [ø1.26“] straight, M8-6H thread
Parallel key **A10x8x45** DIN6885
Max. torque 565 Nm [5000 lb-in]



CQ

ø30 [ø1.181“] straight, M8-6H thread
Parallel key **A8x7x32** DIN6885
Max. torque 300 Nm [2655 lb-in]



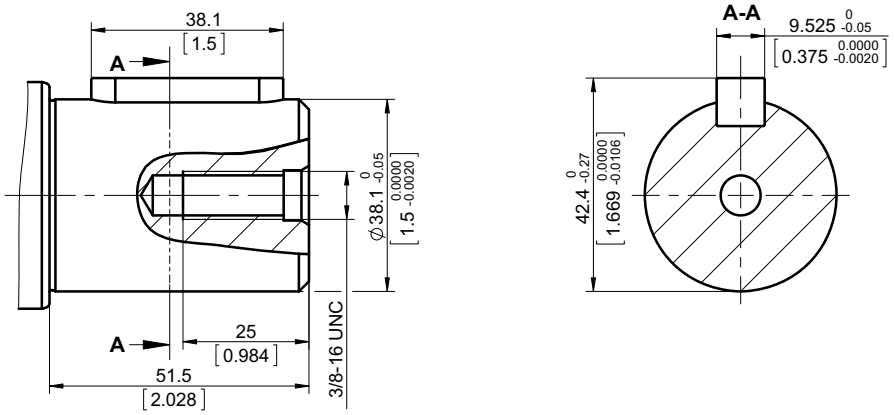
The required max. torque must not be exceeded

mm [in]

Shaft Types and Dimensions

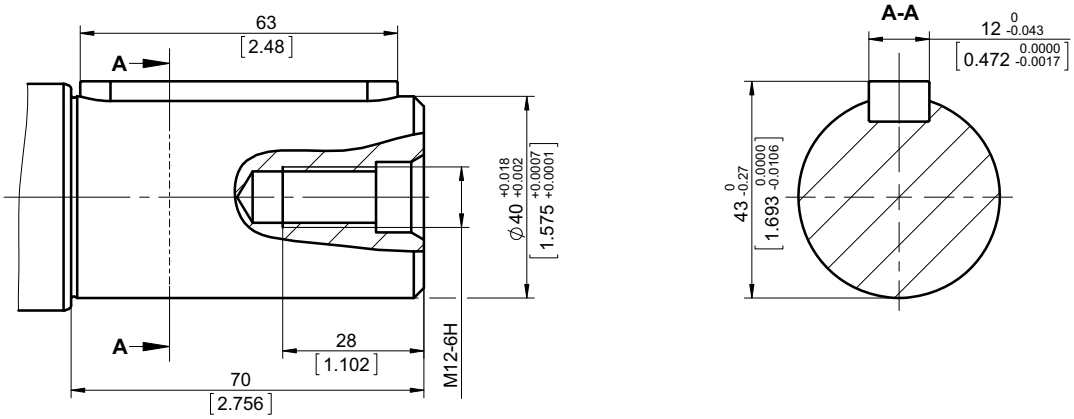
DU

ø38.1 [**ø1½"]** straight, 3/8-16 UNC-2B thread
Parallel key **3/4"x3/4"x1½"** BS46
Max. torque 1000 Nm [8850 lb-in]



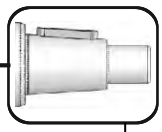
CV

ø40 [**ø1.575"]** straight, M12-6H thread
Parallel key **A12x8x63** DIN6885
Max. torque 1100 Nm [9735 lb-in]



The required max. torque must not be exceeded

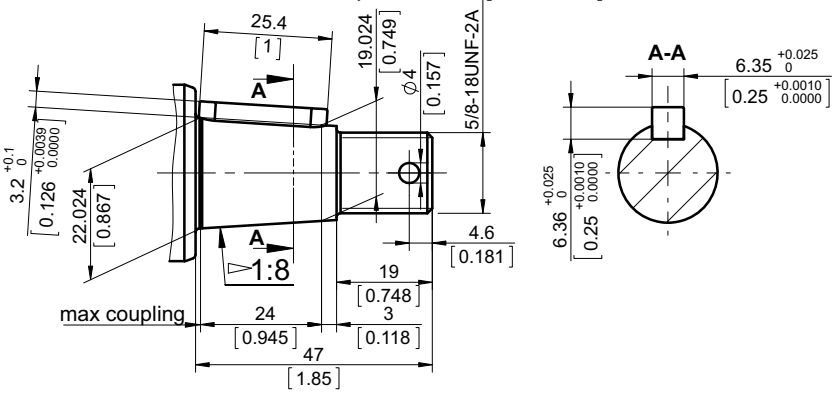
mm [in]



Shaft Types and Dimensions

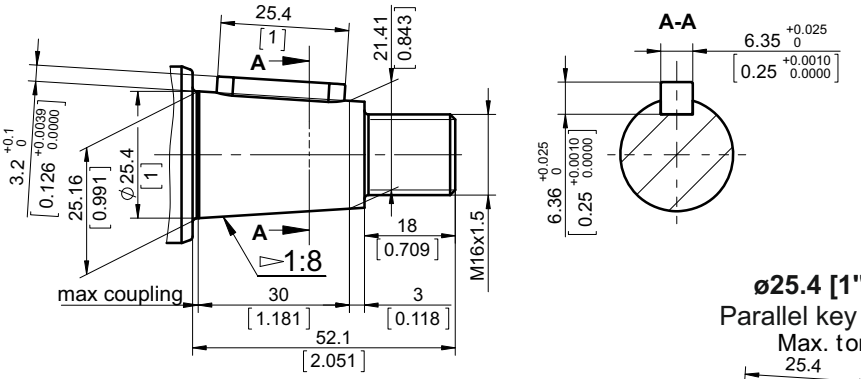
TD

ø22.22 [7/8"] Tapered **1:8 [125:1000],**
Parallel key **1/4"x1/4"x1**", 5/8-18 UNF-2A
Max. torque 220 Nm [1950 lb-in]



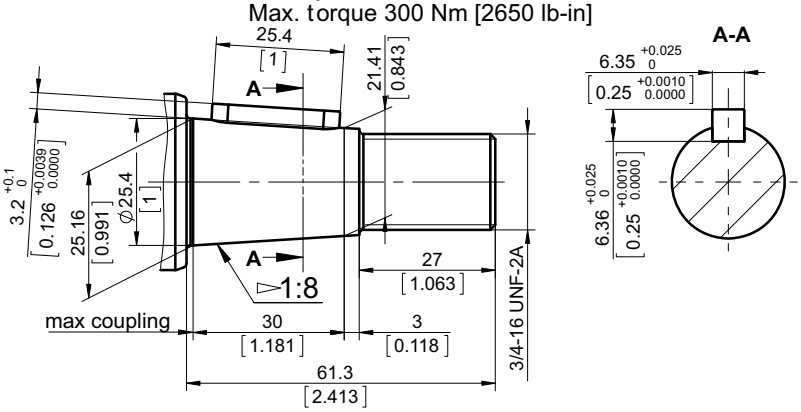
KH

ø25.4 [1"] Tapered **1:8 [125:1000],**
Parallel key **1/4"x1/4"x1**", M16x1.5
Max. torque 300 Nm [2650 lb-in]



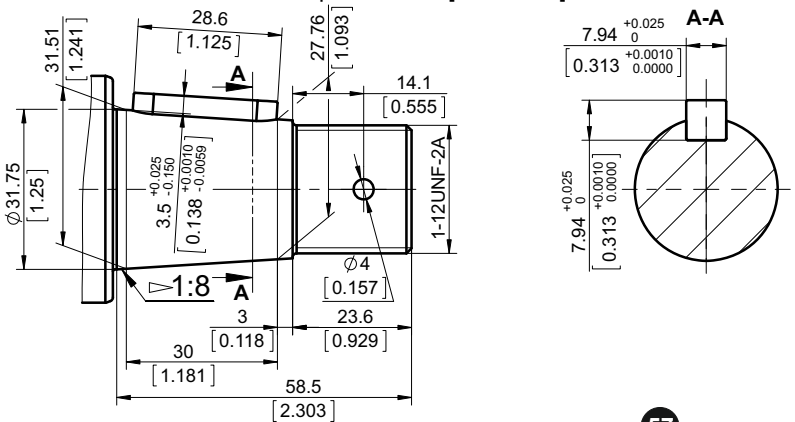
TH

ø25.4 [1"] Tapered **1:8 [125:1000],**
Parallel key **1/4"x1/4"x1**", 3/4-16 UNF-2A
Max. torque 300 Nm [2650 lb-in]

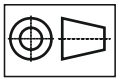


TN

ø31.75 [1¼"] Tapered **1:8 [125:1000],**
Parallel key **5/16"x5/16"x1 1/8**", 1-12UNF-2A
Max. torque 500 Nm [4425 lb-in]



The required max. torque must not be exceeded

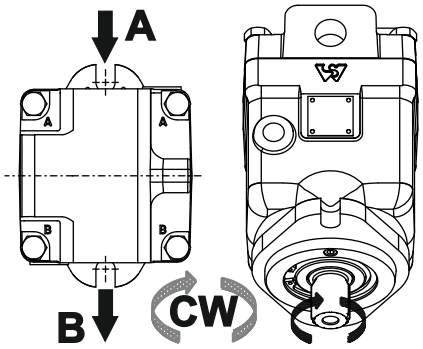


mm [in]

INSTALLATION

DIRECTION OF ROTATION

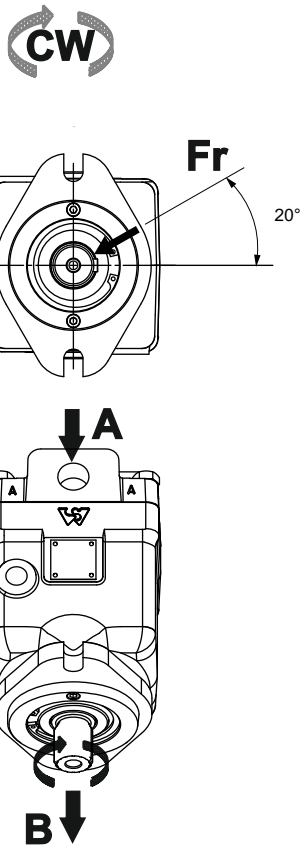
Standard Rotation
Viewed from shaft end
Port **A** Pressurized - **CW**
Port **B** Pressurized - **CCW**



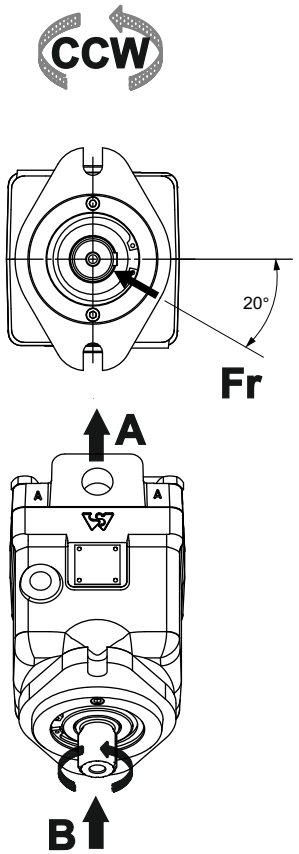
BEST POSITION FOR APPLYING RADIAL LOAD

Optimal position for applying radial load depending on the direction of rotation

Standard Rotation

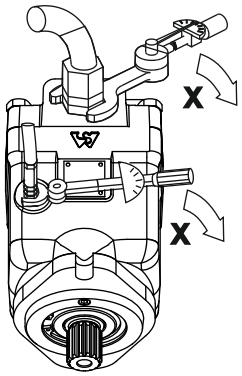


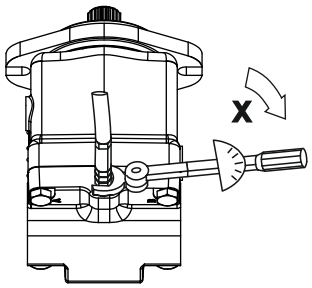
Reverse Rotation



INSTALLATION

Recommended max. tightening torque X for metal plugs and orifice

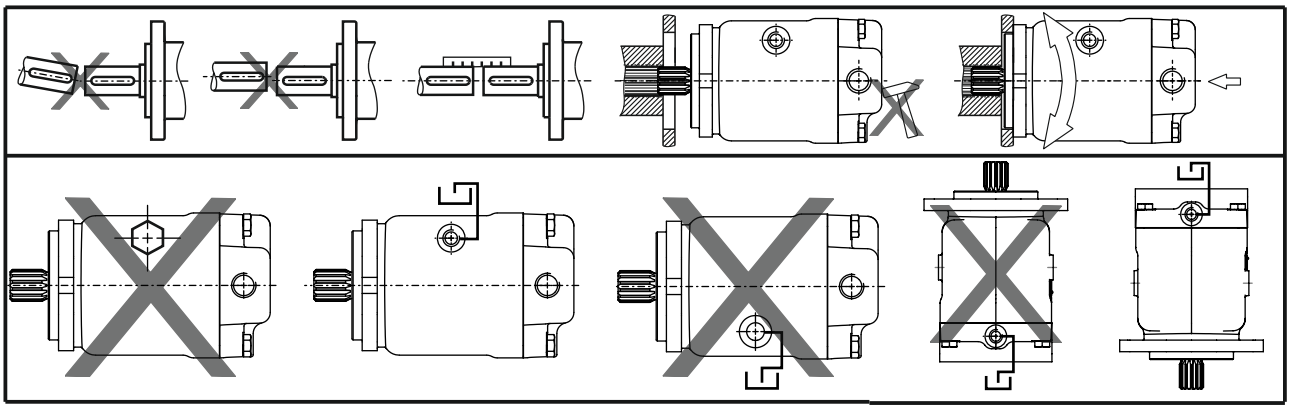




Screwed connection Anschlussart Raccord Tipo di collegamento Especie de unir Присоединительные резбы	**Max. Tightening Torque X, daNm [lb-in] Max. Anzugsmoment X, daNm [lb-in] Couple de serrage maxi X, daNm [lb-in] Momento di serraggio max. X, daNm [lb-in] Momento d'apretadura max. X, daNm [lb-in] Момент затяжки X, daNm [lb-in]**			
	With copper washer Mit Kupferscheibe Avec rondelle en cuivre Con rondella di rame De arandela de cobre С медной шайбой	With aluminium washer Mit Aluminiumscheibe Avec rondelle en aluminium Con rondella di alluminio De arandela d'aluminio С алюминиевой шайбой	With cutting edge Mit Dichtkante Tranchant Con tagliente di guarnizione De borde compactar С крутым бортиком	With "O" ring Mit "O" Ring Avec joint torique Con "O"-anello De "O"-anillo С резиновым кольцом
G 1/4	2 [180]	3 [265]	4 [360]	2 [180]
G 3/8	2 [180]	5 [450]	6 [550]	2 [180]
G 1/2	3 [265]	8 [700]	10 [885]	3 [265]
G 3/4	5 [450]	13 [1150]	16 [1400]	5 [450]
G 1	8 [700]	20 [1770]	25 [2200]	8 [700]
1/8-14 UNF				7 [620]
3/8-24(16) UNF(UNC)				1,5 [130]
7/16-20(16) UNF				2 [180]
9/16-18 UNF				2 [180]
9/16-20 UNF				3.5 [310]
3/4-16 UNF				6 [550]
7/8-14(16) UNF				7 [620]
1 1/16-12 UN				9 [800]
1 5/16-12 UN				16 [1400]
1/2-14 NPTF				3 [265]
1/4-18 NPTF				3 [265]
M 8	2 [180]	1 [88.5]	2 [180]	
M 10	2 [180]	1 [88.5]	2 [180]	
M 12	2 [180]	3 [265]	4 [360]	
M 14x1,5	2 [180]	3 [265]	4 [360]	3 [265]
M 16x1,5	2 [180]	5 [450]	6 [550]	5 [450]
M 18x1,5	2 [180]	5 [450]	6 [550]	5 [450]
M 20x1,5	3 [265]	8 [700]	10 [885]	8 [700]
M 22x1,5	3 [265]	8 [700]	10 [885]	8 [700]
M 24x1,5	2 [180]	3 [265]	4 [360]	10 [885]
M 27x2	5 [450]	13 [1150]	10 [885]	10 [885]

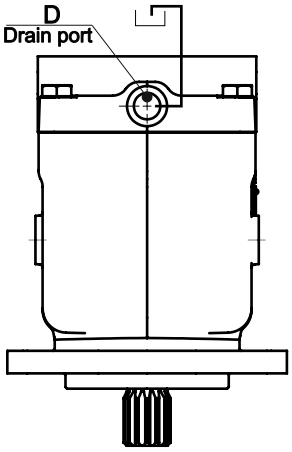
INSTALLATION

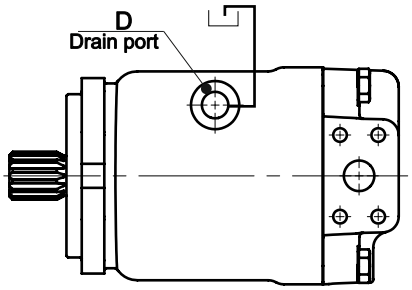
At start-up and during operation the motor(pump) housing has to be filled up with hydraulic fluid. Start-up has to be carried out at low or moderate speed and without load (for example 1000 rpm and pressure 50 bar [725 PSI]) till the motor(pump) and the hydraulic scheme are filled up with oil. Generally the start-up needs 10-15 minutes to finish. The leakage oil in the housing has to be discharged to the tank through the highest positioned drain port D. The max. pressure in the drain line is 5 bar.



Installation below the tank level (recommended)

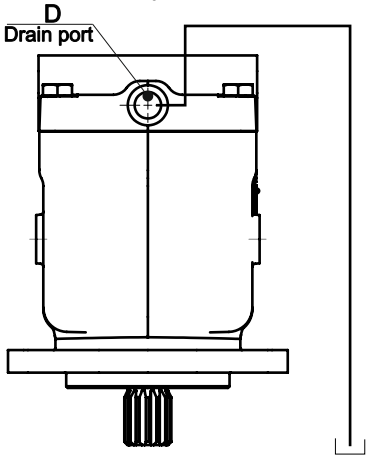
- Fill up the axial piston motor(pump) before the start-up through the highest positioned drain port D;
- Operate the motor(pump) at low speed till the motor system is completely filled up;
- The minimum immersion depth of the drain line in the tank is 200 mm relative to the minimum oil level in the tank.

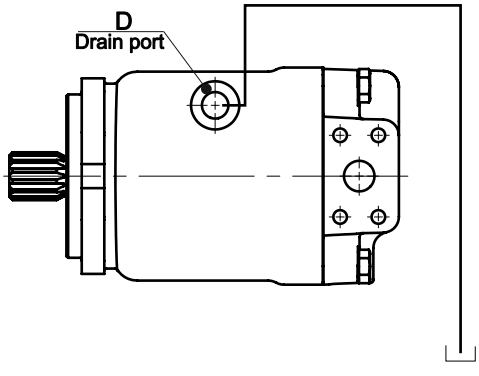




Installation on top of the tank level

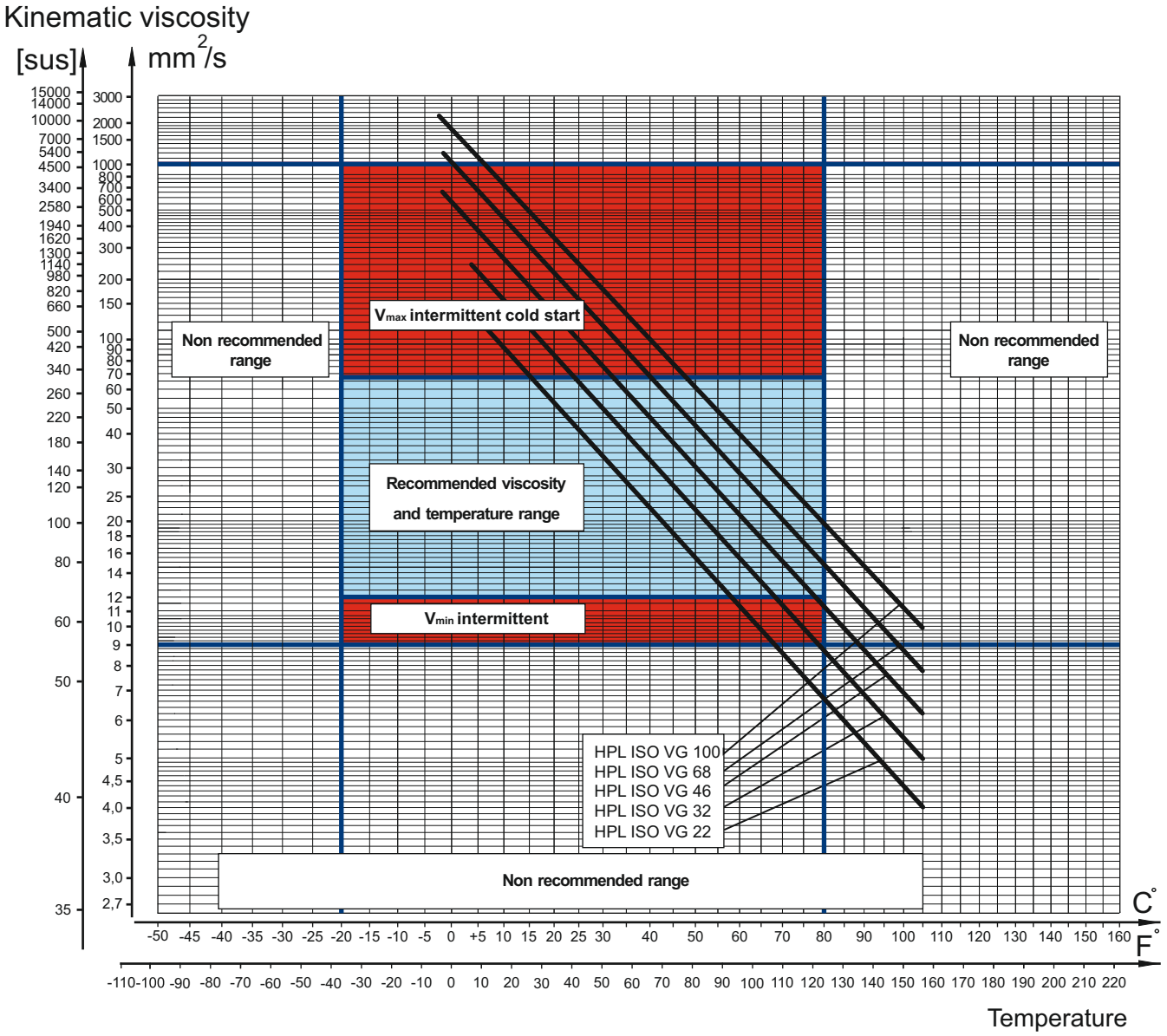
- Fill up the axial piston motor(pump) before the start-up through the highest positioned drain port D;
- Operate the motor(pump) at low speed till the motor system is completely filled up;
- The minimum immersion depth of the drain line in the tank is 200 mm relative to the minimum oil level in the tank.





Fluid Viscosity Limits

In order to obtain optimum efficiency and service life, we recommend to select the operating viscosity (at operating temperature) within the range shown on diagram below.



The above - shown viscosity characteristics are for reference only. Please, check the actual viscosity with the manufacturer of the fluid.

Basic Formulas

The motor(pump) size, pressure and flow required for a specific application can be calculated using the formulas below.

Metric System

Efficiency	$\eta_t = \eta_{mh} \cdot \eta_v \quad \eta_{mh} = \frac{\eta_t}{\eta_v} \quad \eta_v = \frac{\eta_t}{\eta_{mh}}$	
Input flow (for Motor)	$Q = \frac{Vg \cdot n}{1000 \cdot \eta_v}$	[l/min]
Output torque (for Motor)	$M = \frac{Vg \cdot \Delta p \cdot \eta_{mh}}{62.8}$	[Nm]
Output power (for Motor)	$P = \frac{M \cdot n}{9550} = \frac{Q \cdot \Delta p \cdot \eta_t}{60}$	[kW]
Speed (for Motor)	$n = \frac{Q \cdot 1000 \cdot \eta_v}{Vg}$	[min^{-1}]
Output flow (for pump)	$Q = \frac{Vg \cdot n \cdot \eta_v}{1000}$	[l/min]
Driving torque (for pump)	$M = \frac{Vg \cdot \Delta p}{62.8 \cdot \eta_{mh}}$	[Nm]
Input power (for pump)	$P = \frac{M \cdot n}{9550} = \frac{Q \cdot \Delta p}{60 \cdot \eta_t}$	[kW]

Vg = Displacement per rev. [cm^3]
Δp = $p_{HP} - p_{LP}$ [bar]
p_{HP} = High pressure [bar]
p_{LP} = Low pressure [bar]
η_v = Volumetric efficiency
η_{mh} = Mechanical-hydraulic efficiency
η_t = Overall efficiency

Inch System

Efficiency	$\eta_t = \eta_{mh} \cdot \eta_v \quad \eta_{mh} = \frac{\eta_t}{\eta_v} \quad \eta_v = \frac{\eta_t}{\eta_{mh}}$	
Input flow (for Motor)	$Q = \frac{Vg \cdot n}{231 \cdot \eta_v}$	[GPM]
Output torque (for Motor)	$M = \frac{Vg \cdot \Delta p \cdot \eta_{mh}}{2 \cdot \pi}$	[lb-in]
Output power (for Motor)	$P = \frac{Vg \cdot n \cdot \Delta p \cdot \eta_t}{396000}$	[hp]
Speed (for Motor)	$n = \frac{Q \cdot 231 \cdot \eta_v}{Vg}$	[min^{-1}]
Output flow (for pump)	$Q = \frac{Vg \cdot n \cdot \eta_v}{231}$	[GPM]
Driving torque (for pump)	$M = \frac{Vg \cdot \Delta p}{2 \cdot \pi \cdot \eta_{mh}}$	[lb-in]
Input power (for pump)	$P = \frac{Vg \cdot n \cdot \Delta p}{396000 \cdot \eta_t}$	[hp]

Vg = Displacement per rev. [in^3]
Δp = $p_{HP} - p_{LP}$ [PSI]
p_{HP} = High pressure [PSI]
p_{LP} = Low pressure [PSI]
η_v = Volumetric efficiency
η_{mh} = Mechanical-hydraulic efficiency
η_t = Overall efficiency

Application Formulas

Motor speed: n [min^{-1}]

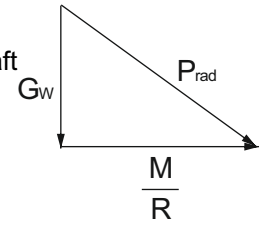
$$n = \frac{2{,}65 \cdot v_{km} \cdot i}{R_m} \qquad n = \frac{168 \cdot v_{mi} \cdot i}{R_{in}}$$

v_{km} - vehicle speed [km/h]
v_{mi} - vehicle speed [mil/h]
R_m - wheel rolling radius [m]
R_{in} - wheel rolling radius [in]
i - gear ratio between motor and wheels.
If no gearbox, use i=1.

Radial motor loading: P_{rad}, N [lbs]
When the motor is used for motion with a ring or gear mounted directly on the motor shaft, the total radial load of the motor shaft **P_{rad}** is the sum of the motion force and the weight force acting on ring.

G_W - Weight held by the shaft
P_{rad} - Total radial load of the motor shaft
M/R - Motion force

$$P_{rad} = \sqrt{G_W^2 + \left(\frac{M}{R}\right)^2}$$



Total tractive effort: TE, N [lbs]
Total tractive effort **TE** is the total effort necessary for vehicle motion i.e. the sum of the calculated forces increased by 10 % because of air resistance.

$$TE = 1{,}1 \cdot (RR + GR + FA + DP)$$

RR - force required to overcome the rolling resistance
GR- force required to slope upwards
FA- force required to accelerate (acceleration force)
DP- additional tractive effort (trailer)

Motor Torque moment: M, Nm [lb-in]
Necessary torque for the hydraulic motor:

$$M = \frac{TE \cdot R_m [R_{in}]}{N \cdot I \cdot \eta_M}$$

I – motor numbers
η_M - mechanical gearbox efficiency (if it is available)

Depending on the results of the load calculations, the most appropriate type of motor from the catalogue is selected.