

External Gear Motors F & N Series

RA 14 025/04.07
Replaces: 07.04

1/52

AZMF ... , AZMN ...

Model F = 8.2...22.9 cm³ (0.51...1.40 in³)
N = 20.4...36.4 cm³ (1.24...2.28 in³)



Contents

General	3
Product Overview	3
Installation	6
Drive Arrangements	7
F-Series External Gear Motor	
- Ordering Code	10
- Product Index	11
- Drive Shafts	12
- Front Cover	13
- Port Connections	14
- Performance Ratings	15
- SAE O-Ring BOSS - Standard Porting	15
- SAE Porting-Specifications & Dimensions	15
- Performance Curves	16
- Drawings and Charts	18
N-Series External Gear Motor	
- Ordering Code	40
- Product Index	41
- Performance Ratings	42
- SAE O-Ring BOSS - Standard Porting	42
- Performance Curves	43
- Drawings and Charts	45
Spare Parts	51
Part Number Index	52

Page

General

Rexroth external gear motors are produced in two different models, with a wide range of displacements, and a variety of port, shaft and mounting options.

Features

- Nominal pressure 3000 psi (210 bar)
- Plain Bearings for heavy duty applications
- Drive Shafts to SAE or DIN
- Port connections: flange or screw thread
- Consistent high quality
- Considerably longer life due to reinforced shaft and housing

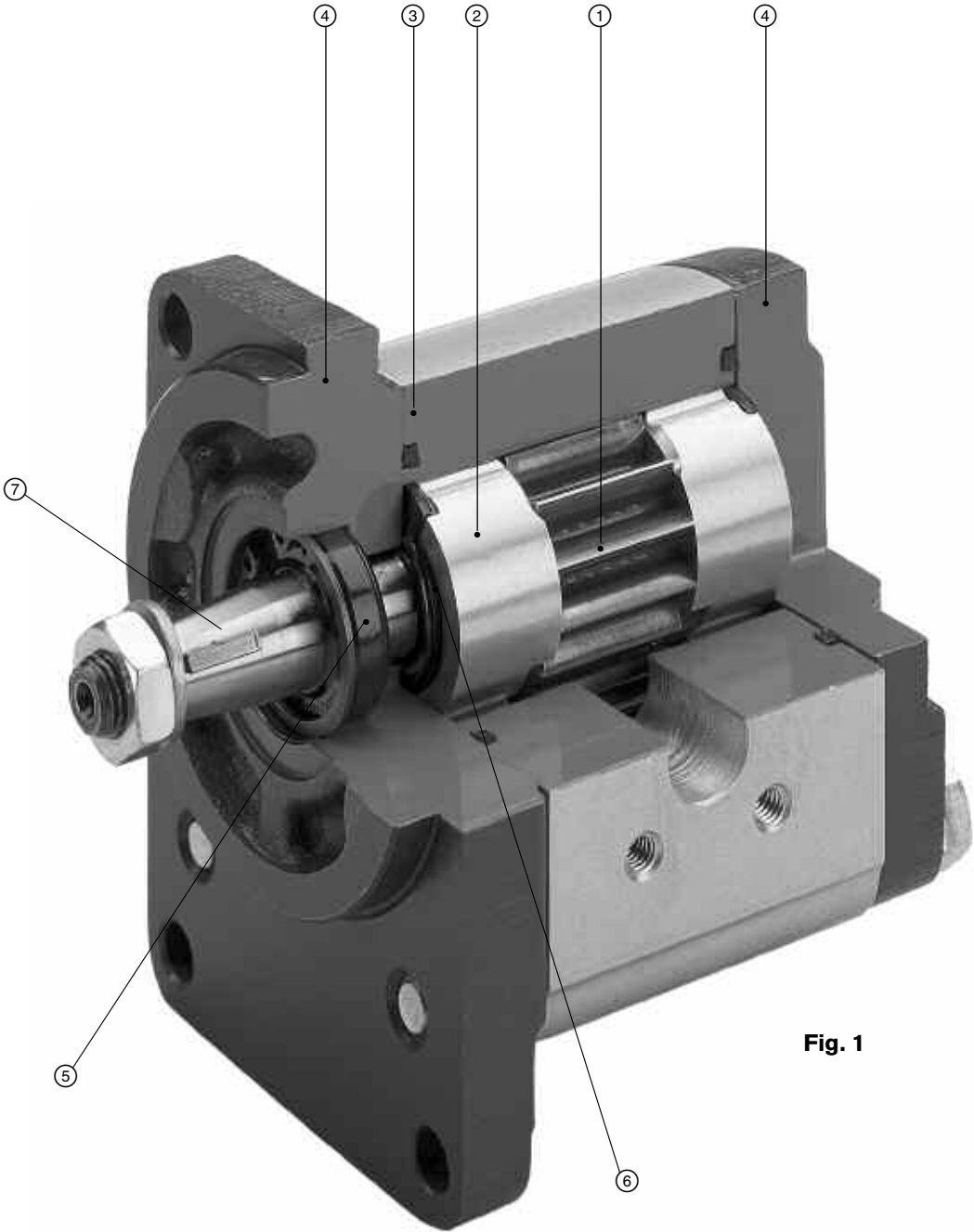


Fig. 1

General

Basic design

Referencing Fig. 1, the motor essentially consists of a pair of gears ① supported in bearing blocks ②, and a housing ③ with front and rear covers ④. The output shaft ⑦ extends from the front cover where it is sealed by a shaft seal ⑤.

The bearing forces are absorbed by special bearings with sufficient elasticity to produce surface contact instead of line contact ②. They also assure good operation under emergency conditions, especially at low speed. The internal sealing is pressure-sensitive, which ensures optimum efficiency.

The bearing blocks ② provide the seal at the ends of the gaps between the teeth which carry the pressurized oil. The sealing zone between the gear teeth and the bearings is controlled by the communication of operating pressure to the rear of the bearings.

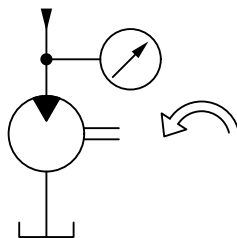
Special seals ⑥ form the boundary of the zone.

If pressurized oil is fed into the motor, a torque can be obtained from the shaft leading out of the housing. Here, a distinction is made between motors for one direction of rotation and reversible motors.

Motors for one direction of rotation

These are of asymmetrical design, i.e. the high and low pressure sides are defined and not interchangeable at will. In this case, reversible operation is not possible.

In order to ensure a high efficiency level, a special running in method is used for motors. Leakage oil is discharged internally to the outlet side. Pressure loading of the outlet is limited by the shaft seal.



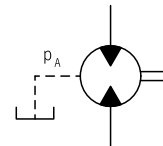
Reversible motors

These motors are of symmetrical design. Depending upon the effective direction of the high pressure, the gears and bearing blocks are pressed against one of the sides of the housing. Depending upon the direction of rotation, sealing zones are formed which provide radial clearance. There are therefore two sealing zones opposite one another. The pressure zones which provide axial clearance are defined by symmetrical shaped seal rings.

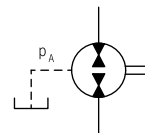
The leakage oil from the bearing bushings is discharged through a separate leakage-oil fitting in the housing cover. Here, the faces of the two gears are joined by means of a bore in the shaft which is not used for power take-off. Due to this external discharge of leakage oil, the return port in question can be loaded. (Series connection of a number of motors.)

Reversible motors are distinguished as follows:

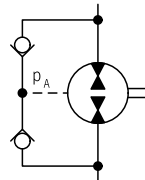
- Motors for 2-quadrant operation, i.e. output torque in both directions.



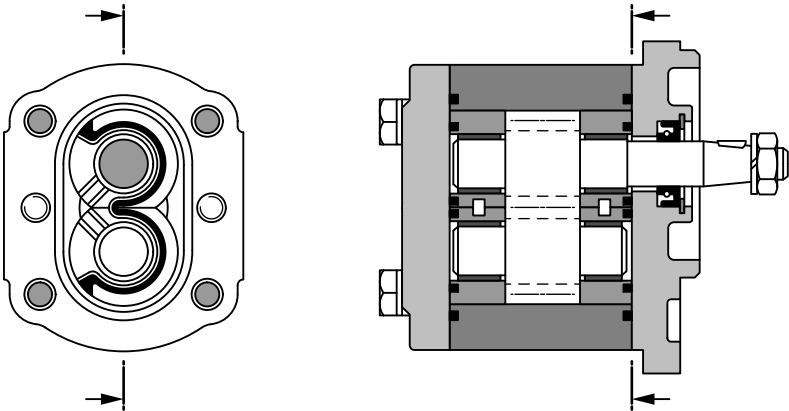
- Motors for 4-quadrant operation, i.e. both output and input torque in both directions. (Hydraulic motor becomes a pump if load reversal occurs.)



- To avoid the need for an additional leakage-oil connection, the internal leakage oil may be routed into the respective outlet via internal check valves. The pressure in the outlet p_A is limited correspondingly.



Motor for One Direction of Rotation



Bi-Rotational Motor

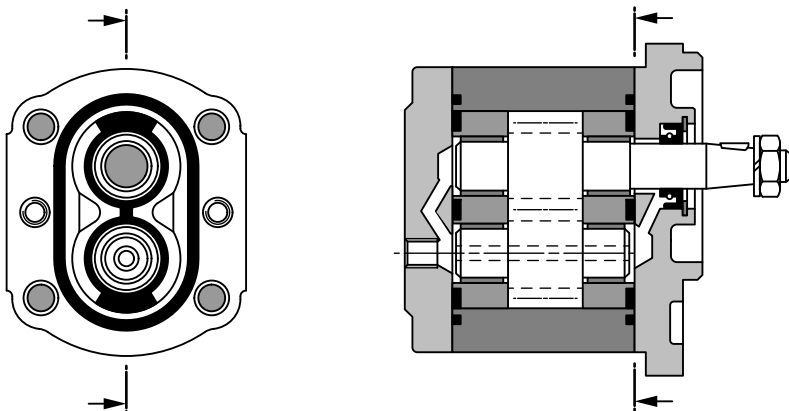


Fig. 2

Bosch Rexroth Gear Motors

Specification

General	
Construction	External gear-type motor
Mounting	Flange or through-bolting with pilot
Line connections	Flange
Direction of rotation (Fig. 3)	One direction of rotation or reversible
Mounting position	any
Ambient temperature range	- 15 °C ... + 60 °C (+5° F... 140° F)
Fluid	Mineral oil-based hydraulic fluids to DIN/ISO, other fluids to order
Viscosity	12 ... 800 mm²/s permitted range 20 ... 100 mm²/s recommended range ... 2000 mm²/s permitted for starting
Fluid temperature range	- 15 °C ... + 80 °C (+5° F... 176°F)
Filtration	NAS 1638, class 10; ISO/DIS 4406, class 19/16; obtained with filter fineness $\beta_{25} \geq 75^1)$

1) Dirt particles retention > 25 µm is 1 : 75, i.e. 98.67 %

Safety requirements pertaining to the whole system must be observed.
In the case of applications with high numbers of load cycles, please consult us.

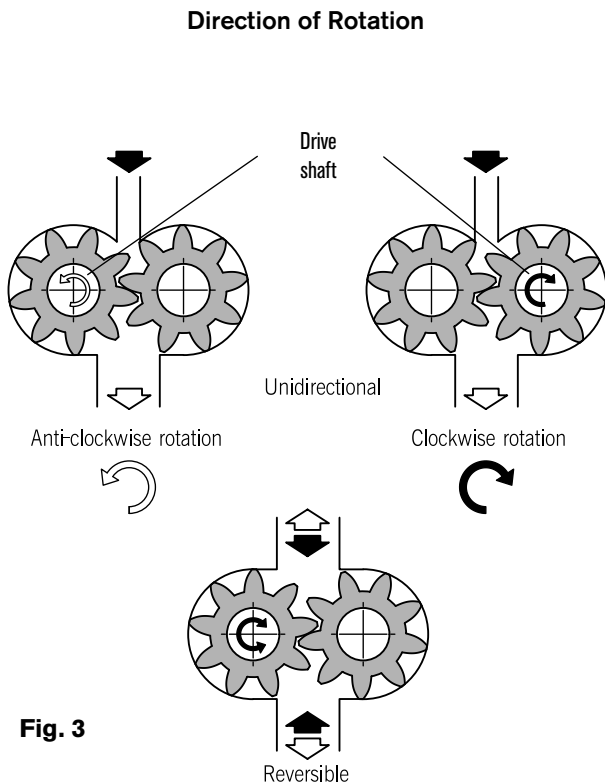
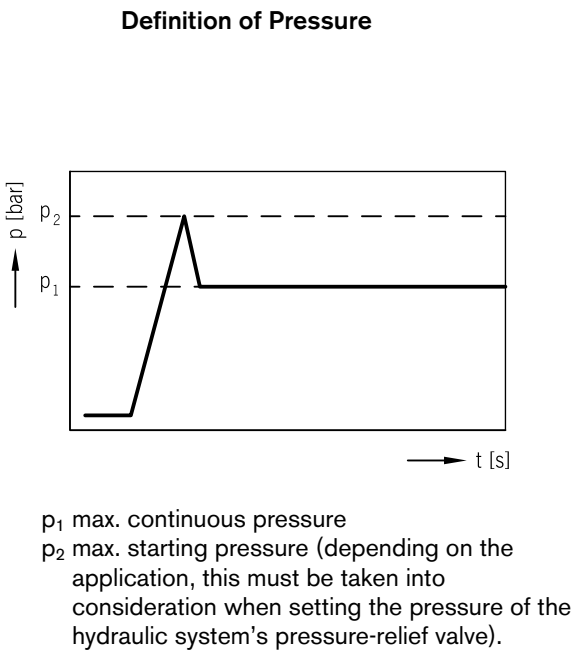


Fig. 3

* As viewed looking at end of drive shaft.



Bosch Rexroth Gear Motors

Design Calculations of Gear Motors (Reference chart 1)

The design calculations for motors are based on the following parameters:

V	[cm³/rev]	Displacement
Q	[l/min]	Flow consumption
Δp	[bar]	Pressure (p ₁ , p _A)
M	[Nm]	Output torque
n	[rev/min]	Speed
P	[kW]	Power output

It is also necessary to allow for different efficiencies such as:

η _v	Volumetric efficiency
η _{hm}	Hydraulic-mechanical efficiency
η _t	Total efficiency

The following formulas describe the various relationships. They include correction factors for adapting the parameters to the usual units encountered in practice.

Note: For approximate selection data, please use the graphs on the following pages. These graphs contain the levels of efficiency in each case.

Installation and commissioning

- Fill the motor with fluid before installing.
- Check the direction of rotation.
- Before installing the motor, clean the pipes thoroughly of all dirt, scale, sand, swarf, etc. Welded pipes in particular must be pickled or flushed out.
- Before starting up the motor for the first time, the entire hydraulic system must be thoroughly purged of air.
- Cover the shaft seal when spraying or brush-painting the equipment.
- Pay close attention to the specification, especially speeds and pressures.

For further information, see “Service Instruction Manual”, RA 14 025-S

Filter recommendations

By far the largest number of premature failures of gear motors are due to contaminated fluid. Our guarantee does not apply to wear resulting from dirt in the system. We recommend filtering, which reduces the size and concentration of the contamination particles to a permitted minimum.

Operating pressure [bar]	>160	<160
Contamination class NAS 1638	9	10
Contamination class ISO 4406	18/15	19/16
Achieved with filter β _x = 75	20	25

Full-flow filtering is always recommended. The initial contamination of the fluid with which the system is filled must not exceed Class 10 to NAS 1638. Past experience has shown that even brand new fluids often exceed this value. In such cases, filling appliance incorporating a special filter will have to be used.

Chart 1

	$Q = \frac{V \cdot n}{\eta_{v\%}} \cdot 10^{-1}$	$V = \frac{Q \cdot \eta_{v\%}}{n} \cdot 10$	$n = \frac{Q \cdot \eta_{v\%}}{V} \cdot 10$
	$\Delta p = \frac{M}{1,59 \cdot V \cdot \eta_{hm}} \cdot 10^4$	$V = 1,59 \cdot \frac{M}{\Delta p \cdot \eta_{hm\%}} \cdot 10^4$	$M = 1,59 \cdot V \cdot \Delta p \cdot \eta_{hm\%} \cdot 10^{-4}$
	$P = \frac{Q \cdot \Delta p \cdot \eta_{t\%}}{6} \cdot 10^{-4}$		
Q Δp Δp · Q η_v η_{hm} η_t [%] → n → M → P	V cm³/U n U/min	Q l/min P kW	Δp bar M Nm Achtung Note Attention η %

Drive Arrangements

1. Flexible couplings (Fig. 4)

The coupling must not transfer any radial or axial forces to the motor.

The maximum radial runout of shaft spigot is 0.2 mm.

Refer to the fitting instructions provided by the coupling manufacturer for details of the maximum permitted shaft misalignment.

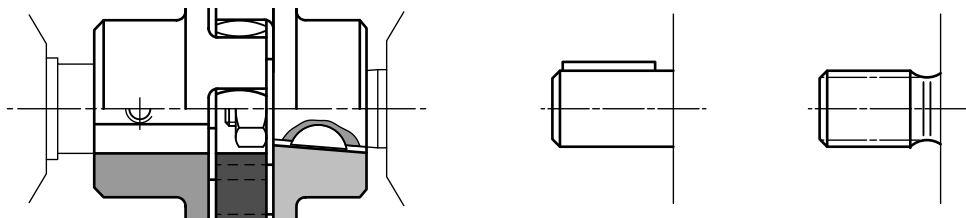


Fig. 4

2. Sleeve couplings (Fig. 5)

Used on shafts with DIN or SAE splining.

Note: There must be no radial or axial forces exerted on the motor shaft or sleeve coupling.

The sleeve must be free to move axially. The distance between the motor shaft and drive shaft must be 2^{+1} .

Oil-bath lubrication is necessary.

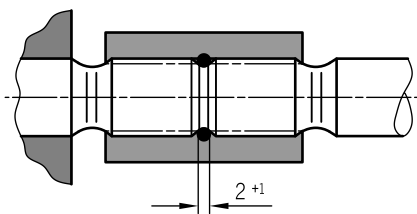


Fig. 5

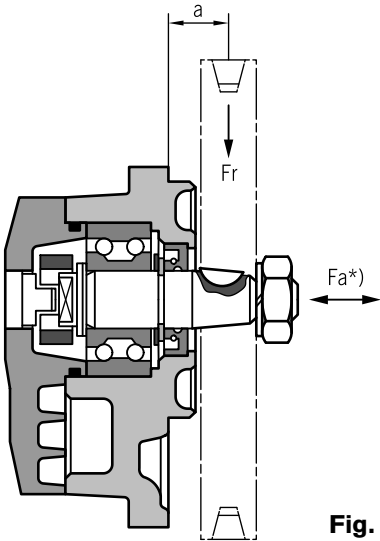
Size F
B 17 x 14 DIN 5482
 $M_{\max.} = 190 \text{ Nm}$

5. Outrigger bearings

Outrigger bearings eliminate possible problems associated with side load when the motors are driven by V-belts or gear-wheels. The diagrams below show the maximum overhung and thrust loads that can be tolerated referred to a bearing life of $L_H = 1,000$ hours.

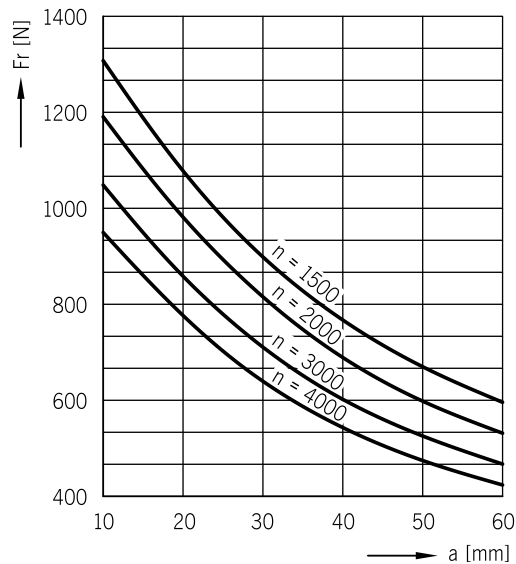
Size **F** Typ 1

$M_{max.}$ [Nm]	$V \left[\frac{cm^3}{rev} \right]$ $\frac{U}{t}$	$p_{max.}$ [bar]
65	16	230
	19	190
	22.5	160



* F_r is reduced by 0.7 F_a when axial loading F_a is applied.

Fig. 7



* Common S0 Codes:
 S0018 – Cross check valves in rear cover (internal case drain)
 S0022 – 5/8" Long keyed shaft
 S0030 – S0018 & S0022
 S0028 – Pressure relief valve and anti-cavitation valve

Size **F**
4 ... 28 cm³/rev

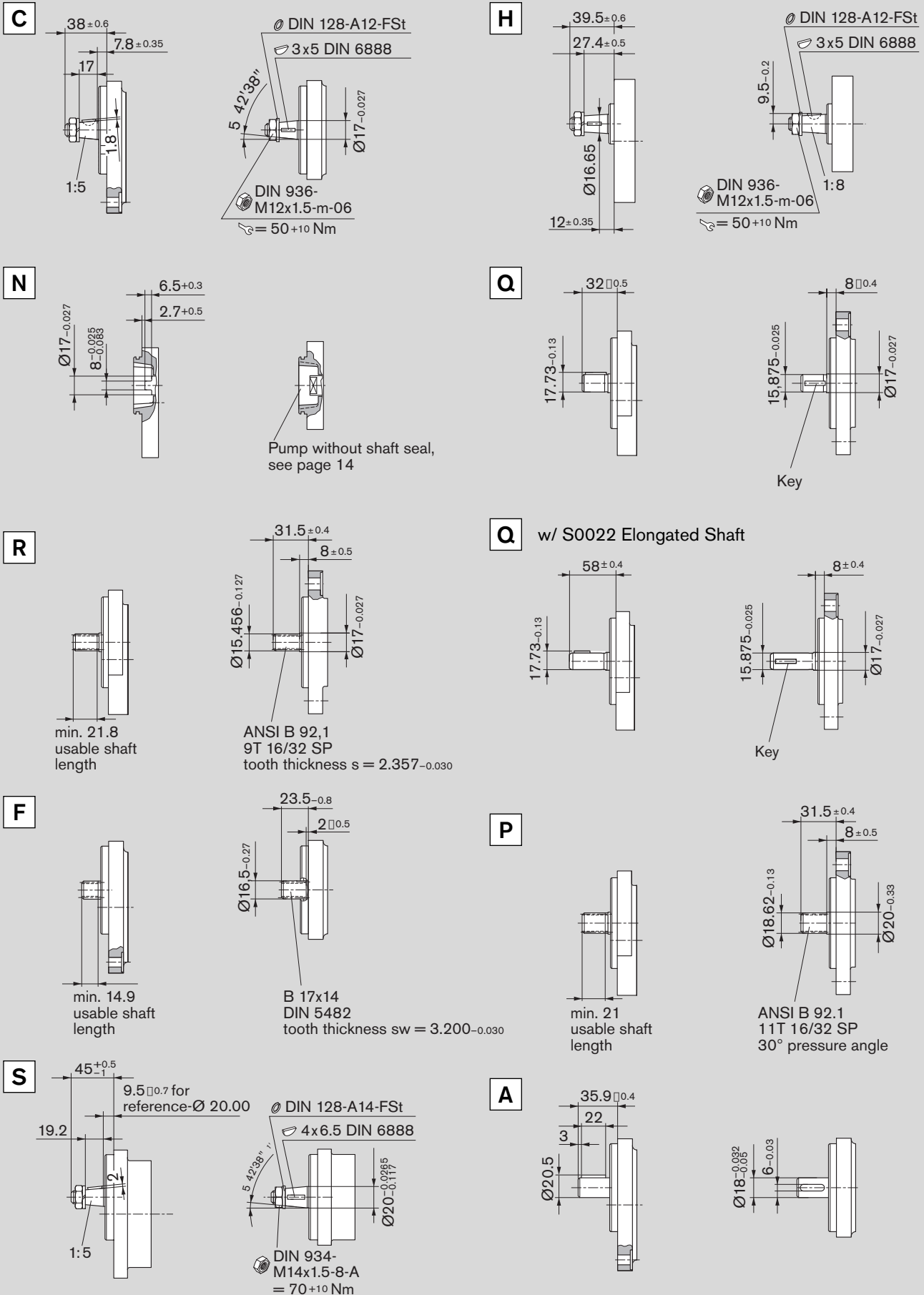
F Series Motor Product Index

(Reference page 10 for ordering code designators)

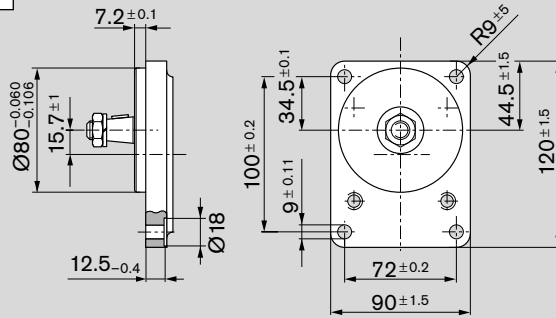
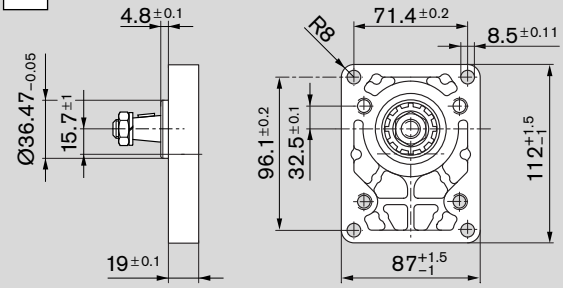
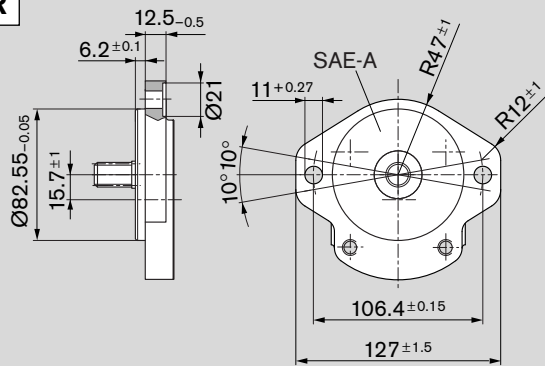
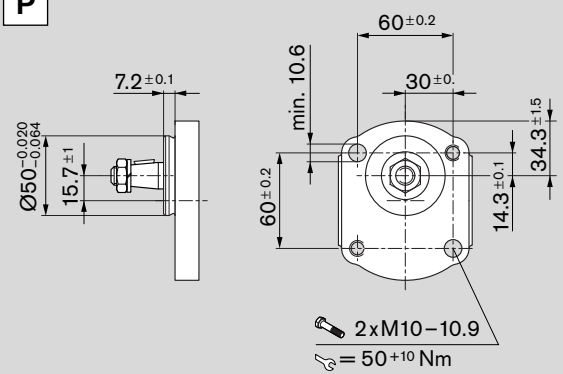
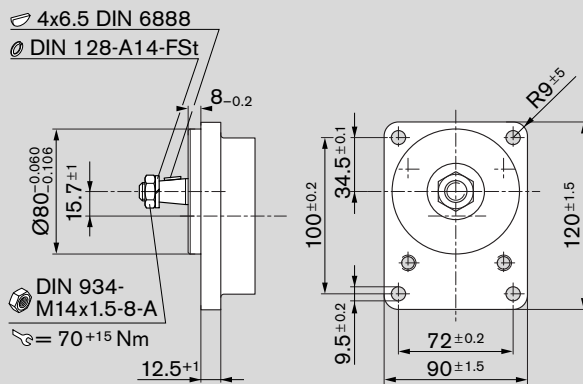
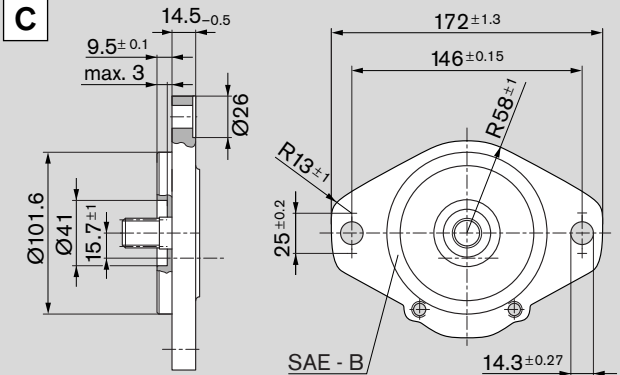
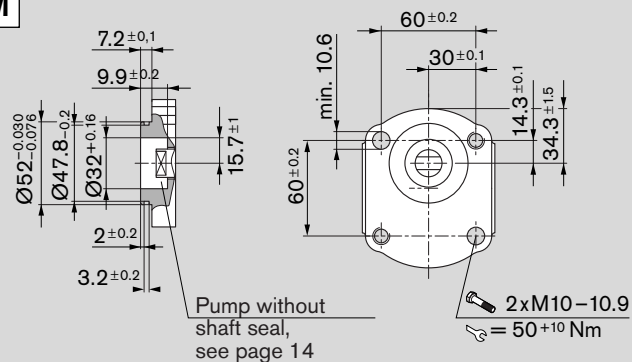
AZPF-XX-XXXX - - ML

Page Number	Ordering code	Shaft Type	Mounting Flange	Ports	Port Orientation	Case Drain
18	AZMF-12-XXXURR12ML	R	R	12	side	rear
19	AZMF-12-XXXURR12MA	R	R	12	rear	rear
20	AZMF-12-XXXURR12ML-S0018	R	R	12	side	internal
21	AZMF-12-XXXUQR12ML	Q	R	12	side	rear
22	AZMF-12-XXXUQR12MA	Q	R	12	rear	rear
23	AZMF-12-XXXUQR12ML-S0018	Q	R	12	side	internal
24	AZMF-12-XXXUQR12ML-S0022	Q-S0022	R	12	side	rear
25	AZMF-12-XXXUQR12MA-S0022	Q-S0022	R	12	side	rear
26	AZMF-12-XXXUQR12ML-S0030	Q-S0022	R	12	rear	internal
27	AZMF-1X-XXXXCB20MB	C	B	20	side	no case
28	AZMF-1X-XXXXFB20MB	F	B	20	side	no case
29	AZMF-1X-XXXXSA20MB	S	A	20	side	no case
30	AZMF-1X-XXXXNM20MB	N	M	20	side	no case
31	AZMF-1X-XXXUCB20ML	C	B	20	side	rear
32	AZMF-1X-XXXUFB20ML	F	B	20	side	rear
33	AZMF-1X-XXXUSA20ML	S	A	20	side	rear
34	AZMF-1X-XXXUNT20ML	N	T	20	side	rear
35	AZMF-1X-XXXUCN20ML	C	N	20	side	rear
36	AZMF-1X-XXXUCN20ML-S0018	C	N	20	side	internal
37	AZMF-1X-XXXUFN01ML	F	N	01	side	rear
38	AZMF-1X-XXXUFN20ML-S0018	F	N	20	side	internal
39	AZMF-1X-XXXUFN01ML-S0018	F	N	01	side	internal

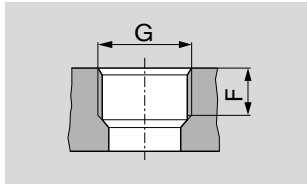
F Series Drive Shafts



F Series Front Cover

B**O****R****P****A****C****M**

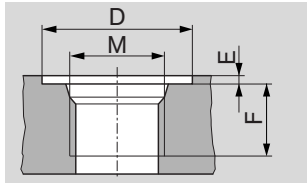
F Series Port Connections



01 Pipe thread
ISO 228/1

when pressure $p_2 > 210$ bar
limited fatigue strength

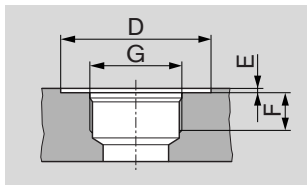
Synopsis of Types	Size	Pressure port		Suction port	
		G	F	G	F
01	4 ... 16 cm ³	G 1/2	16	G 3/4	16
	19 ... 28 cm ³	G 3/4		G1	19



03 Thread metric
ISO 6149
with O-ring

when pressure $p_2 > 210$ bar
limited fatigue strength

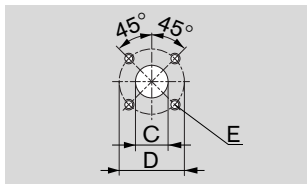
Synopsis of Types	Size	Pressure port				Suction port			
		M	D	E	F	M	D	E	F
03	4 ... 5.5 cm ³	M 18 x 1.5	29	0.5	14.5	M 18 x 1.5	29	0.5	14.5
	8 ... 16 cm ³	M 22 x 1.5	34		18	M 27 x 1.5	40		19
	19 ... 28 cm ³					M 33 x 1.5	46		22



12 Thread
(UN-2B) SAE
O-ring BOSS

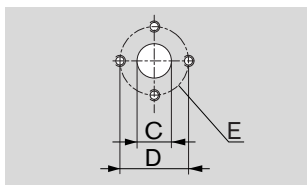
when pressure $p_2 > 210$ bar
limited fatigue strength

Synopsis of Types	Size	Pressure port				Suction port			
		G	D	E	F	G	D	E	F
12	4 ... 5.5 cm ³	SAE - 12	25	0.5	13	SAE - 12	25	0.5	13
	8 cm ³	SAE - 12	35		16	SAE - 12	35		16
	11 ... 22 cm ³					SAE - 12	45		19



20 Rectangular flange
DIN 3901/3902

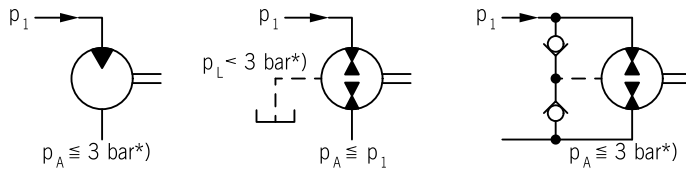
Synopsis of Type	Size	Pressure port			Suction port		
		C	D	E	C	D	E
20	4 ... 5.5 cm ³	15	35	M 6 depth 13	15	40	M 6 depth 13
	8 ... 16 cm ³				20		
	19 ... 28 cm ³				26	55	M 8 depth 13



30 Rectangular flange

Synopsis of Type	Size	Pressure port			Suction port		
		C	D	E	C	D	E
30	4 ... 8 cm ³	13.5	30.2	M 6 depth 13	13.5	30.2	M 6 depth 13
	11 ... 28 cm ³				20.0	39.7	M 8 depth 13

F Series Performance Ratings

Size		008	011	014	016	019	022
Displacement	cm ³ /rev	8.2	11.3	14.3	16.5	19.5	22.9
max. continuous pressure p_1	bar	210	210	210	210	180	180
	psi	3045	3045	3045	3045	2610	2610
max. starting pressure p_2	bar	280	280	280	280	210	210
	psi	4060	4060	4060	4060	3045	3045
min. rotational speed	min ⁻¹	500	500	500	500	500	500
max. rotational speed	p_1	4000	3500	3000	3000	3000	3000
Motor outlet pressure	p_A						
Leakage-oil line pressure	p_L						

*) Short-term when starting 10 bar

F Series Motor**SAE O-Ring BOSS - Standard Porting**

Displacement (cc)	Side Ports		Rear Port	
	Inlet	Outlet	Inlet	Outlet
4	-12	-12	-12	-12
5	-12	-12	-12	-12
8	-12	-12	-12	-12
11	-12	-12	-12	-12
14	-12	-12	-12	-12
16	-12	-12	-12	-12
19	-12	-12	-12	-12
22	-12	-12	-12	-12

**SAE Porting - Specifications and Dimensions
per SAE J1926/1**

Dash Size	Thread Size (in)
-2	5/16-24 UNF-2B
-3	3/8-24 UNF-2B
-4	7/16-20 UNF-2B
-5	1/2-20 UNF-2B
-6	9/16-18 UNF-2B
-8	3/4-16 UNF-2B
-10	7/8-14 UNF-2B
-12	1-1/16-12 UN-2B
-14	1-3/16-12 UN-2B
-16	1-5/16-12 UN-2B
-20	1-5/8-12 UN-2B
-24	1-7/8-12 UN-2B
-32	2-1/2-12 UN-2B

Note: Ratings represent units incorporating SAE O-Ring BOSS threaded ports.
Pressure ratings may differ for other types of ports.

Diagrams

Size **F**

$\nu = 35 \text{ mm}^2/\text{s}$, $T = 50 \text{ }^\circ\text{C}$

Unit Conversions

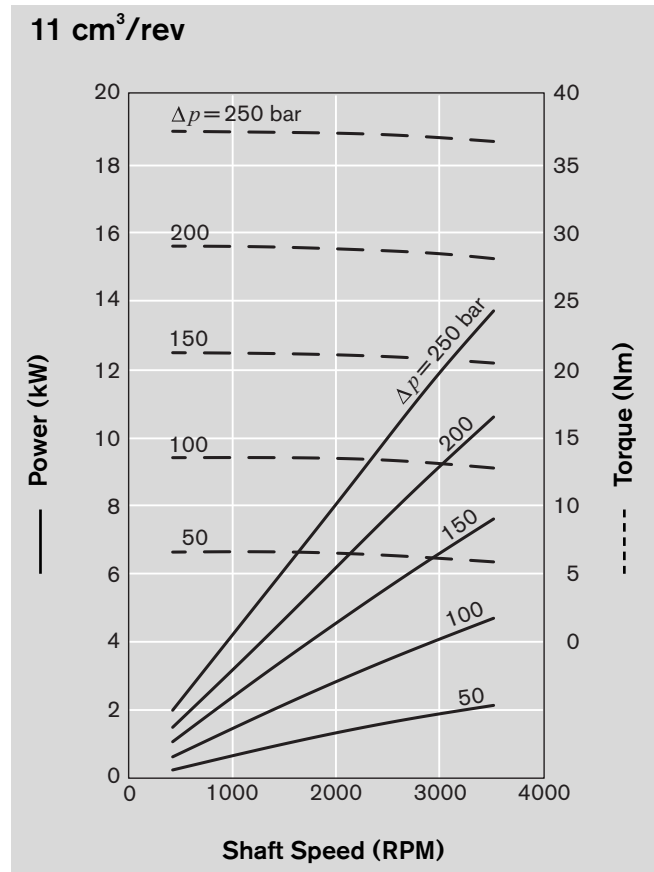
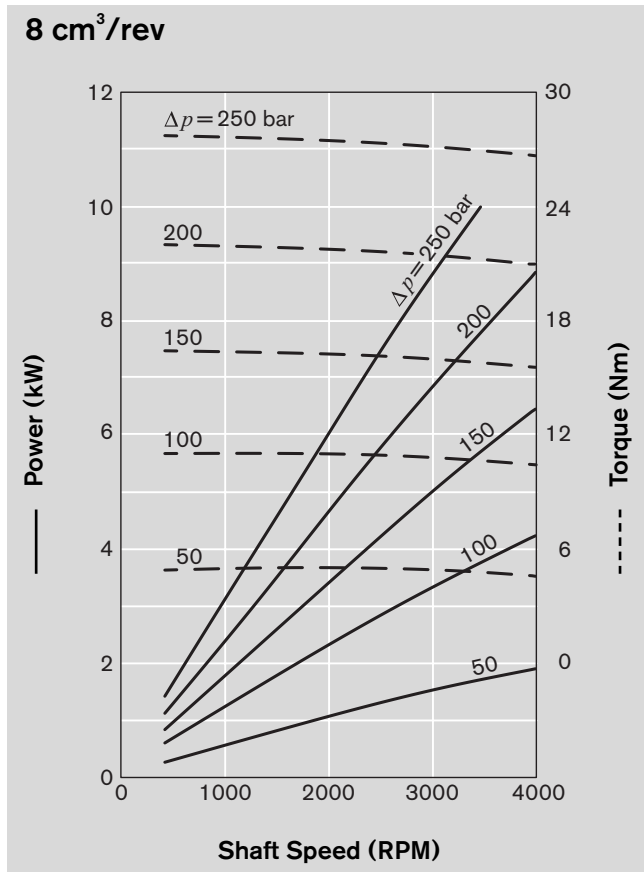
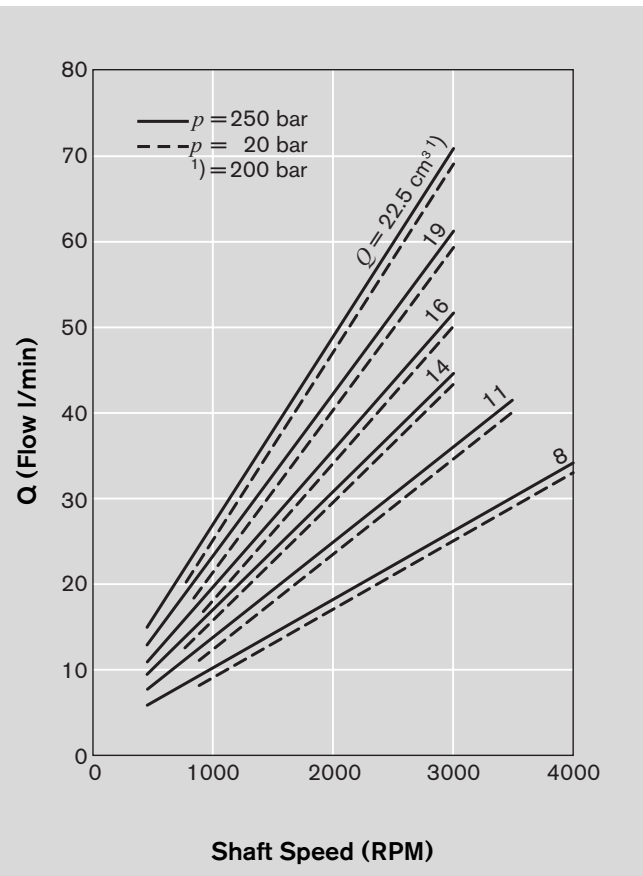
Pressure: $\text{psi} = \text{bar} \times 14.7$

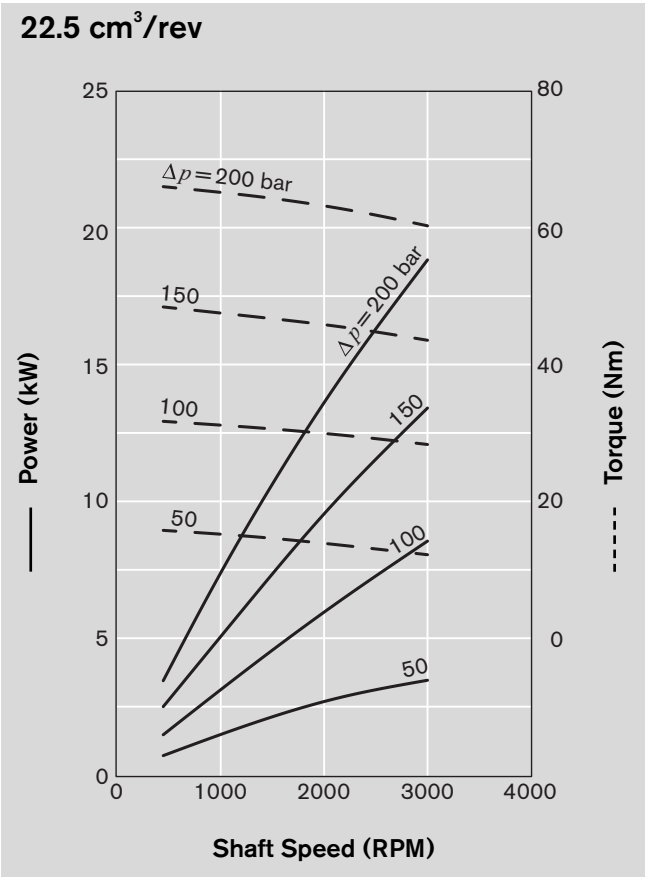
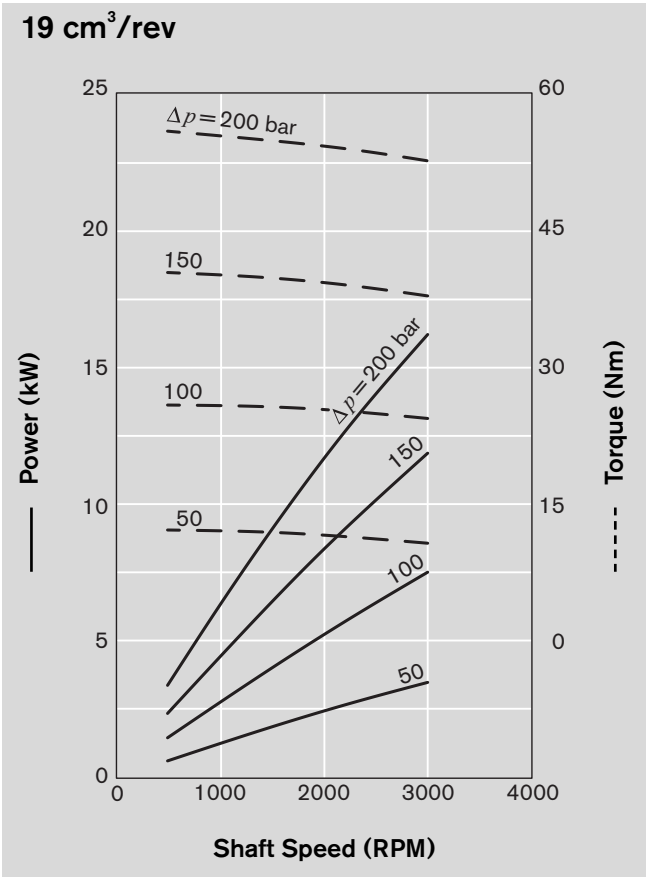
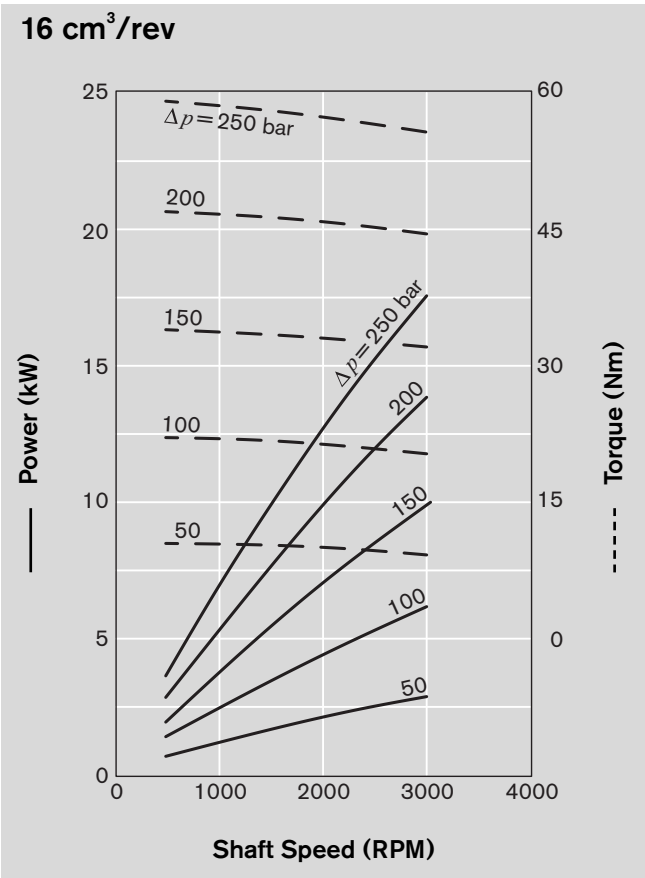
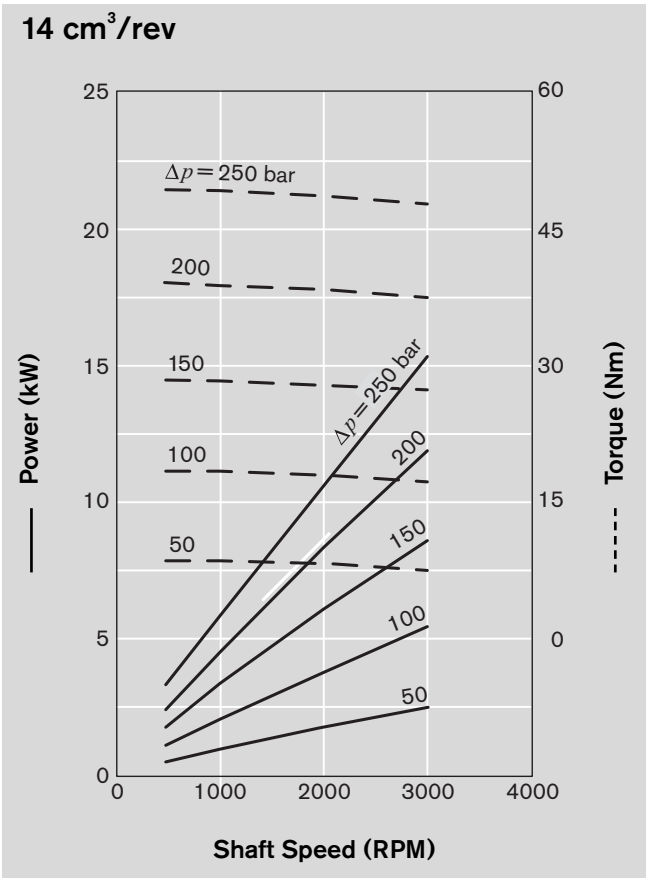
Torque: $\text{ft-lbs} = (\text{Nm}) \times .738$

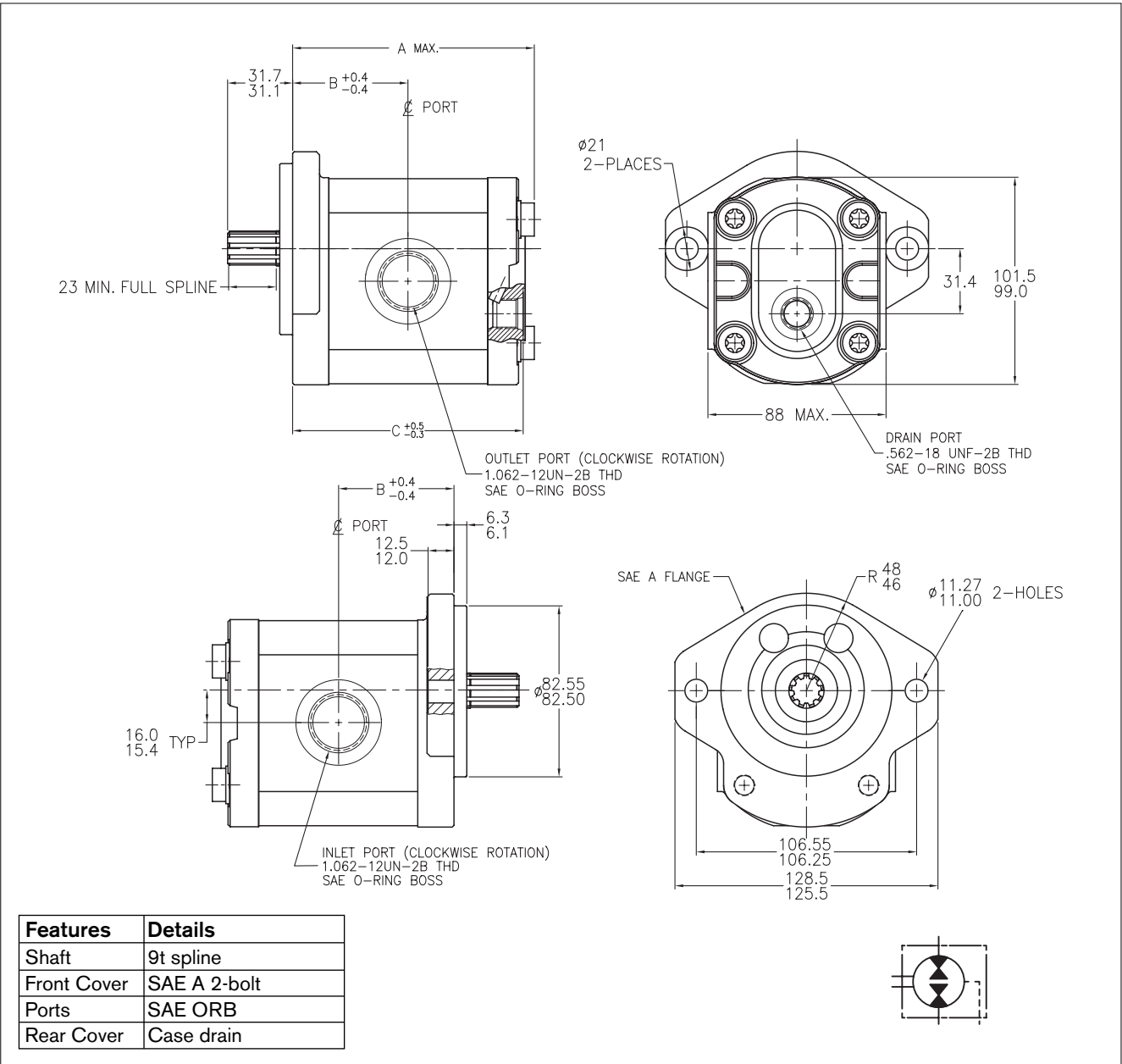
Power: $\text{hp} = (\text{kW}) \times 1.341$

Volume: $\text{in}^3 = (\text{cc}) \times 0.061$

$\text{gpm} = (\text{LPM}) \times 0.2642$





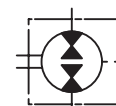


Ordering code
AZMF - 12 - ☐☐☐ U R R 12 ML

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
8.0		9 511 290 001	210	4000	91.6	43.2	85.8	-12	-12
11.0		9 511 290 002	210	3500	96.6	45.7	90.8	-12	-12
14.0		9 511 290 003	210	3000	101.6	48.2	95.8	-12	-12
16.0		9 511 290 004	210	3000	105.0	49.9	99.2	-12	-12
19.0		9 511 290 005	180	3000	110.0	52.4	104.2	-12	-12
22.0		9 511 290 006	180	3000	115.4	55.1	109.6	-12	-12

* Contact factory for availabilty of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)



Features	Details
Shaft	9t spline
Front Cover	SAE A 2-bolt
Ports	SAE ORB
Rear Cover	Rear ports/case drain

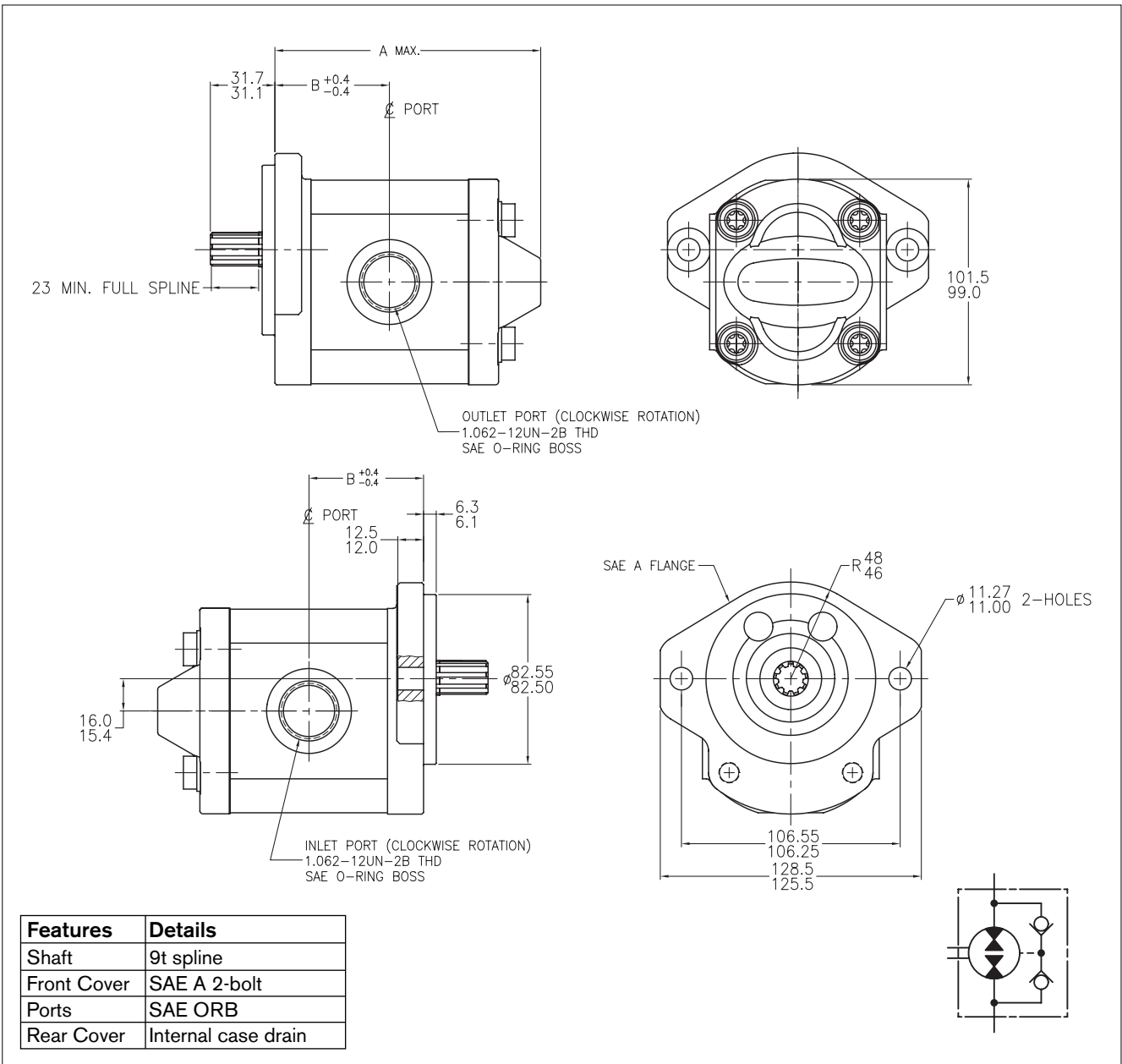
Ordering code

AZMF - 12 - U R R 12 MA

[illegible]

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)

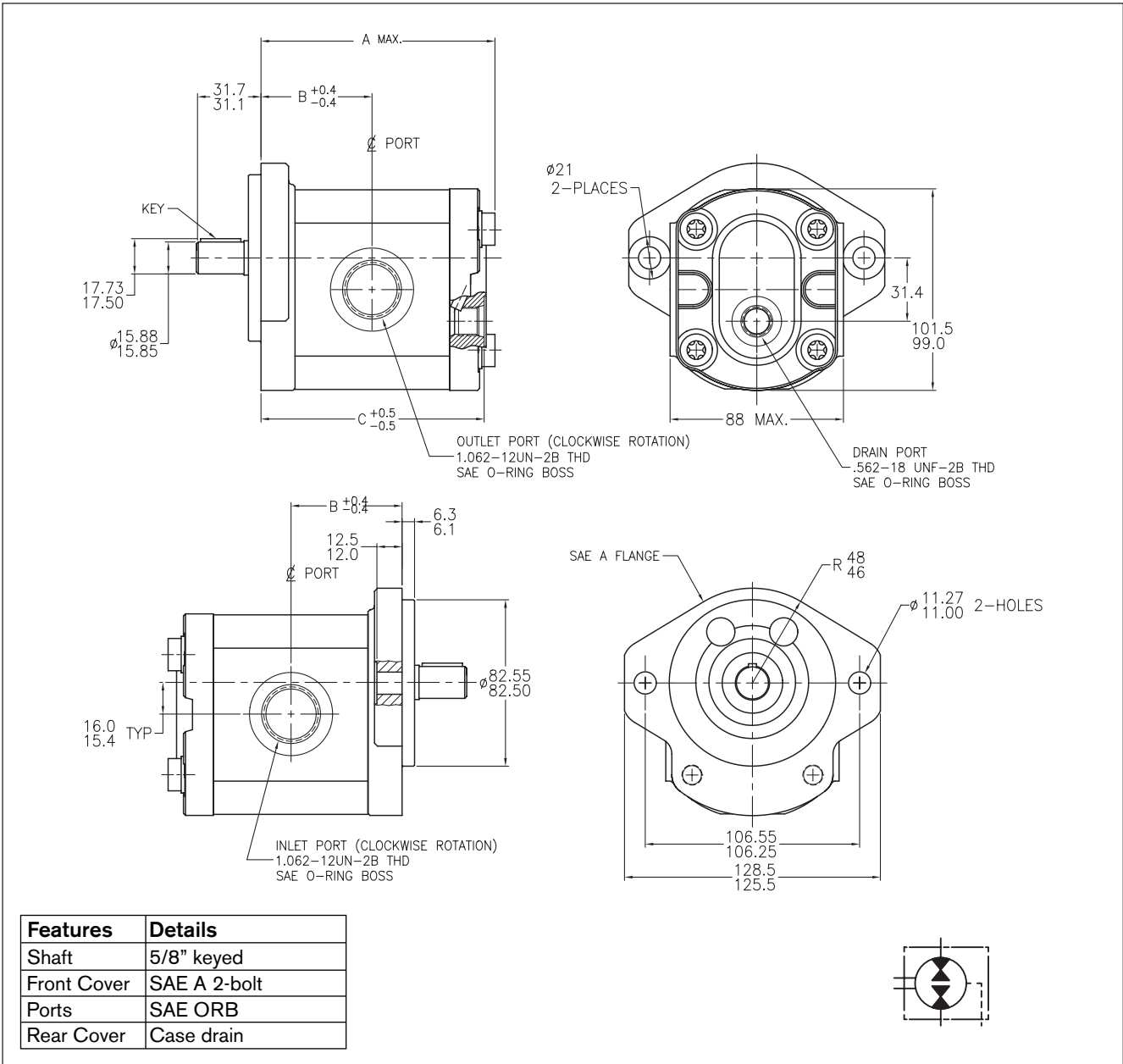


Ordering code
AZMF - 12 - ☐ ☐ ☐ U R R 12 ML - S0018

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]		Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B		
8.0		9 511 290 019	210	4000	105.7	43.2	-12	-12
11.0		9 511 290 020	210	3500	110.7	45.7	-12	-12
14.0		9 511 290 021	210	3000	115.7	48.2	-12	-12
16.0		9 511 290 022	210	3000	119.1	49.9	-12	-12
19.0		9 511 290 023	180	3000	124.1	52.4	-12	-12
22.0		9 511 290 024	180	3000	129.5	55.1	-12	-12

* Contact factory for availability of units with no ordering number listed.

** This unit contains internal leakage valves



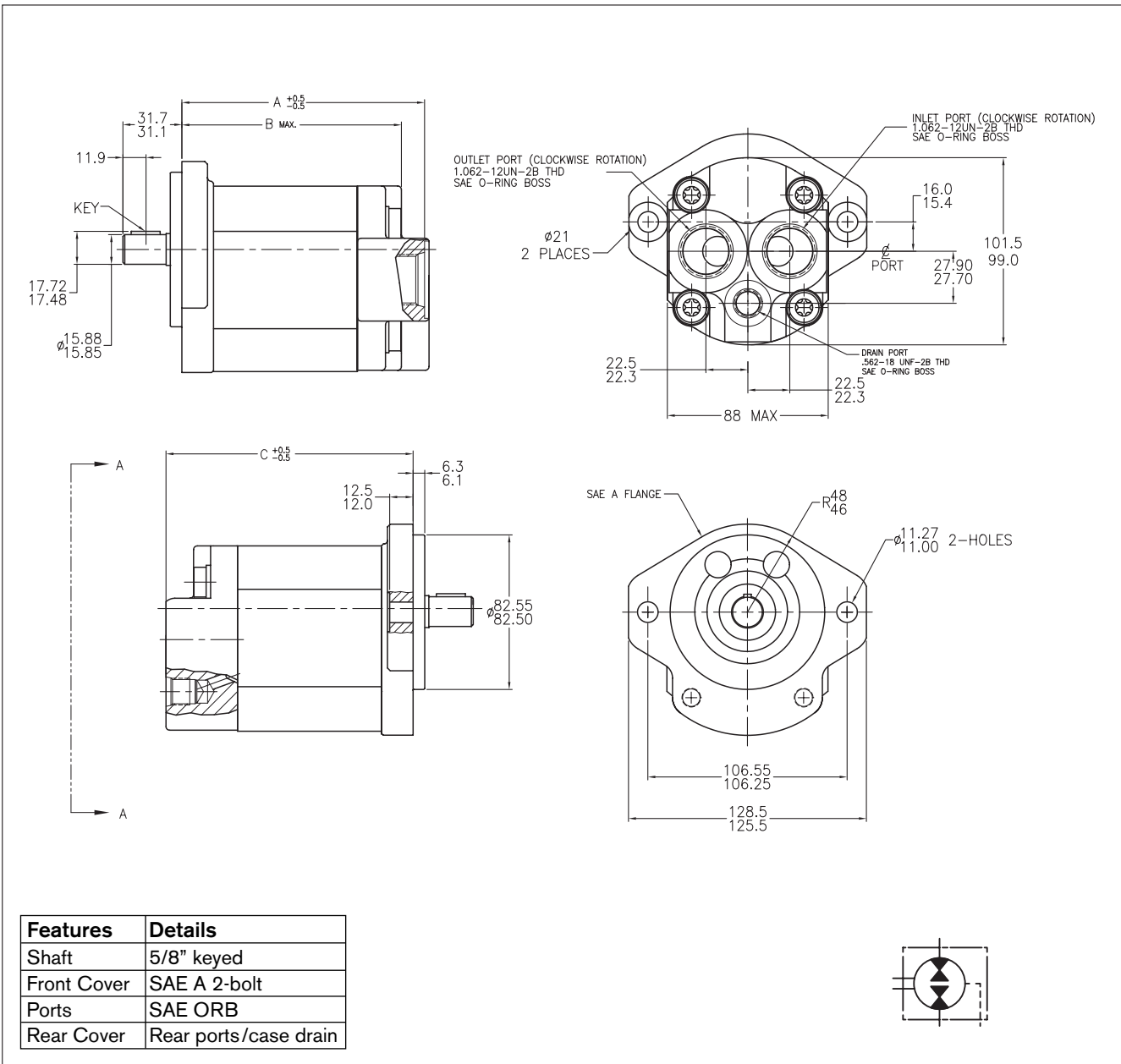
Ordering code

AZMF - 12 - ☐ ☐ ☐ U Q R 12 ML

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
8.0		9 511 290 007	210	4000	91.6	43.2	85.8	-12	-12
11.0		9 511 290 008	210	3500	96.6	45.7	90.8	-12	-12
14.0		9 511 290 009	210	3000	101.6	48.2	95.8	-12	-12
16.0		9 511 290 010	210	3000	105.0	49.9	99.2	-12	-12
19.0		9 511 290 011	180	3000	110.0	52.4	104.2	-12	-12
22.0		9 511 290 012	180	3000	115.4	55.1	109.6	-12	-12

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)

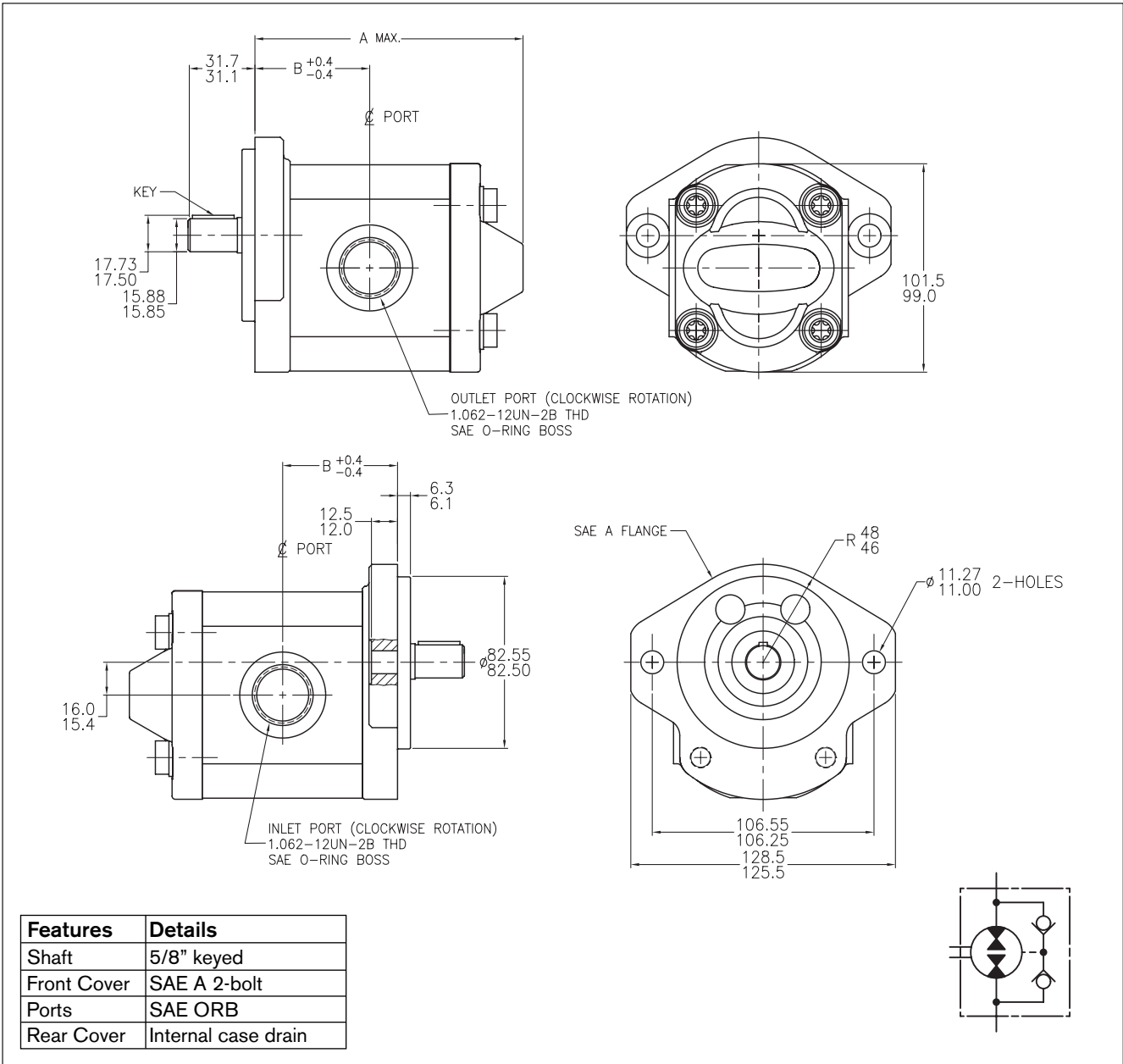


Ordering code
AZMF - 12 - ☐☐☐ U Q R 12 MA

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
	Bi-Rotational				A	B	C		
8.0		9 511 290 058	210	4000	107.1	93.7	107.1	-12	-12
11.0		9 511 290 059	210	3500	112.1	98.7	112.1	-12	-12
14.0		9 511 290 060	210	3000	117.1	103.7	117.1	-12	-12
16.0		9 511 290 061	210	3000	120.5	107.1	120.5	-12	-12
19.0		9 511 290 062	180	3000	125.5	112.1	125.5	-12	-12
22.0		9 511 290 063	180	3000	130.9	117.5	130.9	-12	-12

* Contact factory for availabilty of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)



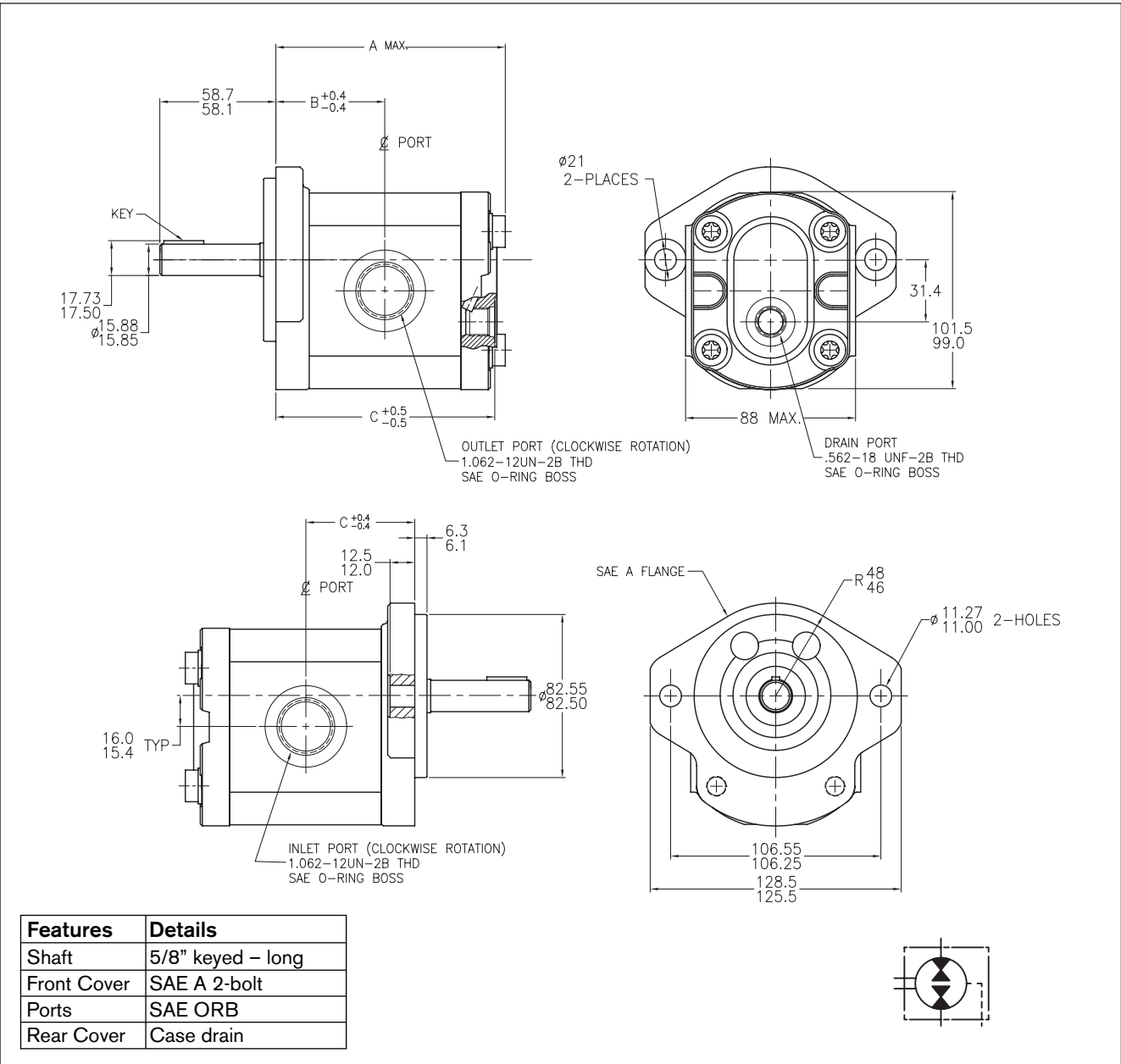
Ordering code

AZMF - 12 - ☐ ☐ ☐ U Q R 12 ML - S0018

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B			
8.0		9 511 290 025	210	4000	105.7	43.2		-12	-12
11.0		9 511 290 026	210	3500	110.7	45.7		-12	-12
14.0		9 511 290 027	210	3000	115.7	48.2		-12	-12
16.0		9 511 290 028	210	3000	119.1	49.9		-12	-12
19.0		9 511 290 029	180	3000	124.1	52.4		-12	-12
22.0		9 511 290 030	180	3000	129.5	55.1		-12	-12

* Contact factory for availability of units with no ordering number listed.

** This unit contains internal leakage valves



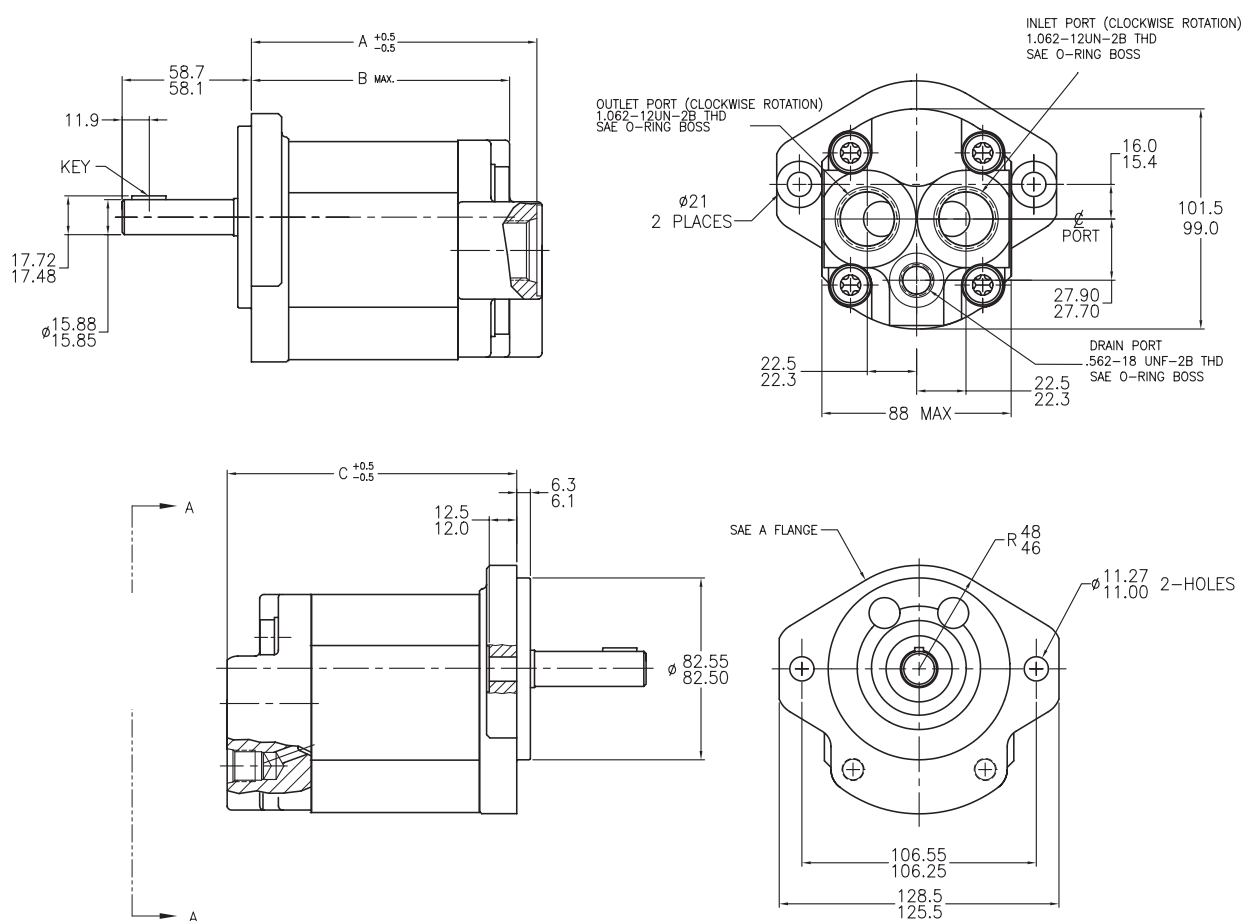
Ordering code

AZMF – 12 – ☐ ☐ ☐ U Q R 12 ML – S0022

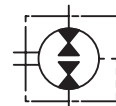
Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
8.0		9 511 290 013	210	4000	91.6	43.2	85.8	-12	-12
11.0		9 511 290 014	210	3500	96.6	45.7	90.8	-12	-12
14.0		9 511 290 015	210	3000	101.6	48.2	95.8	-12	-12
16.0		9 511 290 016	210	3000	105.0	49.9	99.2	-12	-12
19.0		9 511 290 017	180	3000	110.0	52.4	104.2	-12	-12
22.0		9 511 290 018	180	3000	115.4	55.1	109.6	-12	-12

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)



Features	Details
Shaft	5/8" keyed – long
Front Cover	SAE A 2-bolt
Ports	SAE ORB
Rear Cover	Rear ports/case drain



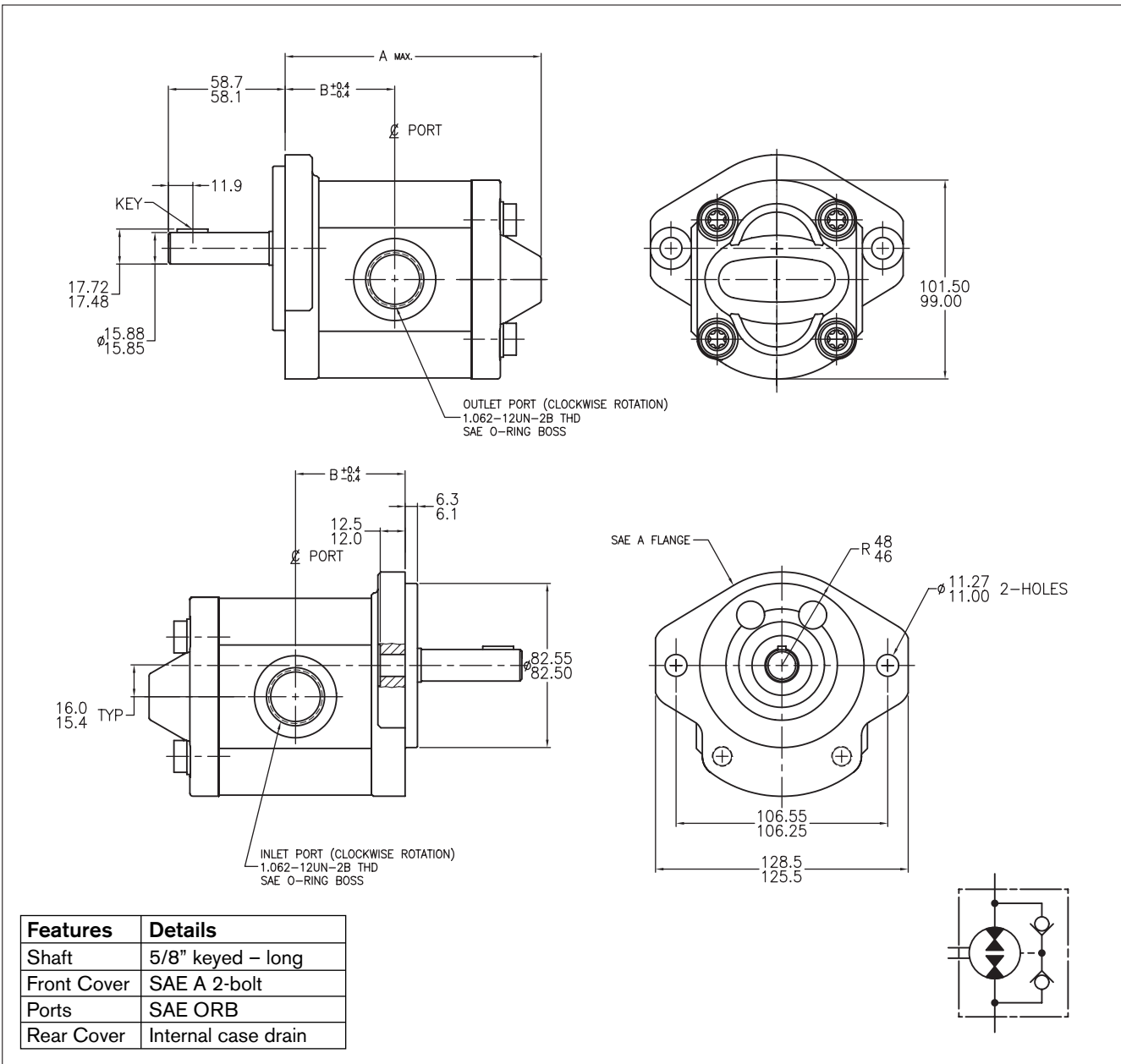
Ordering code

AZMF - 12 - U Q R 12 MA - S0022

[illegible]

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)

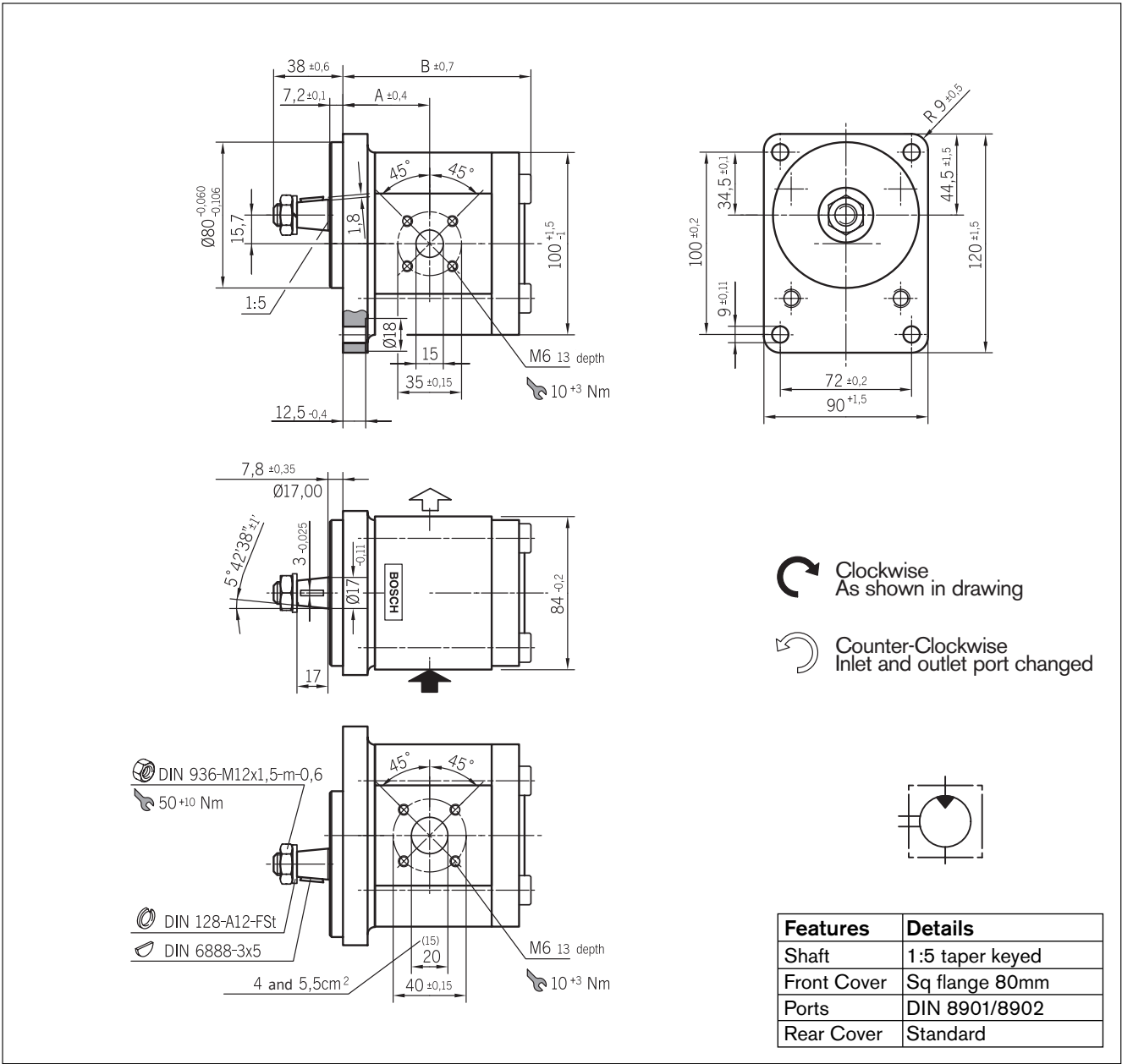


Ordering code
AZMF – 12 – ☐ ☐ ☐ U Q R 12 ML – S0030

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
8.0		9 511 290 031	210	4000	105.7	43.2	105.7	-12	-12
11.0		9 511 290 032	210	3500	110.7	45.7	110.7	-12	-12
14.0		9 511 290 033	210	3000	115.7	48.2	115.7	-12	-12
16.0		9 511 290 034	210	3000	119.1	49.9	119.1	-12	-12
19.0		9 511 290 035	180	3000	124.1	52.4	124.1	-12	-12
22.0		9 511 290 036	180	3000	129.5	55.1	129.5	-12	-12

* Contact factory for availability of units with no ordering number listed.

** This unit contains internal leakage valves.

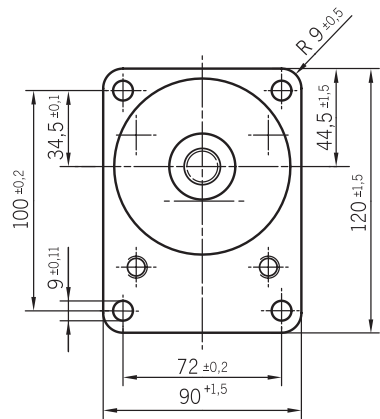
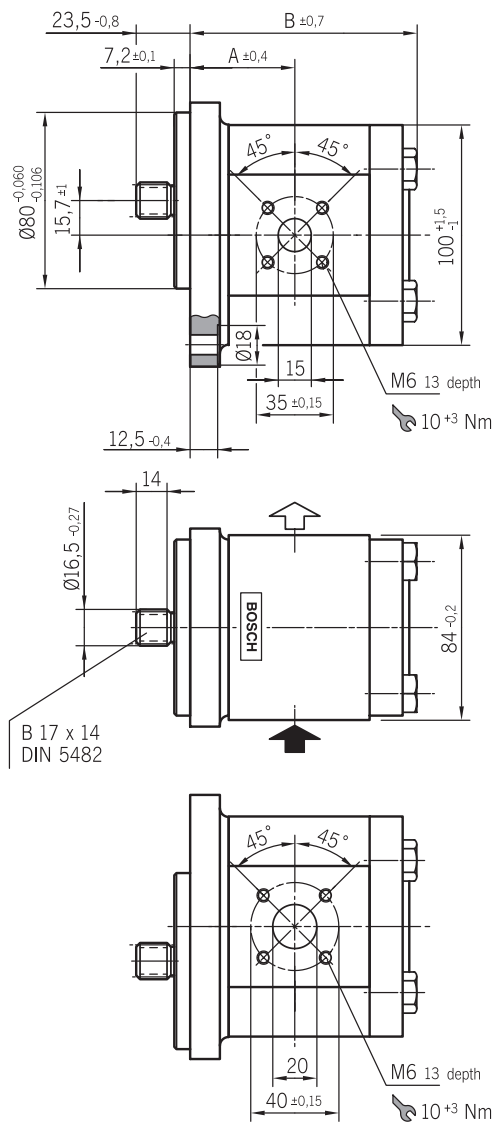


Ordering code

AZ M F - 1 X - □ □ □ □ C B 20 MB

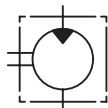
Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			
	L	R			A	B	C	
8.0	0 511 425 300	0 511 425 001	210	4000	43.2	91.6		
11.0	0 511 525 300	0 511 525 001	210	3500	47.0	96.6		
14.0	0 511 525 304		210	3000	47.5	101.6		
16.0		0 511 625 005	210	3000	47.5	105.0		
19.0		0 511 625 003	180	3000	47.5	110.0		
19.0		0 511 625 009	180	3000	47.5	110.0		
19.0	0 511 625 308		180	3000	47.5	110.0		
22.0	0 511 725 304	0 511 725 005	180	3000	61.1	127.4		

* Contact factory for availability of units with no ordering number listed.



 Clockwise
As shown in drawing

 Counter-Clockwise
Inlet and outlet port changed

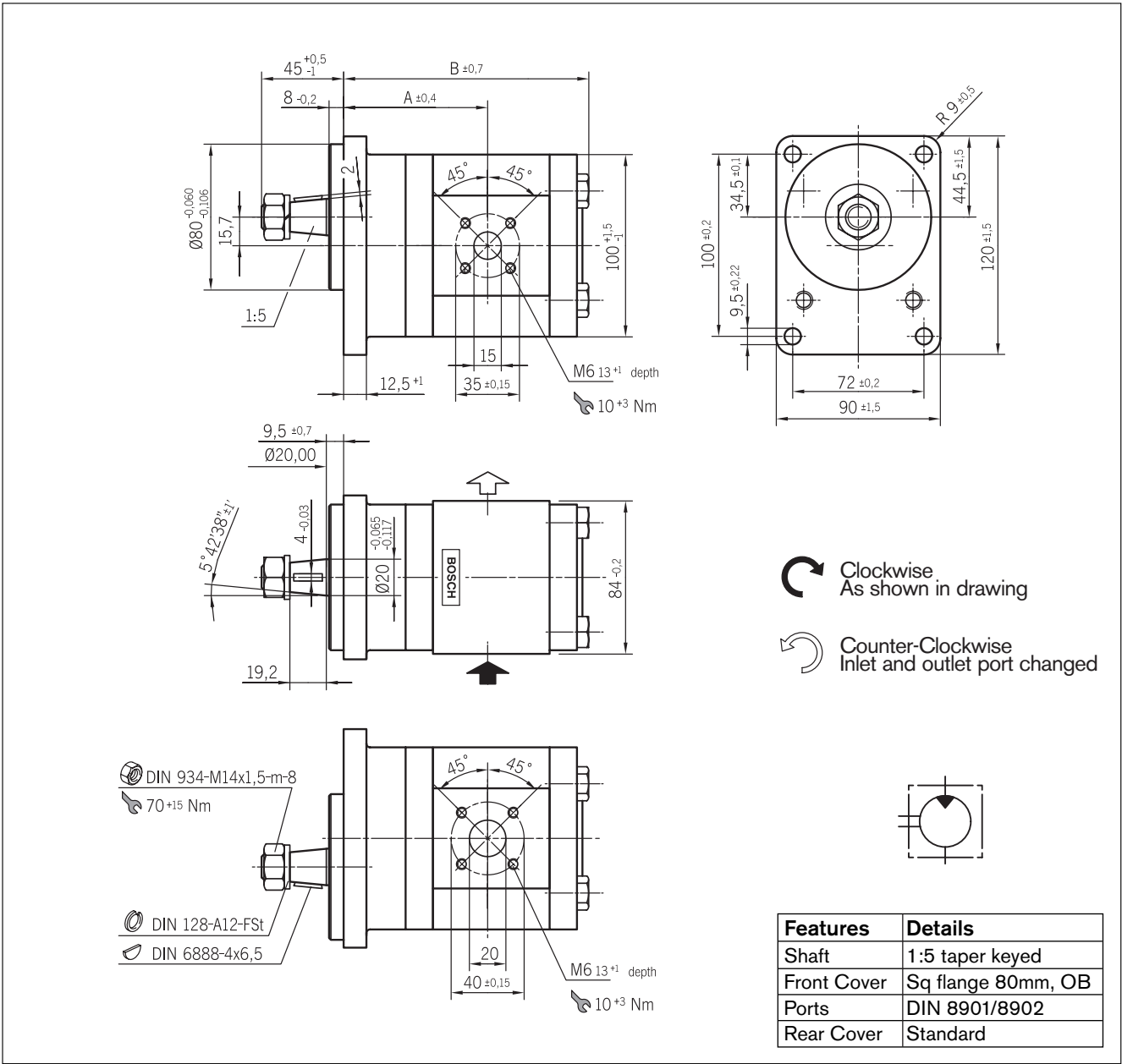


Features	Details
Shaft	DIN 5482 spline
Front Cover	Sq flange 80mm
Ports	DIN 8901/8902
Rear Cover	Standard

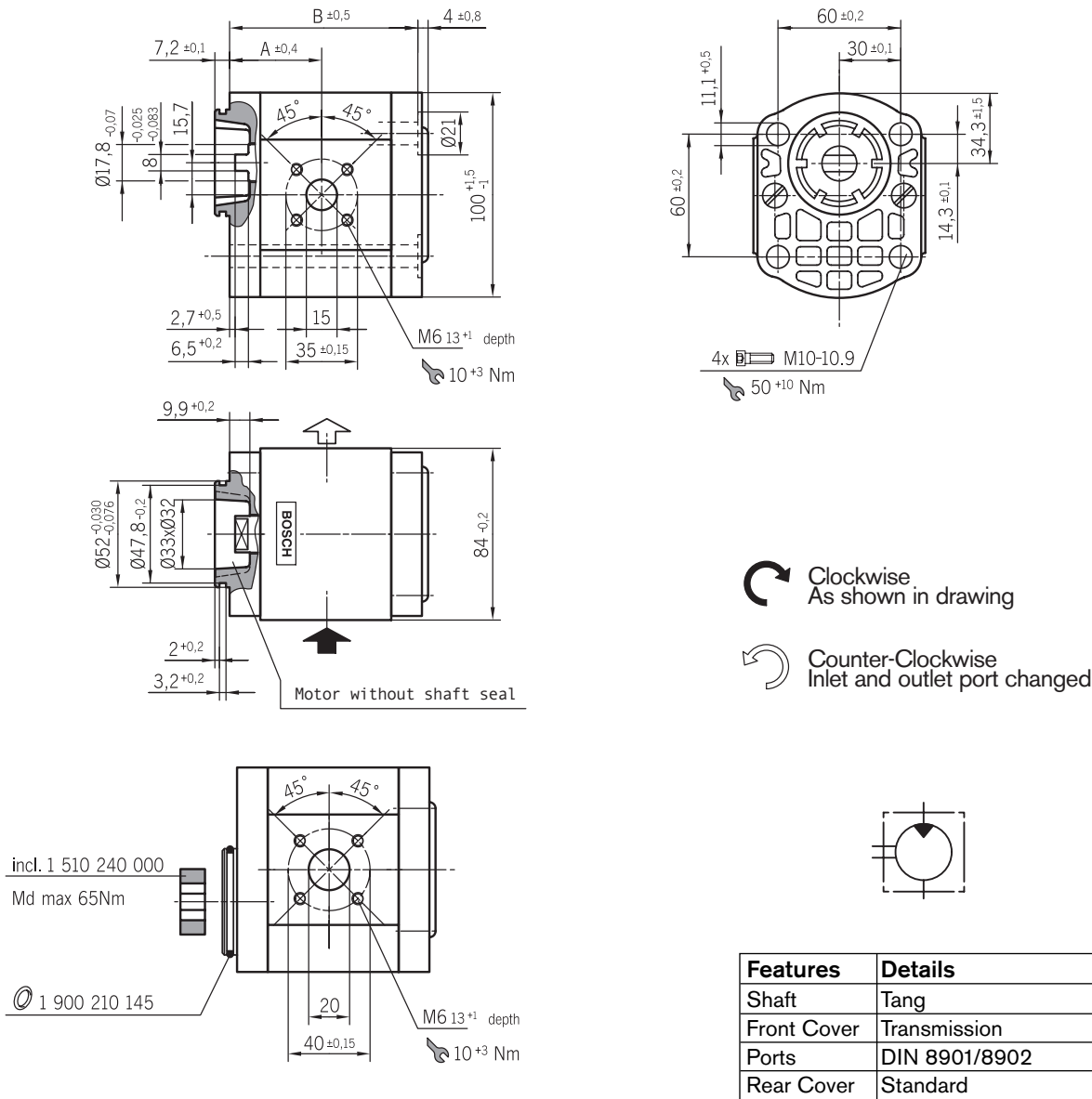
Ordering code
AZ M F - 1 X - □ □ □ □ F B 20 MB

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			
	 L	 R			A	B		
8.0	0 511 425 301	0 511 425 002	210	4000	43.2	91.6		
11.0	0 511 525 301	0 511 525 002	210	3500	47.0	96.6		
14.0	0 511 525 303		210	3000	47.5	101.6		
16.0	0 511 625 301	0 511 625 001	210	3000	47.5	105.0		
19.0	0 511 625 300	0 511 625 002	180	3000	47.5	110.0		
22.0	0 511 725 303	0 511 725 004	180	3000	61.1	127.4		

* Contact factory for availabilty of units with no ordering number listed.



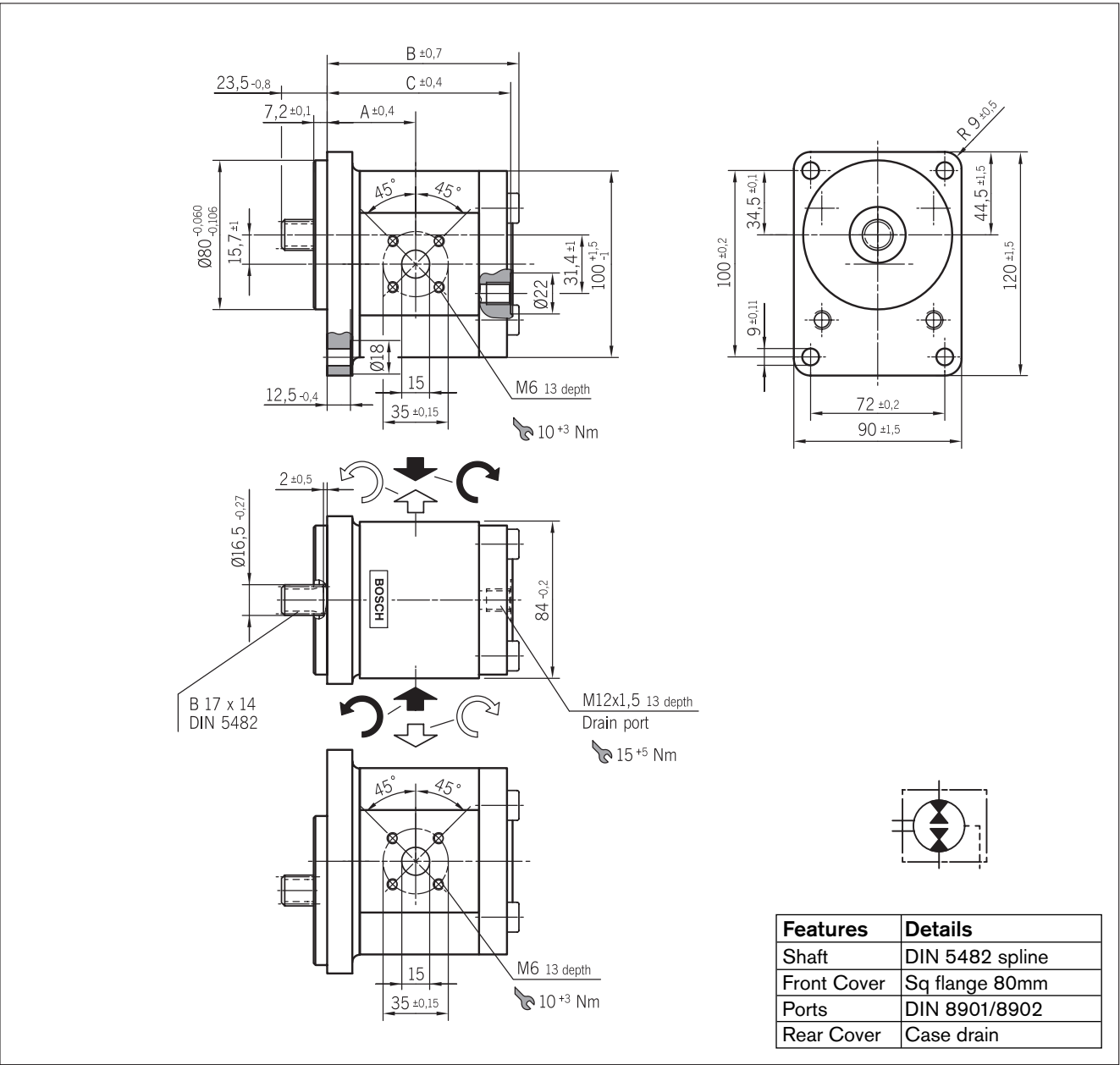
* Contact factory for availability of units with no ordering number listed.



Ordering code
AZ M F - 1 X - □ □ □ □ N M 20 MB

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			
	 L	 R			A	B		
8.0	0 511 415 300	0 511 415 001	210	4000	40.7	80.3		
11.0	0 511 515 300	0 511 515 001	210	3500	44.5	85.3		
16.0	0 511 615 301	0 511 615 002	210	3000	45.0	93.7		
19.0	0 511 615 300	0 511 615 001	180	3000	45.0	98.7		
22.0	0 511 715 300	0 511 715 001	180	3000	52.6	104.1		

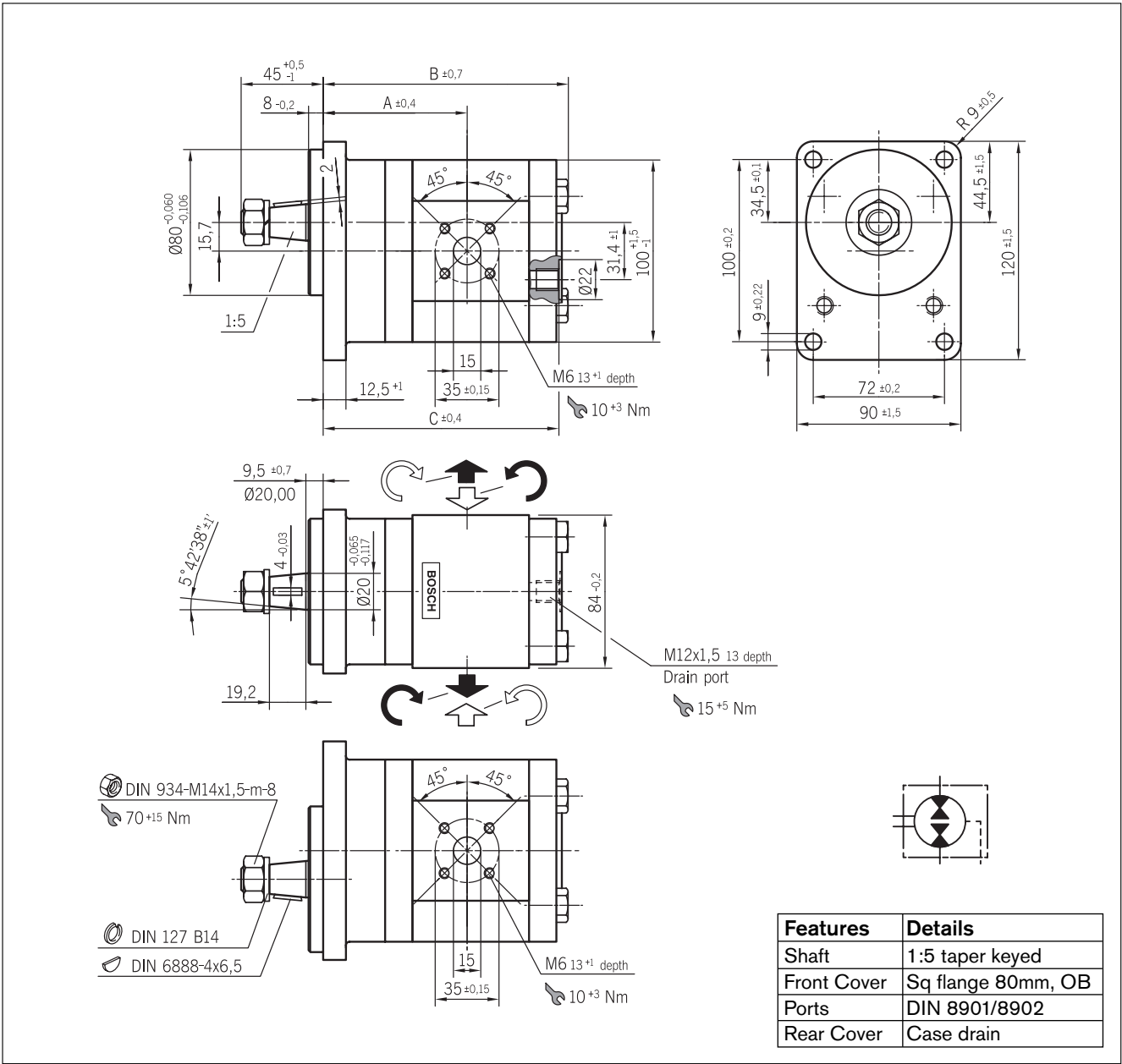
* Contact factory for availability of units with no ordering number listed.



Ordering code
AZ M F - 1 X - □ □ □ U F B 20 ML

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]					
					A	B	C			
8.0		0 511 425 603	210	4000	43.2	91.6	85.8			
11.0		0 511 525 601	210	3500	47.0	96.6	90.8			
16.0		0 511 625 603	210	3000	47.5	105.0	99.2			
19.0		0 511 625 605	180	3000	47.5	110.0	104.2			
22.0		0 511 725 602	180	3000	55.1	115.4	109.6			

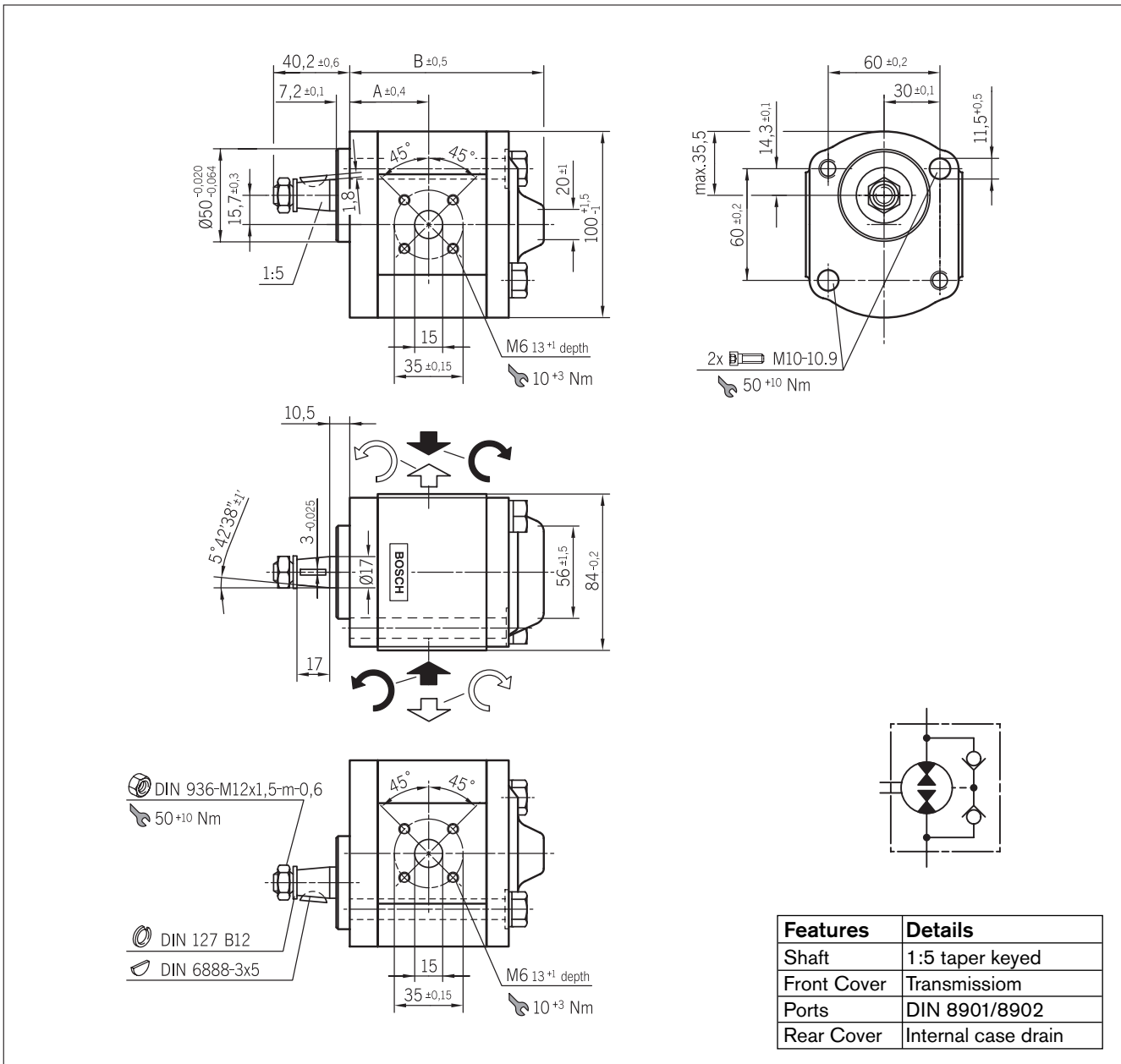
* Contact factory for availabilty of units with no ordering number listed.



Ordering code
AZ M F - 1 X - □ □ □ U S A 20 ML

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			
					A	B	C	
8.0		0 511 445 601	210	4000	74.7	121.3	117.3	
11.0		0 511 545 601	210	3500	78.5	126.3	122.3	
16.0		0 511 645 601	210	3000	79.0	134.7	130.7	
19.0		0 511 645 603	180	3000	79.0	139.7	135.7	

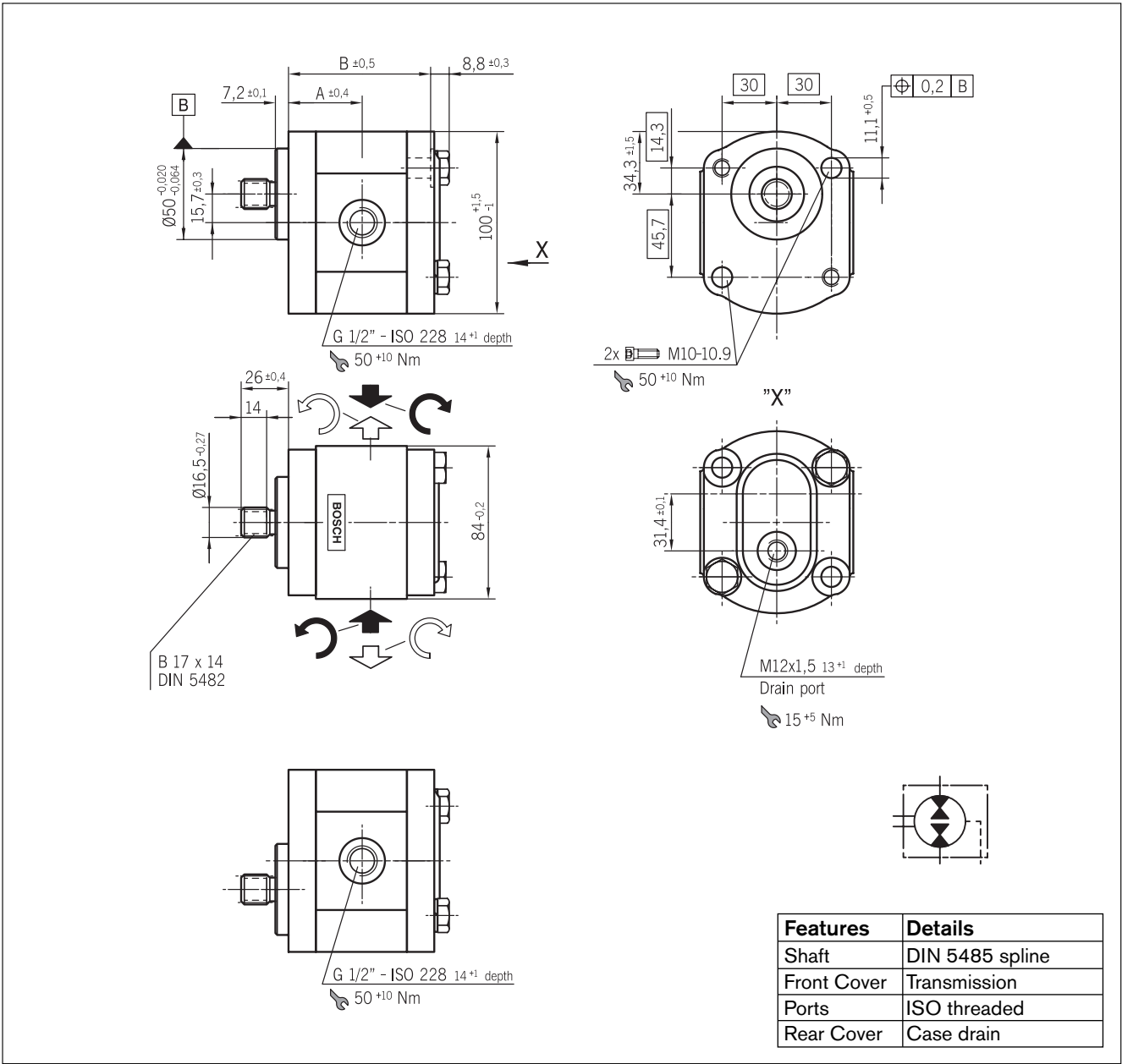
* Contact factory for availability of units with no ordering number listed.



Ordering code
AZ M F - 1 X - □ □ □ - U C N 20 M □ - S0018

Displacement	Ordering-Number *		Max. operating pressure	Max. rotation speed	Dimension [mm]					
[cm³/rev]	Bi-Rotational		[bar]	[rpm]	A	B	C			
8.0	0 511 415 603		210	4000	40.7	80.3	104.0			

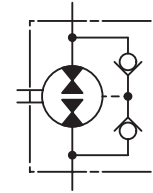
* Contact factory for availabilty of units with no ordering number listed.



Ordering code
AZ M F - 1 X - ☐ ☐ ☐ U F N 01 ML

Displacement	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]				
[cm ³ /rev]	Bi-Rotational				A	B			
8.0	0 511 415 608		210	4000	40.7	80.3			

* Contact factory for availability of units with no ordering number listed.

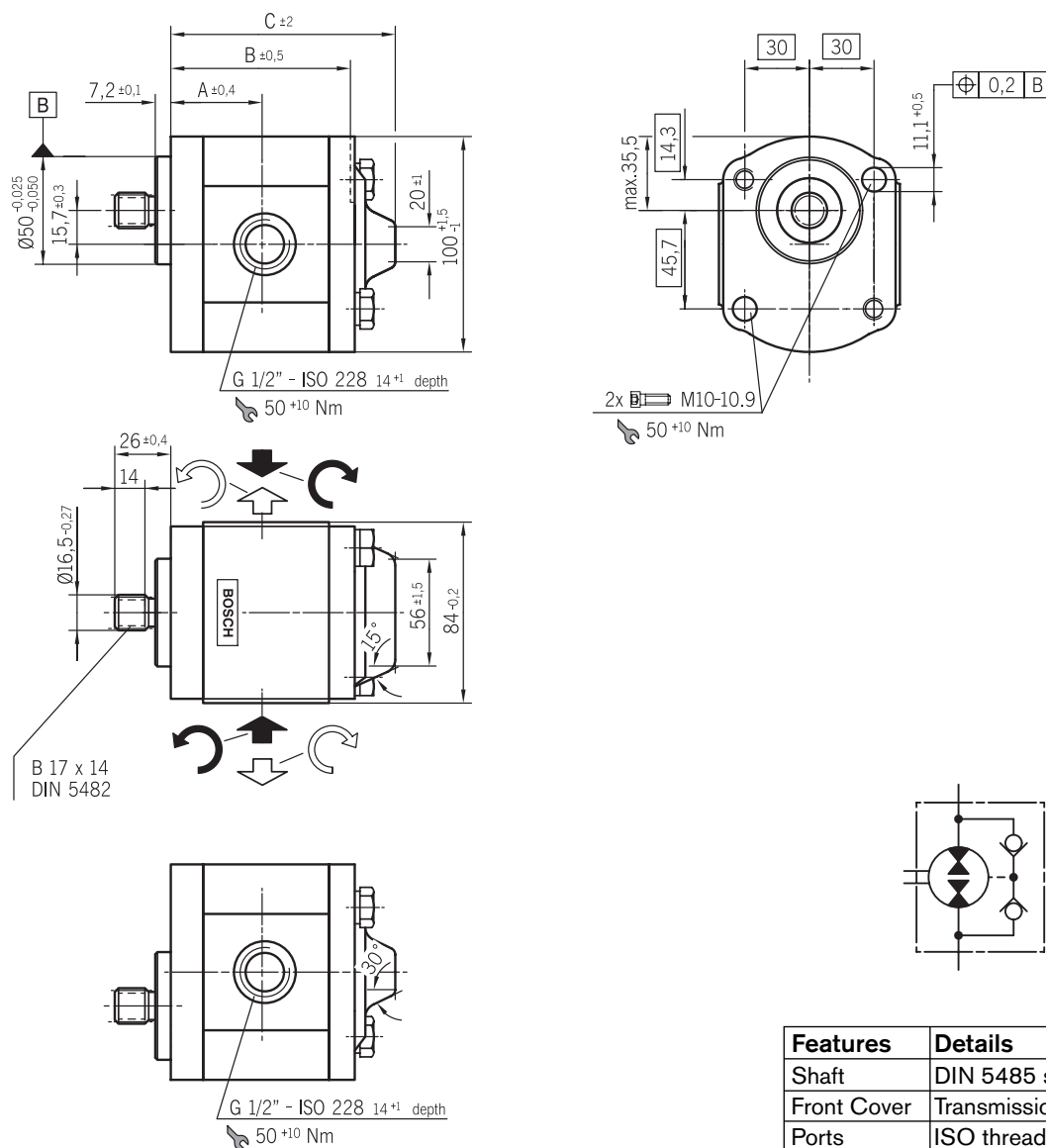


Features	Details
Shaft	DIN 5485 spline
Front Cover	Transmission
Ports	DIN 8901/8902
Rear Cover	Internal case drain

AZ M F-1 X-□□□ UFN 20 ML-S0018

[illegible]

* Contact factory for availability of units with no ordering number listed.



Ordering code

AZ M F-1 X- UFN 01 ML - S0018

[illegible]

* Contact factory for availability of units with no ordering number listed.

Ordering Code (N Series Motor)

AZ		M		N - 1□ or 2□ - 028		U		D		C		12		M		L		- □ □ □ - S □ □ □ □			
Function M = Motor Size (N) 1.24 in ³ (20.4 cm ³) = 020 1.41 in ³ (23.1 cm ³) = 022 1.57 in ³ (25.8 cm ³) = 025 1.74 in ³ (28.4 cm ³) = 028 1.98 in ³ (32.4 cm ³) = 032 2.22 in ³ (36.4 cm ³) = 036 Direction of rotation Right = R Left = L Universal = U (Bi-rotational)																		PRV (bar)		Special Design End cover B - Standard A - Rear ports L - Case drain port L S0018 - Internal case drain D - PRV (bar)	
																		EXAMPLE: 180 bar = 180			
																		Seals		NBR = M FPM = P NBR, shaft seal in FPM = K	
																		Drive shafts			
C Conical 1:5 (Tapered key)  B Matching front flange						B Square flange Pilot Ø 100 mm 						20 Rectangular flange 									
N Dog (Tang)  M						C SAE B 2-bolt 						12 Thread (UN-2B) SAE O-ring BOSS 									
D Spline shaft SAE B 13T  C						M Transmission flange Pilot Ø 52 mm with O-ring 						07 Split flange SAE Code 61 Metric bolts 									
P Spline shaft SAE 11T  R C						R SAE A 2-bolt 						40 Split flange SAE Code 61 UNC bolts 									
Q SAE 3/4" Keyed - Short  R C																					
Q SAE 3/4" Keyed - Long *S0022 Suffix  R C																					
X Special (S0 Code Defines Special Shaft) R C																					

* Common Special Design Codes:

S0018 – Internal case drain

S0022 – 3/4" Long keyed shaft

S0030 – S0018 & S0022

S0275 – Tapered key shaft with thread per SAE J744 Size 22-3

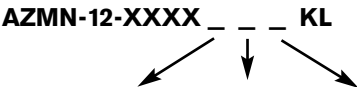
Size

N

20 ... 36 cm³/rev

N Series Motor Product Index

(Reference page 40 for ordering code designators)



Page Number	Ordering code	Shaft Type	Mounting Flange	Ports	Port Orientation	Case Drain
45	AZMN-12-XXXUDC12KL	D	C	12	side	rear
46	AZMN-12-XXXUXC12KL-S0275	SAE Taper	C	12	side	rear
47	AZMN-12-XXXUPC12KL	P	C	12	side	rear
48	AZMN-12-XXXUQC12KL	Q	C	12	side	rear
49	AZMN-12-XXXUQC12KL-S0022	Q-S0022	C	12	side	rear
50	AZMN-11-XXXXCB20KB	C	B	20	side	rear

N Series Performance Ratings

Size		020	022	025	028	032	036
Displacement	cm³/rev	20.4	23.1	25.8	28.4	32.4	36.4
max. continuous pressure	p ₁ bar	210	210	210	210	180	160
	psi	3045	3045	3045	3045	2610	2320
max. starting pressure	p ₂ bar	240	240	240	240	210	190
	psi	3480	3480	3480	3480	3045	2755
min. rotational speed	min ⁻¹	500	500	500	500	500	500
max. rotational speed	p ₁	3000	3000	3000	2800	2800	2500
Motor outlet pressure	p _A bar						
Leakage-oil line pressure	p _L						

*) Short-term when starting 10 bar

N Series Motor
SAE O-Ring BOSS - Standard Porting

Displacement (cc)	Side Ports		Rear Port	
	Inlet	Outlet	Inlet	Outlet
20	-10	-10		
22	-10	-10		
25	-12	-12		
28	-12	-12		
32	-12	-12		
36	-12	-12		

SAE Porting - Specifications and Dimensions
per SAE J1926/1

Dash Size	Thread Size (in)
-2	5/16-24 UNF-2B
-3	3/8-24 UNF-2B
-4	7/16-20 UNF-2B
-5	1/2-20 UNF-2B
-6	9/16-18 UNF-2B
-8	3/4-16 UNF-2B
-10	7/8-14 UNF-2B
-12	1-1/16-12 UN-2B
-14	1-3/16-12 UN-2B
-16	1-5/16-12 UN-2B
-20	1-5/8-12 UN-2B
-24	1-7/8-12 UN-2B
-32	2-1/2-12 UN-2B

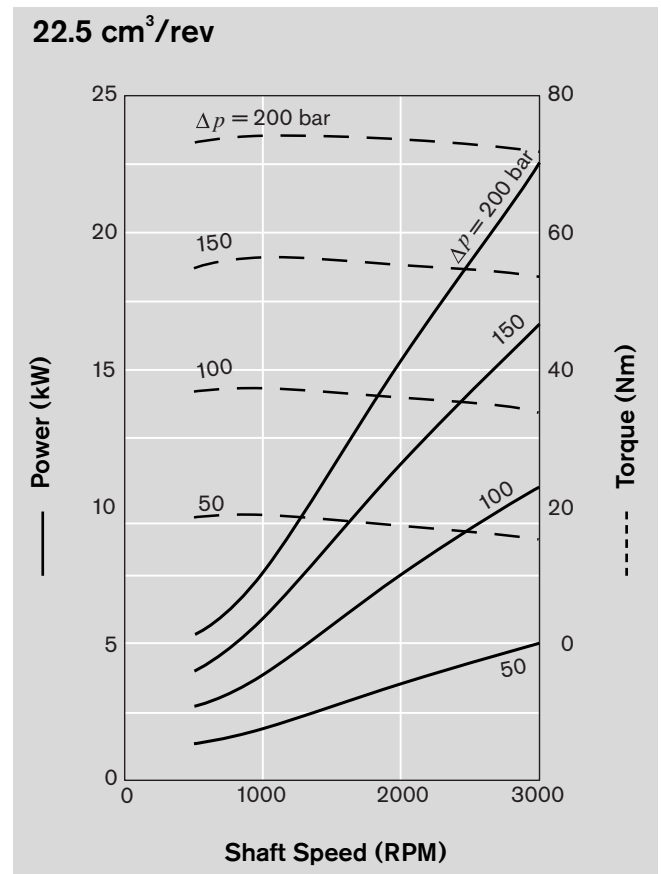
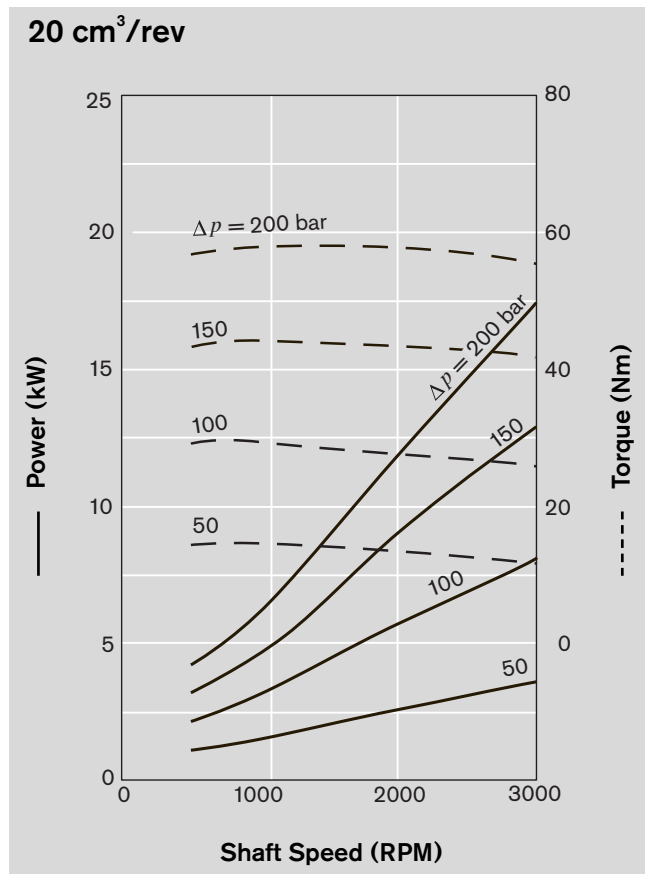
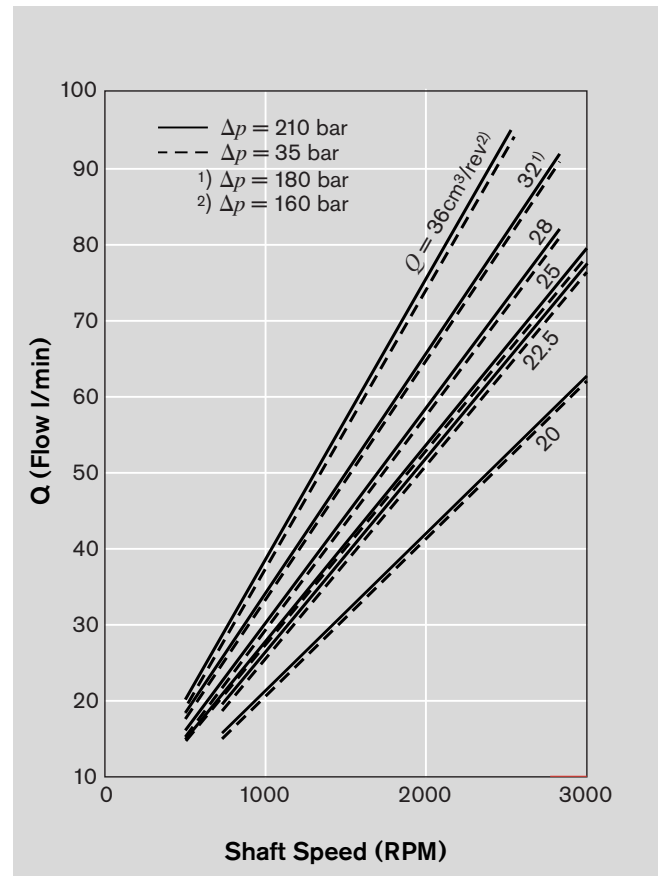
Diagrams

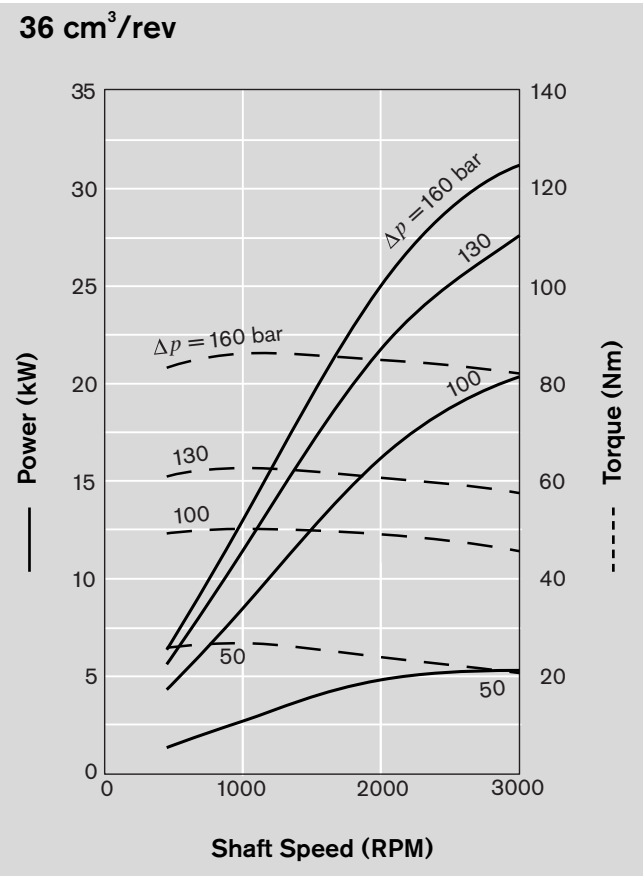
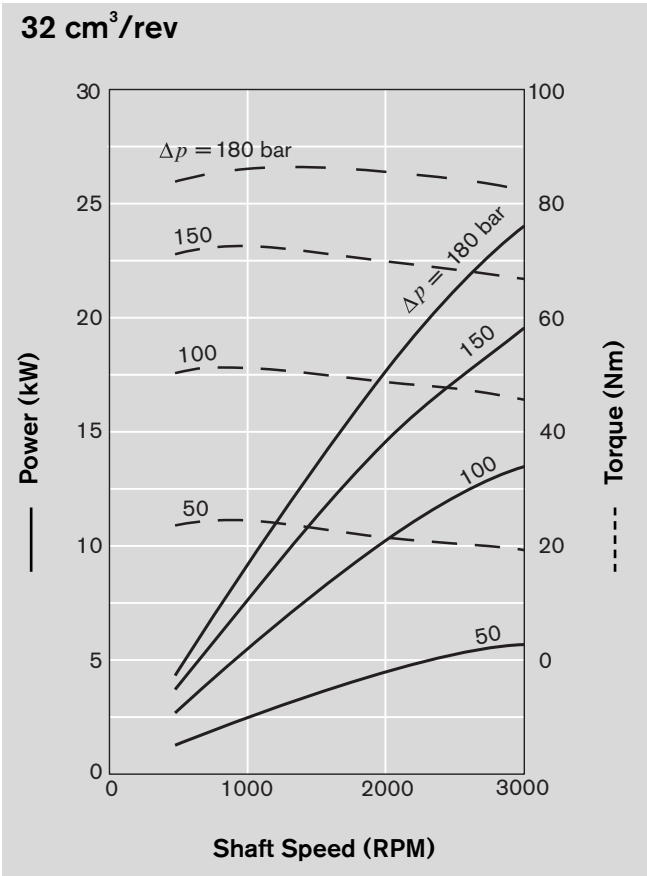
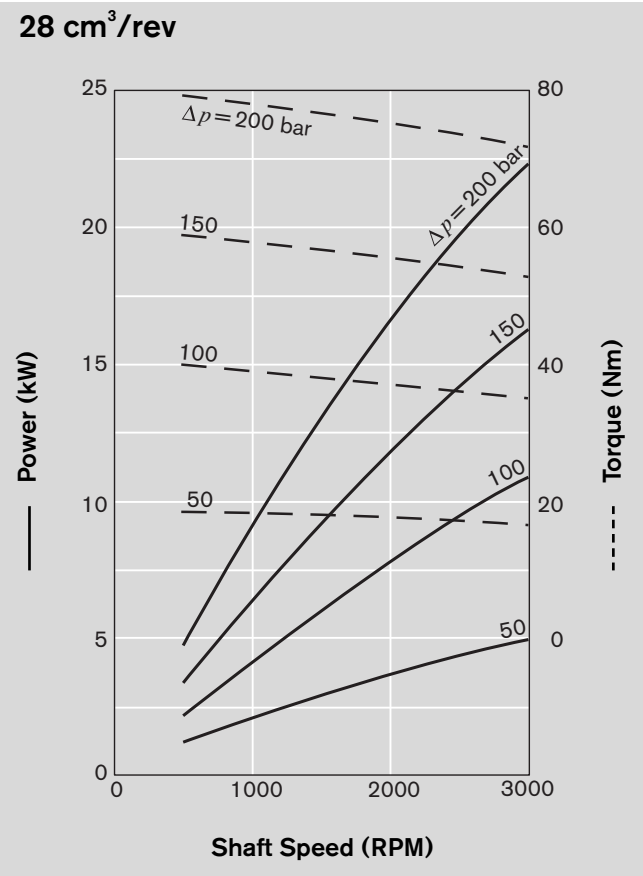
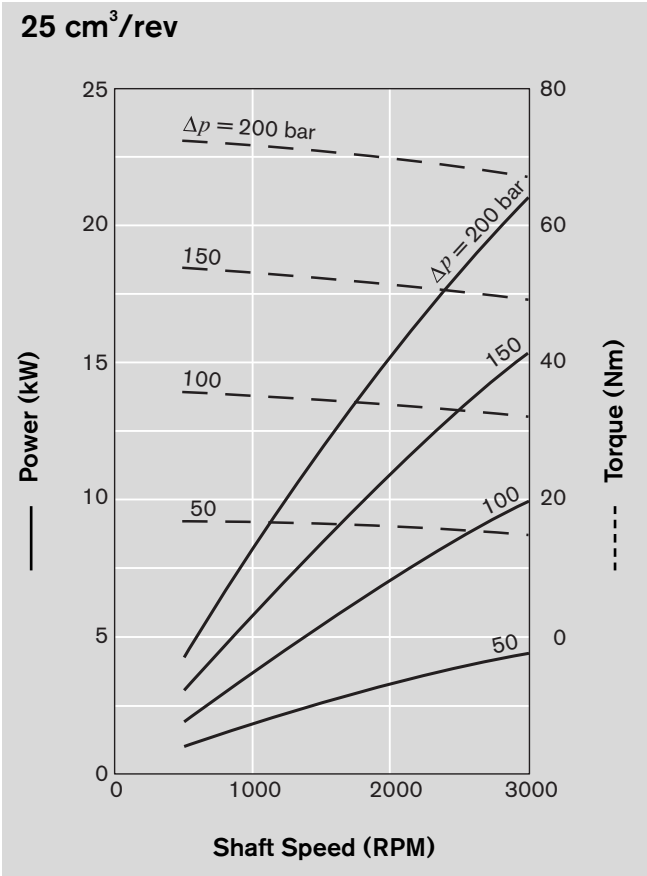
Size **N**

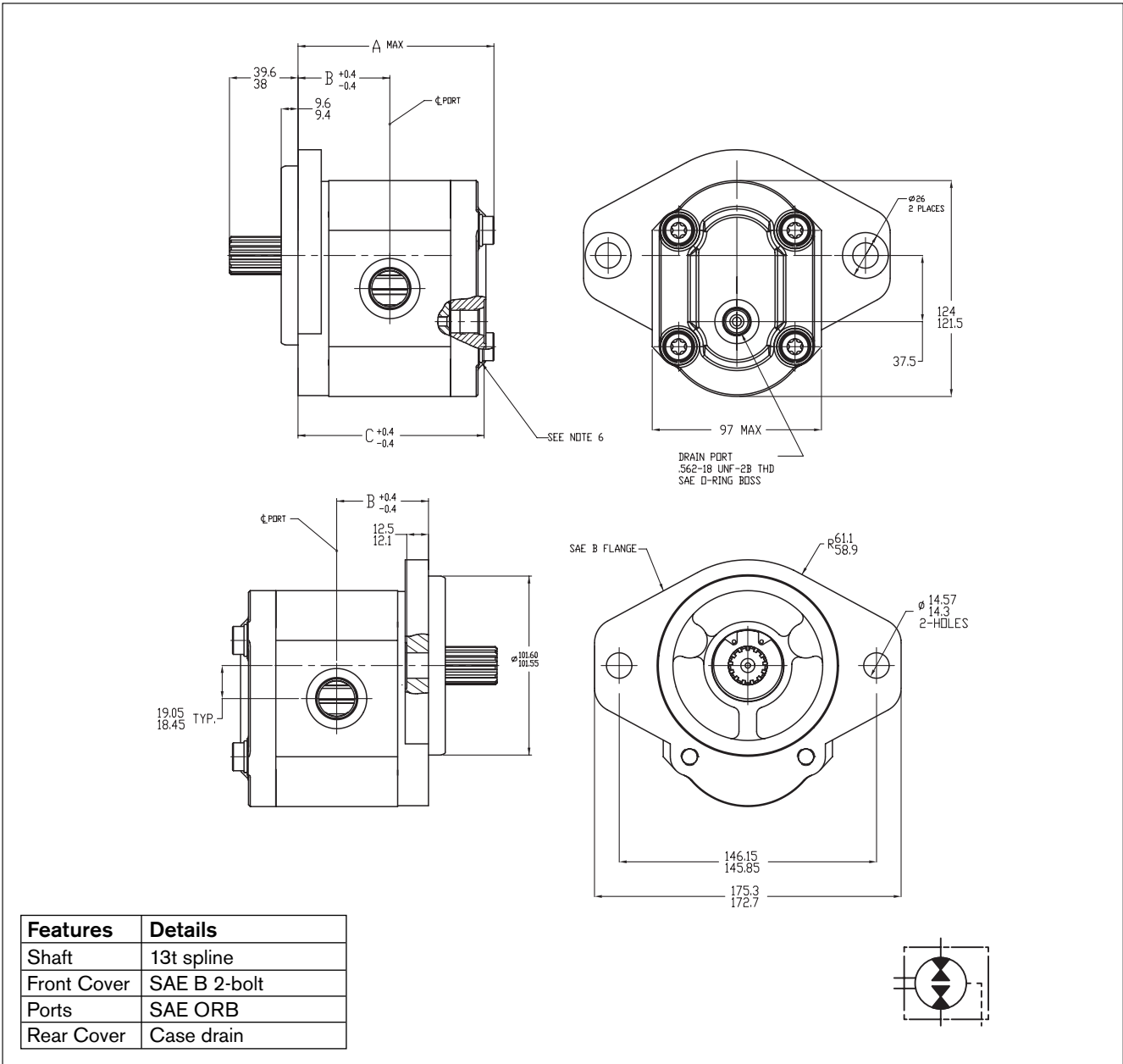
$\nu = 35 \text{ mm}^2/\text{s}$, $T = 50 \text{ }^\circ\text{C}$

Unit Conversions

Pressure: $\text{psi} = \text{bar} \times 14.7$
 Torque: $\text{ft-lbs} = (\text{Nm}) \times .738$
 Power: $\text{hp} = (\text{kW}) \times 1.341$
 Volume: $\text{in}^3 = (\text{cc}) \times 0.061$
 $\text{gpm} = (\text{LPM}) \times 0.2642$





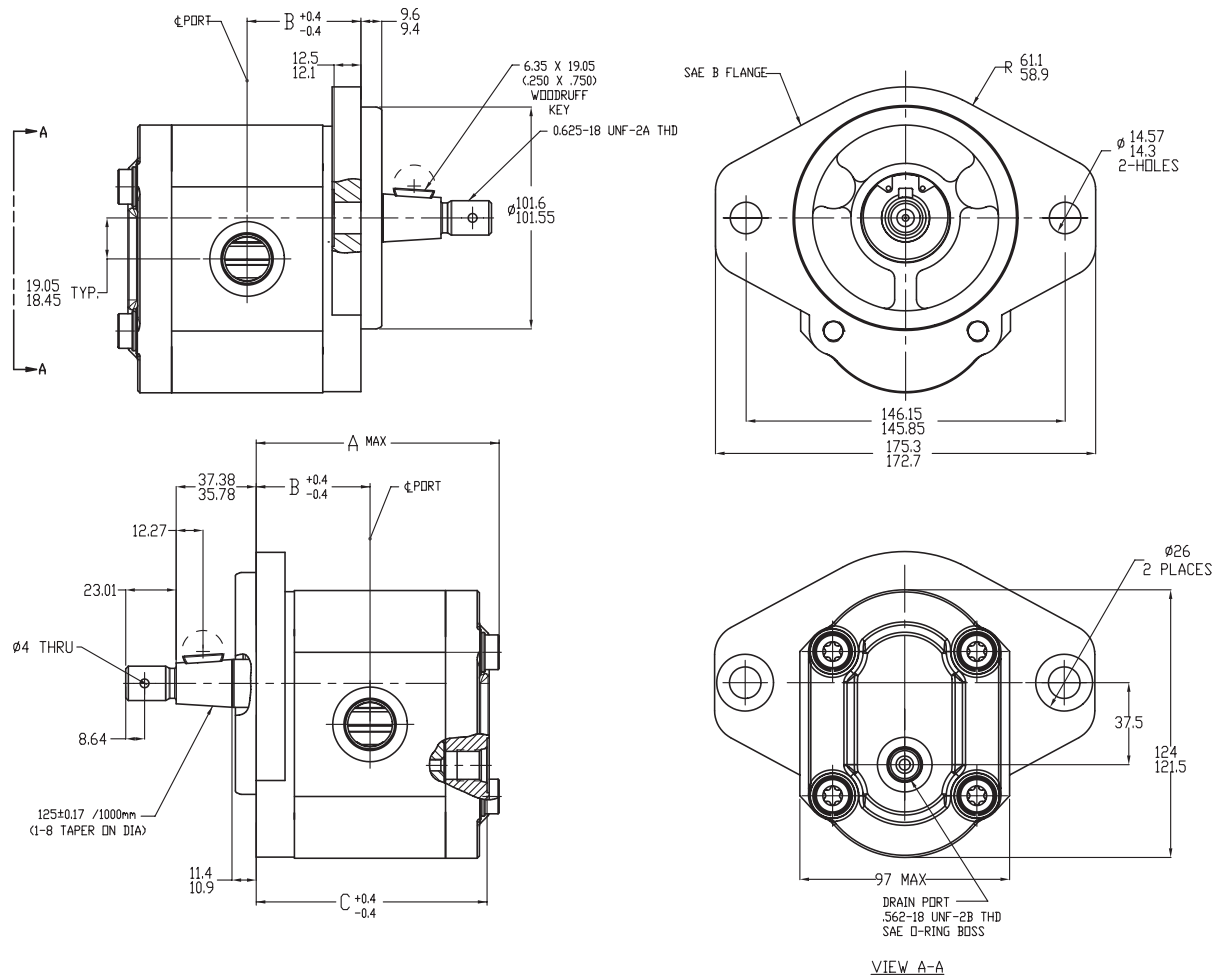


Ordering code
AZMN - 12 - ☐☐☐ U D C 12 KL

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
20.0		9 511 390 001	210	3000	109.8	52.1	105.6	-10	-10
22.5		9 511 390 002	210	3000	114.7	53.6	108.6	-10	-10
25.0		9 511 390 003	210	3000	115.8	55.1	111.6	-12	-12
28.0		9 511 390 004	210	2800	118.8	56.6	114.6	-12	-12
32.0		9 511 390 005	180	2800	123.3	58.6	119.1	-12	-12
36.0		9 511 390 006	160	2500	129.7	61.1	123.6	-12	-12

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)



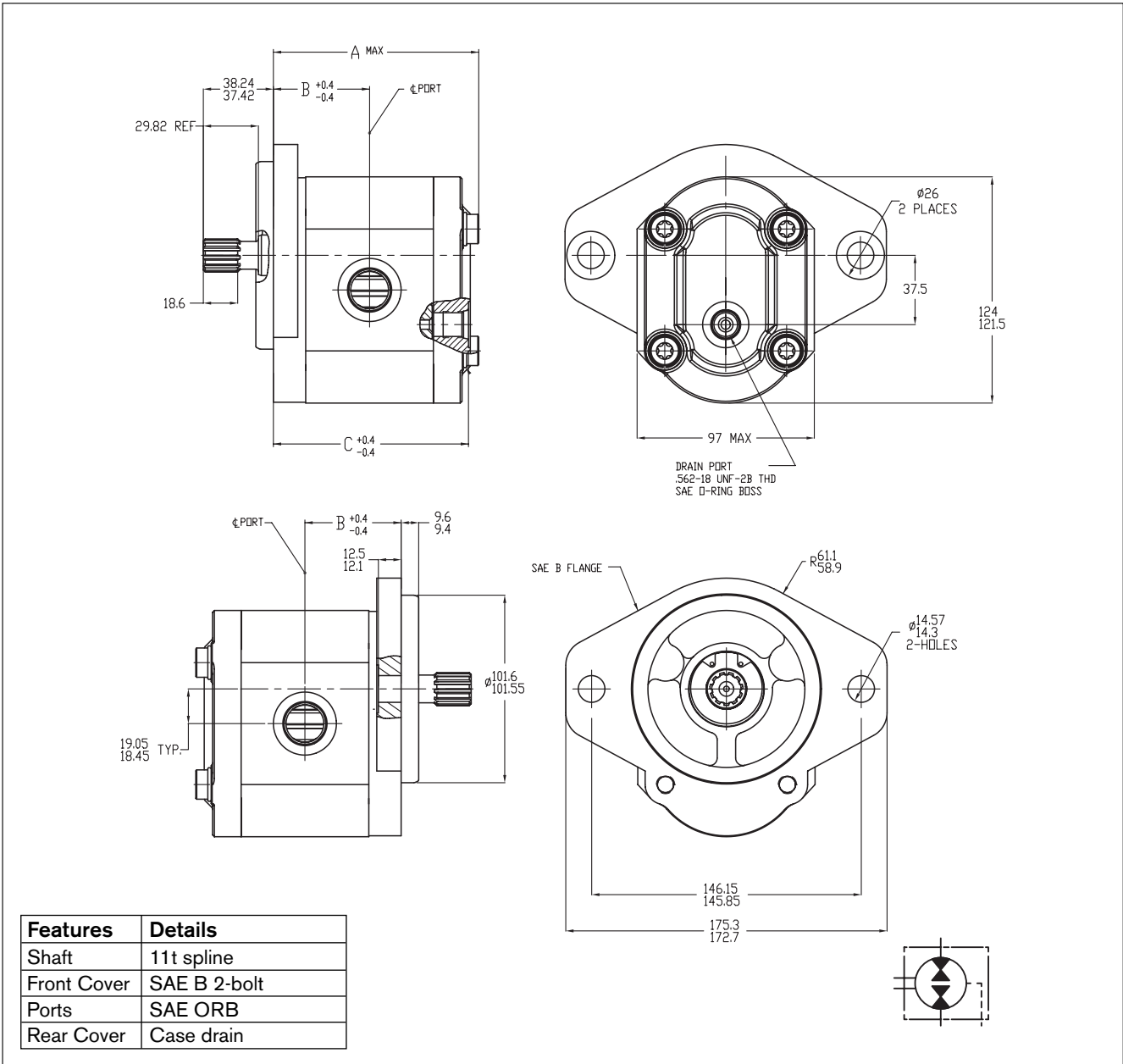
Features	Details
Shaft	SAE tapered key
Front Cover	SAE B 2-bolt
Ports	SAE ORB
Rear Cover	Case drain

Ordering code
AZMN – 12 – □ □ □ U X C 12 KL – S0275

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
20.0		9 511 390 031	210	3000	109.8	52.1	105.6	-10	-10
22.5		9 511 390 032	210	3000	114.7	53.6	108.6	-10	-10
25.0		9 511 390 033	210	3000	115.8	55.1	111.6	-12	-12
28.0		9 511 390 034	210	2800	118.8	56.6	114.6	-12	-12
32.0		9 511 390 035	180	2800	123.3	58.8	119.1	-12	-12
36.0		9 511 390 036	160	2500	129.7	61.1	123.6	-12	-12

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)

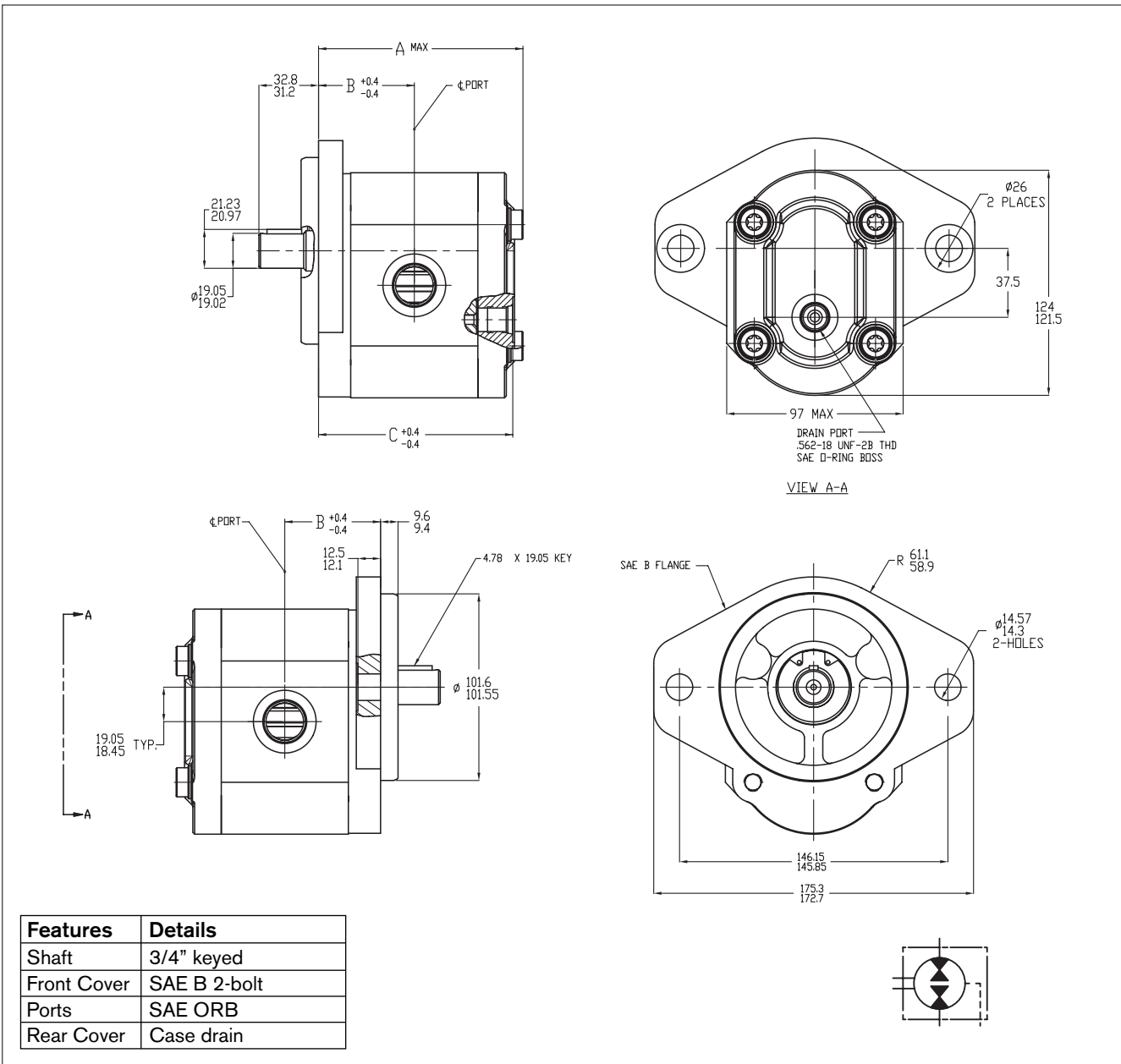


Ordering code
AZMN - 12 - ☐☐☐ U P C 12 KL

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
		Bi-Rotational			A	B	C		
20.0		9 511 390 025	210	3000	109.8	52.1	105.6	-10	-10
22.5		9 511 390 026	210	3000	114.7	53.6	108.6	-10	-10
25.0		9 511 390 027	210	3000	115.8	55.1	111.6	-12	-12
28.0		9 511 390 028	210	2800	118.8	56.6	114.6	-12	-12
32.0		9 511 390 029	180	2800	123.3	58.8	119.1	-12	-12
36.0		9 511 390 030	160	2500	129.7	61.1	123.6	-12	-12

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)

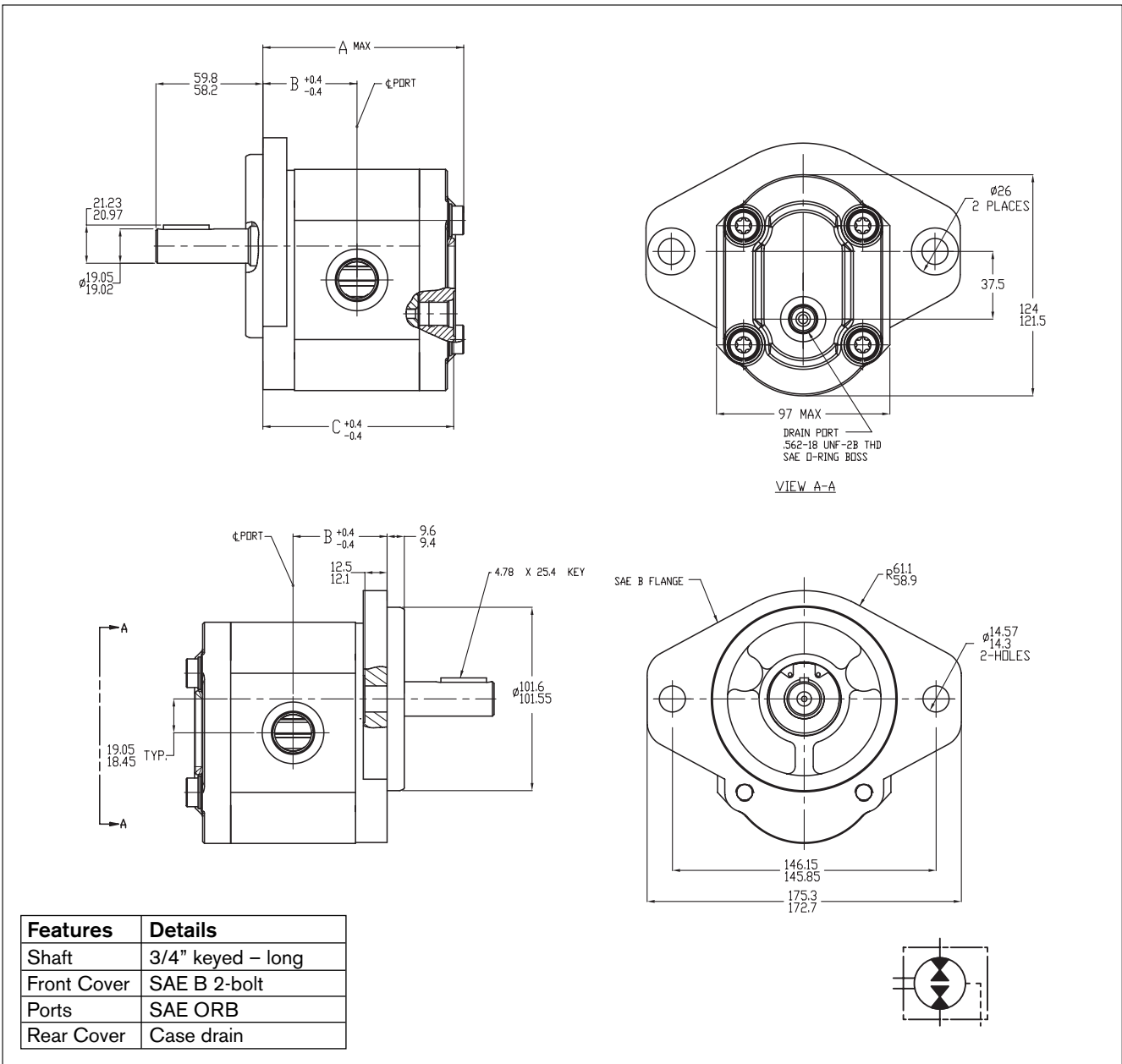


Ordering code
AZMN – 12 – ☐☐☐ U Q C 12 KL

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
20.0		9 511 390 013	210	3000	109.8	52.1	105.6	-10	-10
22.5		9 511 390 014	210	3000	114.7	53.6	108.6	-10	-10
25.0		9 511 390 015	210	3000	115.8	55.1	111.6	-12	-12
28.0		9 511 390 016	210	2800	118.8	56.6	114.6	-12	-12
32.0		9 511 390 017	180	2800	123.3	58.8	119.1	-12	-12
36.0		9 511 390 018	160	2500	129.7	61.1	123.6	-12	-12

* Contact factory for availabilty of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)

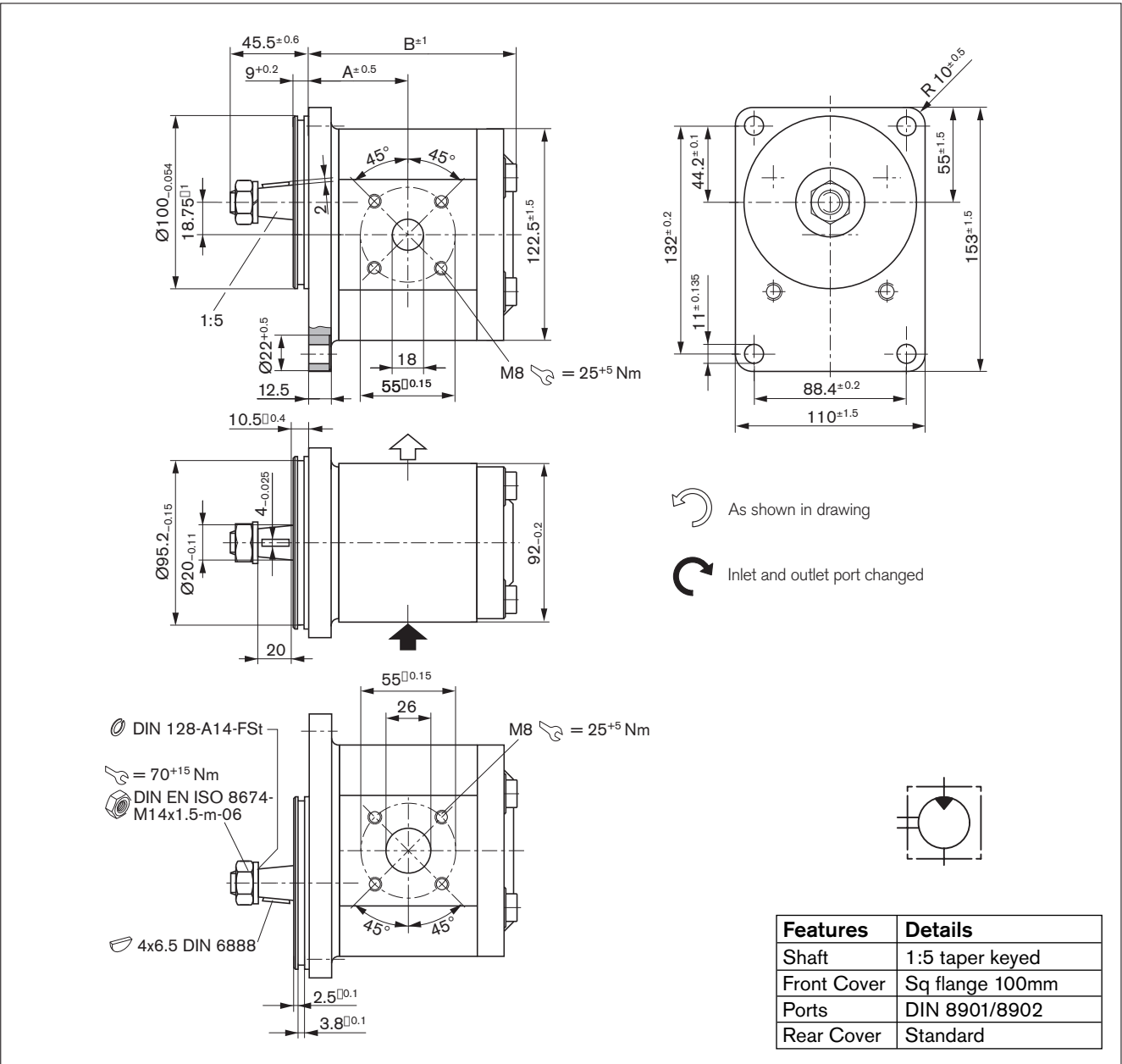


Ordering code
AZMN – 12 – □ □ □ U Q C 12 KL – S0022

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			Inlet Port ** (SAE O-Ring BOSS)	Outlet Port (SAE O-Ring BOSS)
					A	B	C		
20.0		9 511 390 043	210	3000	109.8	52.1	105.6	-10	-10
22.5		9 511 390 044	210	3000	114.7	53.6	108.6	-10	-10
25.0		9 511 390 045	210	3000	115.8	55.1	111.6	-12	-12
28.0		9 511 390 046	210	2800	118.8	56.6	114.6	-12	-12
32.0		9 511 390 047	180	2800	123.3	58.6	119.1	-12	-12
36.0		9 511 390 048	160	2500	129.7	61.1	123.6	-12	-12

* Contact factory for availability of units with no ordering number listed.

** Case drain port size: SAE -6 O-Ring BOSS (.562-18 UNF-2B THD)



Ordering code

AZMN - 12 - □□□□ C B 20 KB

Displacement [cm³/rev]	Ordering-Number *		Max. operating pressure [bar]	Max. rotation speed [rpm]	Dimension [mm]			
	L	R			A	B	C	
20.0								
22.5								
25.0	0511 725 307		210	3000	55.0	116.1		
28.0	0511 725 309	0511 725 019	200	3000	56.6	119.1		
32.0								
36.0								

* Contact factory for availability of units with no ordering number listed.

Spare Parts (reference Fig. 8)

Example Model Code: AZMF – 12 008 – URR 12ML

Model Code Designator for Shaft

Model Code Designator for Seal

	Model Code For Shaft	Shaft Description	Model Code For Seal	Seal Material	Bi-Directional Motor Item 1, 2, & 3	Uni-Directional Motor Item 1, 2, & 3	Shaft Seal Item 4
F Series Motor	R	SAE 9T Spline	M	NBR	1517010195	1517010152	1510283065
			P	FPM	1517010196	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
	Q	5/8" Straight Key	M	NBR	1517010195	1517010152	1510283065
			P	FPM	1517010196	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
	P	SAE 11T Spline	M	NBR	1517010195	1517010152	Consult Factory
			P	FPM	1517010196	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
	C	1:5 Tapered Key	M	NBR	1517010195	1517010152	1510283065
			P	FPM	1517010196	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
	S	1:5 Tapered for Flange A	M	NBR	1517010195	1517010152	1510283015
			P	FPM	1517010193	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
	H	1:8 Tapered Key	M	NBR	1517010195	1517010152	1510283065
			P	FPM	1517010196	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
	N	Dog (Tang)	M	NBR	1517010195	1517010152	1510283065
			P	FPM	1517010196	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
	F	Din 5482 B17x14 Spline	M	NBR	1517010195	1517010152	1510283065
			P	FPM	1517010196	1517010193	
			K	NBR W/FPM SHAFT SEAL	1517010195	1517010152	
N Series Motor	D	SAE 13T Spline	M	NBR	R98640146P	---	1510283028
			P	FPM	---	---	
			K	NBR W/FPM SHAFT SEAL	---	---	
	P	SAE 11T Spline	M	NBR	R98640146P	---	1510283028
			P	FPM	---	---	
			K	NBR W/FPM SHAFT SEAL	---	---	
	Q	3/4" Straight Key	M	NBR	R98640146P	---	1510283028
			P	FPM	---	---	
			K	NBR W/FPM SHAFT SEAL	---	---	
	X	S0075 Tapered	M	NBR	R98640146P	---	1510283028
			P	FPM	---	---	
			K	NBR W/FPM SHAFT SEAL	---	---	
	C	1:5 Tapered Key	M	NBR	R98640146P	---	1510283028
			P	FPM	---	---	
			K	NBR W/FPM SHAFT SEAL	---	---	
	N	Dog (Tang)	M	NBR	R98640146P	---	1510283028
			P	FPM	---	---	
			K	NBR W/FPM SHAFT SEAL	---	---	

* Shaft seals are Viton material regardless of material used for other seals

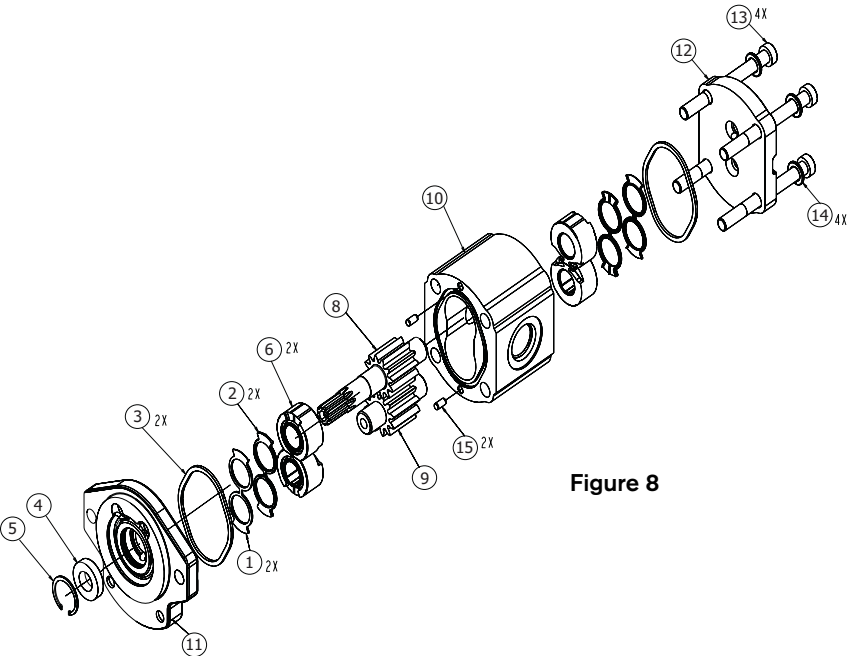


Figure 8

Part Number Index

External Gear Pumps – Multiple Pumps

Part Number	Page	Part Number	Page	Part Number	Page	Part Number	Page
0 511 415 001.....	30	0 511 625 602.....	31	9 511 290 027.....	23	9 511 390 033.....	46
0 511 415 300.....	30	0 511 625 603.....	32	9 511 290 028.....	23	9 511 390 034.....	46
0 511 415 603.....	36	0 511 625 605.....	32	9 511 290 029.....	23	9 511 390 035.....	46
0 511 415 604.....	39	0 511 645 001.....	29	9 511 290 030.....	23	9 511 390 036.....	46
0 511 415 605.....	34	0 511 645 300.....	29	9 511 290 031.....	26	9 511 390 043.....	49
0 511 415 606.....	35	0 511 645 302.....	29	9 511 290 032.....	26	9 511 390 044.....	49
0 511 415 608.....	37	0 511 645 601.....	33	9 511 290 033.....	26	9 511 390 045.....	49
0 511 425 001.....	27	0 511 645 603.....	33	9 511 290 034.....	26	9 511 390 046.....	49
0 511 425 002.....	28	0 511 715 001.....	30	9 511 290 035.....	26	9 511 390 047.....	49
0 511 425 300.....	27	0 511 715 300.....	30	9 511 290 036.....	26	9 511 390 048.....	49
0 511 425 301.....	28	0 511 715 601.....	34	9 511 290 052.....	19		
0 511 425 601.....	31	0 511 725 004.....	28	9 511 290 053.....	19		
0 511 425 603.....	32	0 511 725 005.....	27	9 511 290 054.....	19		
0 511 445 001.....	29	0 511 725 019.....	50	9 511 290 055.....	19		
0 511 445 300.....	29	0 511 725 303.....	28	9 511 290 056.....	19		
0 511 445 601.....	33	0 511 725 304.....	27	9 511 290 057.....	19		
0 511 515 001.....	30	0 511 725 307.....	50	9 511 290 058.....	22		
0 511 515 300.....	30	0 511 725 309.....	50	9 511 290 059.....	22		
0 511 515 601.....	35	0 511 725 601.....	31	9 511 290 060.....	22		
0 511 515 602.....	34	0 511 725 602.....	32	9 511 290 061.....	22		
0 511 515 605.....	35	0 511 745 001.....	29	9 511 290 062.....	22		
0 511 525 001.....	27	0 511 745 300.....	29	9 511 290 063.....	22		
0 511 525 002.....	28	9 511 290 001.....	18	9 511 290 064.....	25		
0 511 525 300.....	27	9 511 290 002.....	18	9 511 290 065.....	25		
0 511 525 301.....	28	9 511 290 003.....	18	9 511 290 066.....	25		
0 511 525 303.....	28	9 511 290 004.....	18	9 511 290 067.....	25		
0 511 525 304.....	27	9 511 290 005.....	18	9 511 290 068.....	25		
0 511 525 601.....	32	9 511 290 006.....	18	9 511 290 069.....	25		
0 511 525 604.....	31	9 511 290 007.....	21	9 511 390 001.....	45		
0 511 545 001.....	29	9 511 290 008.....	21	9 511 390 002.....	45		
0 511 545 300.....	29	9 511 290 009.....	21	9 511 390 003.....	45		
0 511 545 301.....	29	9 511 290 010.....	21	9 511 390 004.....	45		
0 511 545 601.....	33	9 511 290 011.....	21	9 511 390 005.....	45		
0 511 615 001.....	30	9 511 290 012.....	21	9 511 390 006.....	45		
0 511 615 002.....	30	9 511 290 013.....	24	9 511 390 013.....	48		
0 511 615 300.....	30	9 511 290 014.....	24	9 511 390 014.....	48		
0 511 615 301.....	30	9 511 290 015.....	24	9 511 390 015.....	48		
0 511 615 606.....	38	9 511 290 016.....	24	9 511 390 016.....	48		
0 511 615 607.....	34	9 511 290 017.....	24	9 511 390 017.....	48		
0 511 615 608.....	34	9 511 290 018.....	24	9 511 390 018.....	48		
0 511 625 001.....	28	9 511 290 019.....	20	9 511 390 025.....	47		
0 511 625 002.....	28	9 511 290 020.....	20	9 511 390 026.....	47		
0 511 625 003.....	27	9 511 290 021.....	20	9 511 390 027.....	47		
0 511 625 005.....	27	9 511 290 022.....	20	9 511 390 028.....	47		
0 511 625 009.....	27	9 511 290 023.....	20	9 511 390 029.....	47		
0 511 625 300.....	28	9 511 290 024.....	20	9 511 390 030.....	47		
0 511 625 301.....	28	9 511 290 025.....	23	9 511 390 031.....	46		
0 511 625 308.....	27	9 511 290 026.....	23	9 511 390 032.....	46		

Bosch Rexroth Corporation
 Hydraulics
 Product Segment External Gear Units
 8 Southchase Court
 Fountain Inn, SC 29644-9018
 Telephone (864) 967-2777
 Facsimile (864) 962-5338
www.boschrexroth-us.com

© 2007 Bosch Rexroth Corporation

All rights reserved. Neither this document, nor any part of it, may be reproduced, duplicated, circulated or disseminated, whether by copy, electronic format or any other means, without the prior consent and authorization of Bosch Rexroth Corp.

The data and illustrations in this brochure/data sheet are intended only to describe or depict the products. No representation or warranty, either express or implied, relating to merchantability or fitness for intended use, is given or intended by virtue of the information contained in this brochure/data sheet. The information contained in this brochure/data sheet in no way relieves the user of its obligation to insure the proper use of the products for a specific use or application. All products contained in this brochure/data sheet are subject to normal wear and tear from usage.

Subject to change.