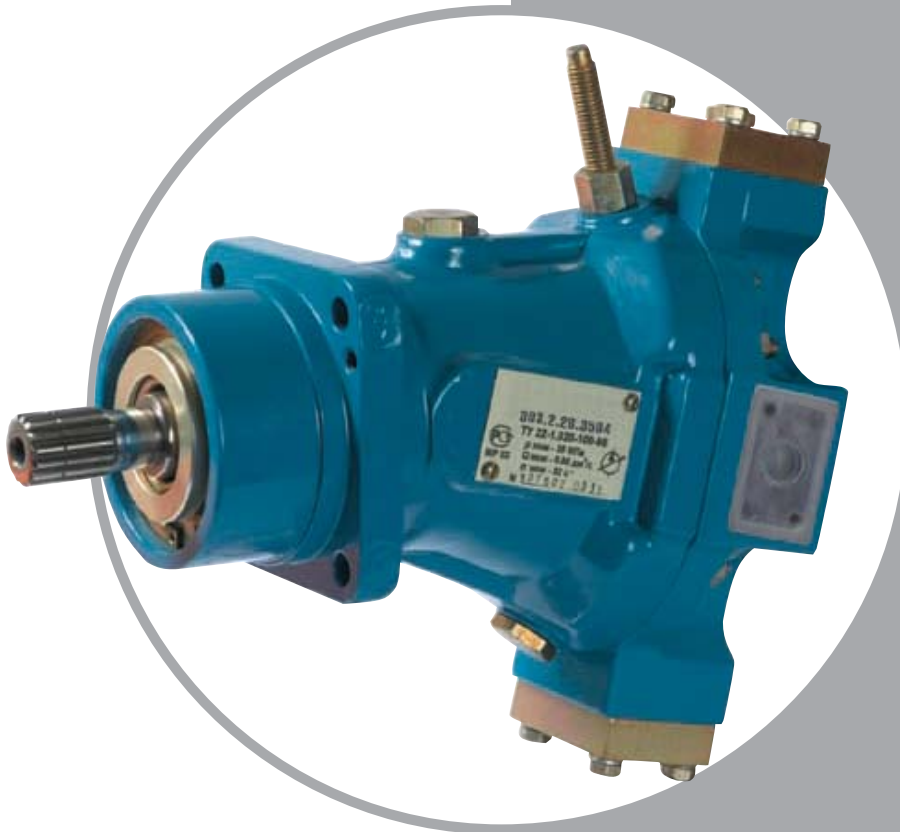




PSM HYDRAULICS

VARIABLE DISPLACEMENT HYDRAULIC MOTORS



SECTION 5



The type 303 variable displacement reversible axial-piston hydraulic motors (hereinafter referred to as hydraulic motors) are characterized by a wide displacement range and different regulation/control modes.

In the initial state the displacement can be both maximal and minimal. The control can be positive (increasing the displacement) or negative (decreasing it).

The rotation direction, torque, and rotational speed of the hydraulic motor shaft are determined by the supply direction, pressure and displacement of the hydraulic motor itself.

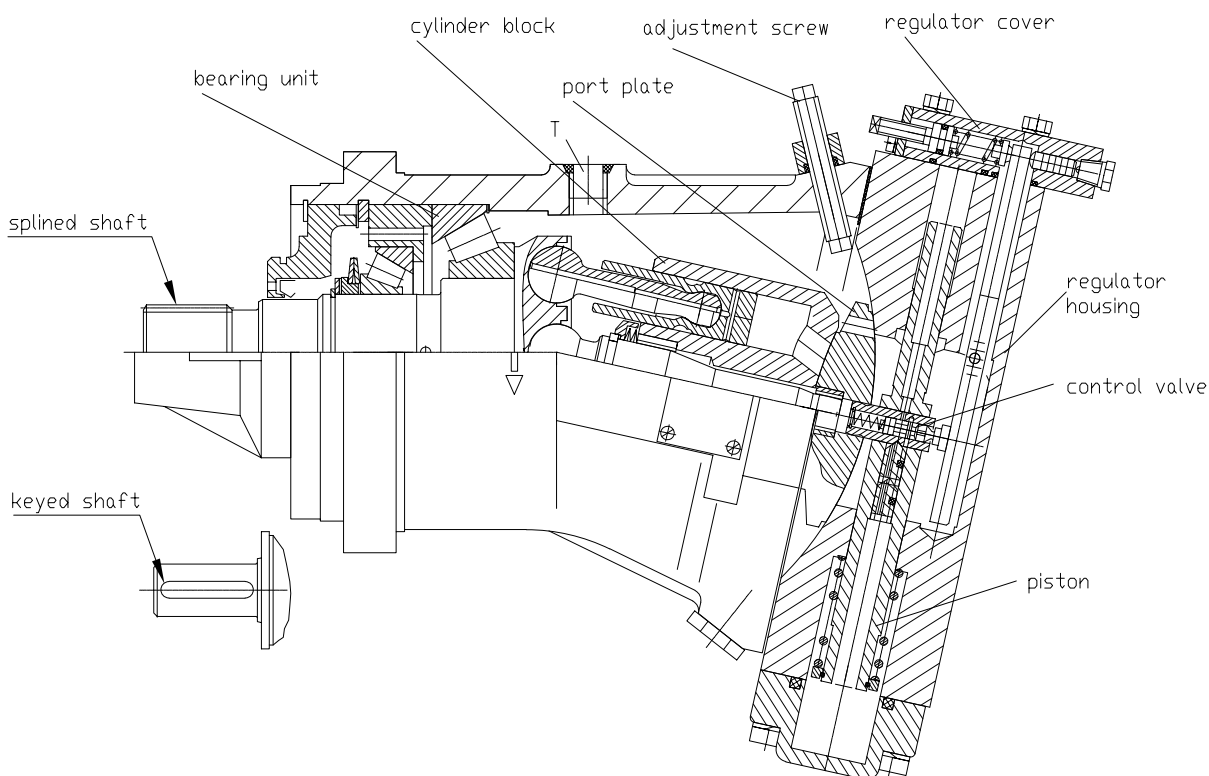
The displacement is determined by the piston diameter and cylinder block bent-axis relative to the shaft axis.

The angle between the shaft axis and cylinder block axis can be changed both automatically by operating pressure in hydraulic system and by external control system with obtaining necessary characteristics.

Limitation of the minimal and maximal displacements is effected by means of adjusting screws.

The version without displacement limitation (without the screws) is the base one.

The variable displacement hydraulic motors are designated by structural diagram.



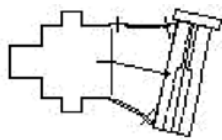


Designation structural diagram

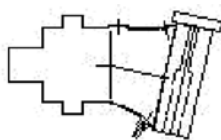
303	
Type: 303 – variable displacement hydraulic motor	
Model 0, 1, 2, 3, 4...	
Working displacement, cm ³ : 12, 28, 45, 55, 56, 80, 107, 112, 160, 250	
Mechanical working displacement limitation*	
	without limitations 0 with limitation V min 5 with limitation Vmax 7 with limitation V min and Vmax 9
	without limitation 1 with limitation V min 2 with limitation Vmax 3 with limitation V min and V max 4
Regulation mode:	
proportional	0
	1
constant pressure	2
	3
pressure regulation on hyperbola	4
	5
	6
without control devices	7
	8
	9
Control mode:	
absent	0
hydraulic negative**	1
hydraulic positive**	2
Electric	discrete 12V, 24V 3 proportional 12V, 24V 4
mechanical	shift by progressive motion 5 shift by rotary motion 6
hydraulic negative with internal limiter	7
	8
	9
direct control	two-chamber versatile piston A one-chamber versatile piston B two-chamber equilateral piston C
Shaft design	
splined	Shaft rotation sense
	reversible 0
	clockwise 3
keyed	anticlockwise 4
	reversible 1
	clockwise 5
	anticlockwise 6

NBR		Climatic version
FKM		
Valve:		
0	absent	
1	with one-sided brake valve	
2	with two-sided brake valve	
3	direct action safety valves	
4	direct action safety valve	
5	docked block of check safety valves	
6		
7		
8		
9		
Pipelines connection and article mounting		
connection	flange	
0	2 flanges at sides	
1	3 flanges	
2	4 flanges at sides 2 on end	
3	2 flanges at sides, 2 threaded on end	
4	2 threaded on end	
5	2 threaded at sides	
6	1 threaded, 1 flange	
7	2 threaded, 1 flange	
8		
9		
4 holes ISO 3019/2		
Secondary control:		
0	absent	
1	non-controlled valve in control line	
2	controlled cut-off valve in control line	
3	cut-off valve (for hydraulic motor without control)	
4	Regulator power supply from external source	
5		
6		

313 0 ...

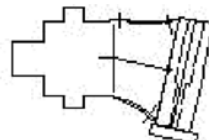


313 7 ...

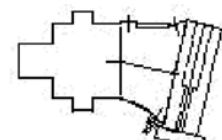


with limitation Vmax

313 1 ...

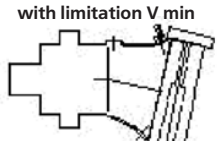


313 3 ...



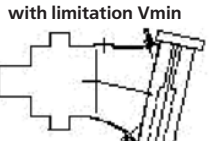
with limitation Vmax

313 5 ...



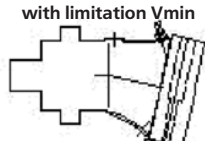
with limitation Vmax

313 9 ...



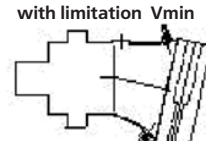
with limitation Vmin

313 2 ...



with limitation Vmin

313 4 ...



with limitation Vmin



Hydraulic motor operation principle

The hydraulic motor functionally consists of two units, namely, a pumping unit and a regulator.

The pumping unit includes a shaft supported in the body in bearings and a cylinder block. On the shaft end side the hydraulic motor is closed with a cover sealed with a rubber ring and a sealing collar. The shaft flange is connected with pistons and a tongue through spherical connecting rod heads.

The pistons take up the working fluid pressure and transfer the force through the connecting rods to a spherical joint where this force is resolved into an axial and a tangential component. The axial load is taken up by angular ball bearings or tapered roller bearings while the tangential one develops a torque at the hydraulic motor shaft.

The cylinder block contacts by means of a spherical surface with a directional control valve whose opposite side adjoins the supporting surface of the regulator body.

The regulator is designed for changing the hydraulic motor displacement by changing the cylinder block slope.

The regulator consists of a stepped piston mounted in the body, a pin fixed in the piston with a screw, a valve spool with a shoe and end thrust bearing, a lever, and a cover containing components which have different functions.

The cylinder chamber of the piston with smaller

diameter is constantly connected with the high pressure channel through a check valve. The cylinder chamber of the piston with greater diameter can be connected to the high pressure line or drainage line through the openings in the pin, valve spool land, and opening in the screw.

In operation, when supplying the control pressure by means of the "X" openings in the cover, the components contained in the cover change the ratio of moments at the lever and valve spool position relative to the pin. Displacement of the valve spool to the right or to the left from the neutral position causes changing pressure in the piston chamber of greater diameter and displacement of the piston. In this case the hydraulic motor operates at a smaller displacement (moment) but at a higher rotational speed. On removing the control pressure the piston moves in the lower position thus increasing the motor displacement. On supplying variable pressure a stepless regulation of the displacement is provided.

Depending on the arrangement conditions, the regulator body can be rotated 180° to the hydraulic motor body.

Technical data

Variable displacement hydraulic motors 303.2. 303.3 series

303.4 series

Max operating pressure (bar):

- Continuous
- Peak

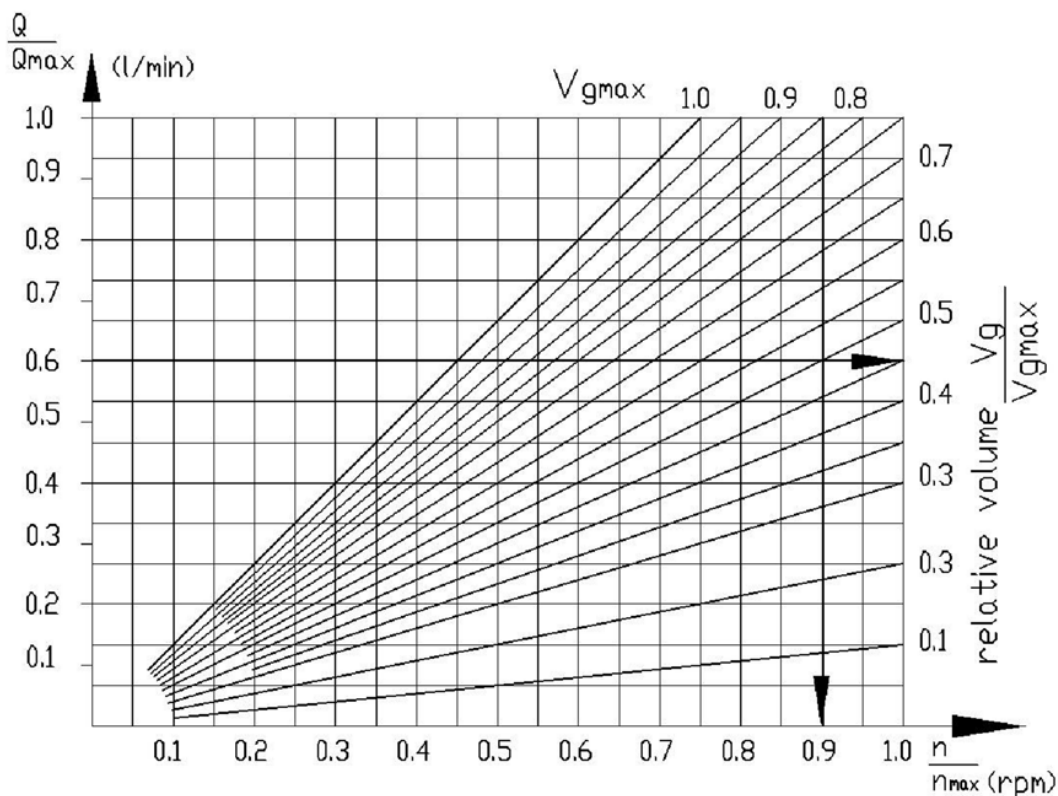
280
350

400
450

Size			12	28	55	56	80	107	112	160
Displacement	$V_{g_{max}}$ V_n	cm ³	11,6	28	55	56	80	107	112	160
			0	0	0	0	0	0	31	0
Rotation speed at $V_{g_{max}}$ V_n	n_{max}	min ⁻¹	6000	4750	3750	3750	3350	3000	3000	2650
			7500	6250	5000	5000	4500	4000	4000	3500
Consumed flow rate at n_{max}	$Q_{v_{max}}$	l/min	70	175	275	280	360	428	448	560
Torque at: $V_{g_{max}}$ и $\Delta p=450$ bar $V_{g_{max}}$ и $\Delta p=400$ bar $V_{g_{max}}$ и $\Delta p=350$ bar $V_{g_{max}}$ и $\Delta p=250$ bar	M_{max}	Nm	74	179	351	358	511	684	715	1022
			66	159	312	318	454	608	636	909
			58	139	273	278	397	532	556	795
			41	99	195	199	284	380	397	568
Weight	m_{max}	kg	6	15,5	24	22	38	40	38	55



Limit values for rotational speed and flow rate



Typical size			28	55	56	80	107	112	160
Displacement	$V_{g\max}$	cm \geq	28,1	54,8	56	80	107	112	160
	$V_{g\min}$	cm \geq	0	0	15.8	0	0	30.8	0
Flow rate	Q_{\max}	l/min	133	206	222	268	321	355	424
Rotational speed	n_{\max} at $V_{g\max}$	rpm	4750	3750	3750	3350	3000	3000	2650
	n_{\max} at $V_g < V_{g\max}$	rpm	6250	5000	5000	4500	4000	4000	3500

Example 1 Typical size 107

At given working fluid flow rate $Q=200$ l/min it is necessary to determine displacement (V_g) if $n \geq n_{\max}$

Solution: $Q_{\max}=321$ l/min (see the table),
if $Q/Q_{\max} = 200/321=0,6$, then according to the plot $V_g/V_{g\max}=0,45$,
then $V_g=0,45 \cdot V_{g\max}=0,45 \cdot 107=48,2$ cm \geq

Answer: $V_g=48,2$ cm \geq at $Q=200$ l/min

Example 2 Typical size 112

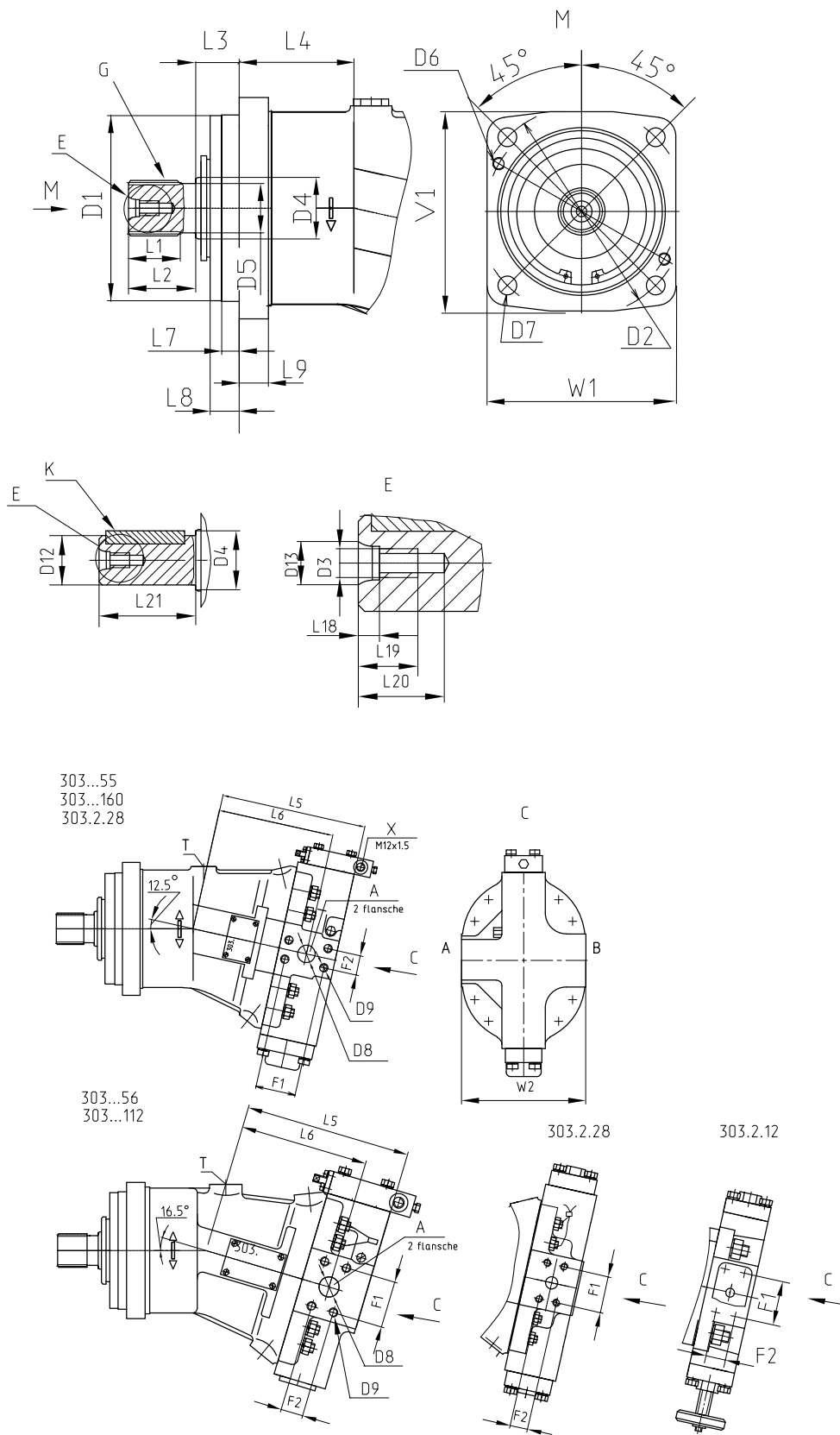
For displacement $V_g=95$ cm \geq ($V_g < V_{g\max}$) it is necessary to determine the maximum permissible rotational speed

Solution: If $V_g/V_{g\max} = 95/112=0,85$, then according to the plot $n/n_{\max}=0,9$
then $n=0,9 \cdot n_{\max}=0,9 \cdot 4000=3600$ r.p.m.

Answer: $n=3600$ r.p.m. for $V_g=95$ cm \geq



Mounting dimensions





Size	303.2.12	303.2.28	303.3.55 303.4.55	303...56 (303.1.56)	303.3.80 303.4.80	303.3.107 303.4.107	303...112 (303.1.112)	303.3.160 303.4.160
G spline DIN 5480	WA20x1,5x30x 12xf7x9g *W20-1,5x30x 12x 9g	WA25x1,5x30x15xf7x9g *W25-1,5x30x 15x 9g	WA35x2x30x16x f7x9g *W35-2x30x16x9g		WA40x2x30x 18xh8x9g *W40-2x30x 18x9g	WA45x2x30x21xh8x9g *W45-2x30x21x9g		
K key DIN 6885	A 6x6x32	A 8x7x40	A 8x7x50	A 10x8x56	A 12x8x63	A 14x9x70	A 12x8x63	A 14x9x70
D1	80 h7	100 h7	125 h7	125 h7	140 h7	160 h7	160 h7	180 h7
D2	100	125	160	160	180	200	200	224
D3	M6-7H	M8-7H	M12-7H	M12-7H	M12-7H	M12-7H	M12-7H	M16-7H
D4	25h8	30h8	40 h8	40 h8	45 h8	50 h8	50 h8	50 h8
D5	16,6	21,2	30 h11	30 h11	35 h11	40 h11	40 h11	40 h11
D6	-	M8-7H		-	M10 -7H	M12-7H	M12-7H	M12-7H
D7	9	11	14	14	14	18	18	18
D8	14	14	22	22	25	25	25	32
D9	M8x14	M8x14	M10x18	M10x18	M12x18	M12x18	M12x18	M14x20
D12	20k6	25k5	30k6	30k6	35k6	40k6	40k6	45k6
D13	11	12,5	17	17	17	17	17	21
F1	40,5	40,5	50,8	50,8	57,2	57,2	57,2	66,7
F2	18,2	18,2	23,8	23,8	27,8	27,8	27,8	31,8
L1	23,5	33	32,5	32,5	34,5	39,5	39,5	39,5
L2	40	50	50	49	50	55	55	55
L3	20	50	32,5	32,5	32	40	40	40
L4	70	62	85		99	101	101	108,5
L5	105	136	180	177	196	210	207	239
L6	85	110	141	147	157	169	171	193
L7	6	10	9	9	9	11	11	10
L8	18	48	18	18	12	25	25	34
L9	13	16	20	20	23	25	25	28
L18	5,5	7	8,5	8,5	8,5	8,5	8,5	8,5
L19	14	17	24	24	24	25	25	36
L20	19	23	35	35	35	35	35	46
L21	40	50	58	58	70	80	80	90
V1	90	118	140	140	160	180	180	200
W1	90	118	140	140	160	180	180	200
W2	90	132	154	154	182	178	182	206
T **	M12x1,5	M18x1,5	M18x1,5	M18x1,5	M18x1,5	M18x1,5	M18x1,5	M22x1.5

* - to be negotiated while ordering

** - joint leakproofness by rubber rings



Hydraulic motor with proportional regulation and hydraulic negative adjustment Delivery sets of hydraulic motors with above mentioned regulation type:

303 . 3 . 55 . 0 0 1

Hydraulic motors

with roller conical bearings

or with bimetal cylinder block

with working displacement: 55 or 56, 80, 107, 112, 160 cm³

regulation mounting - 0°

without limitation

with limitation of V_{min}

with limitation of V_{max}

with limitations of V_{min} and V_{max}

proportional regulation

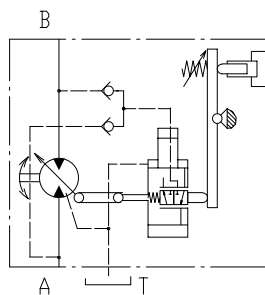
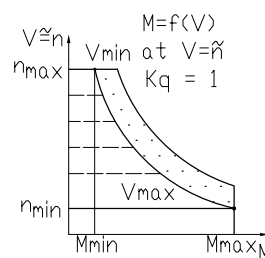
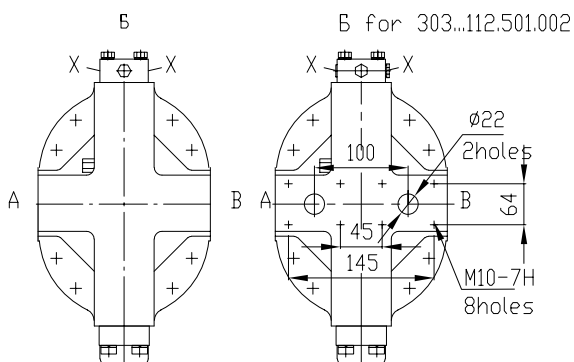
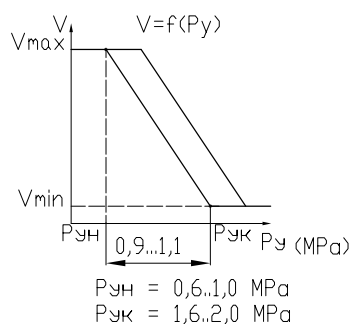
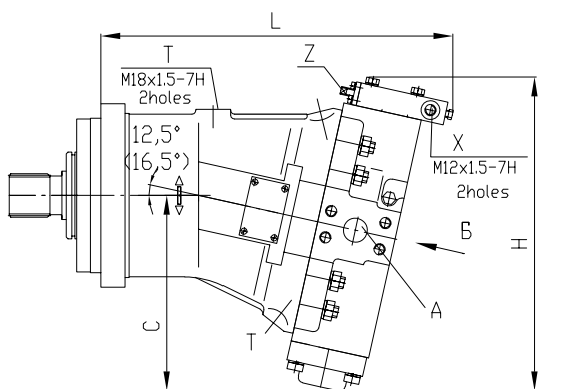
hydraulic negative adjustment

3
4

0
5
7
9

The motor regulator changes the torque and shaft rotational speed proportional to the control signal. In the initial position, when the control pressure P_y is absent, the hydraulic motor operates at the maximal displacement

V_{max} that ensures the minimal rotational speed n_{min} and maximal torque M_{max}.



Hydro motors	L	H	C
303...55.	320	300	185
303...56.	316	240	150
303...80	350	320	196
303...107	365	324	202
303...112	363	270	175
303...160	401	394	255



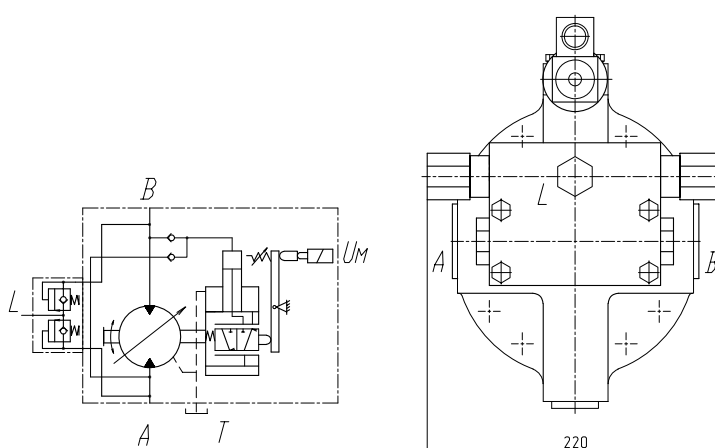
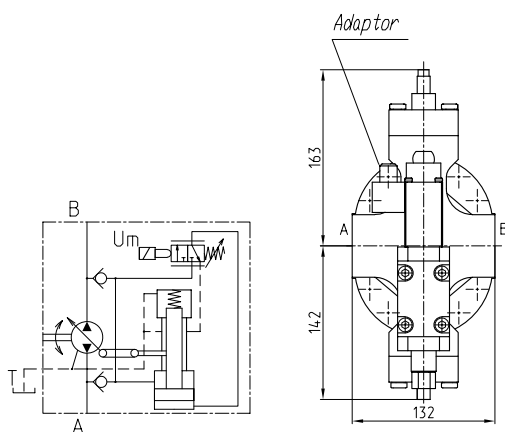
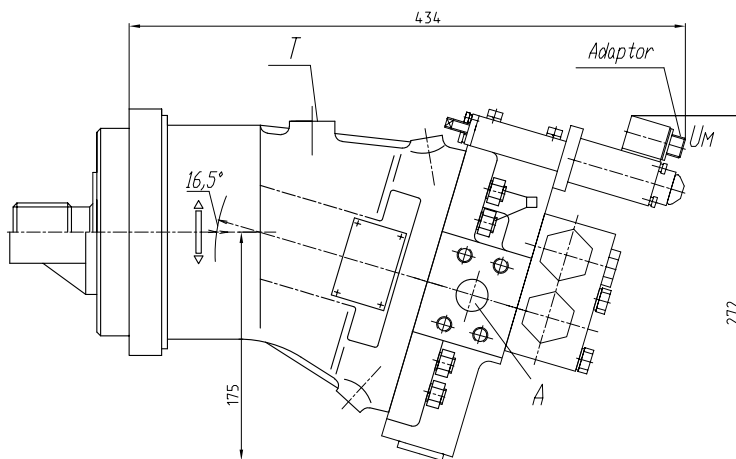
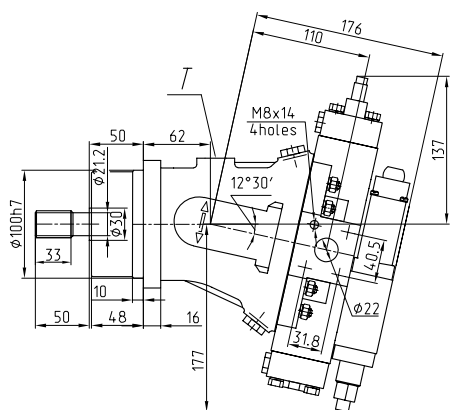
Hydraulic motors with proportional regulation and discrete electric control with docked block of check safety valves

The motor regulator changes the torque and shaft rotational speed on supplying voltage to the electromagnet. The БОПК-20 block of

check safety valves ensures protection of the hydraulic drive against high pressure and vacuum in hydraulic system.

303.2.28.003 hydraulic motor with two-position negative electric control

303.4.112.003.000.5 with proportional regulation, discrete electric control, with butt joint block of check safety valves



T – to connect with drain line (see section 1 Drain pipeline assembly diagram)



Hydraulic motor with pressure regulator

Delivery sets of hydraulic motors with above mentioned regulation type:

303 . 3 . 55 . 1 2 0

Hydraulic motors

with roller conical bearings

or with bimetal cylinder block

with working displacement: 55 and 80, 107, 160 cm³

regulation mounting - 180°

without limitation

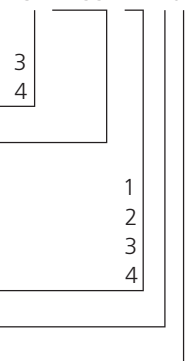
with limitation of V_{min}

with limitation of V_{max}

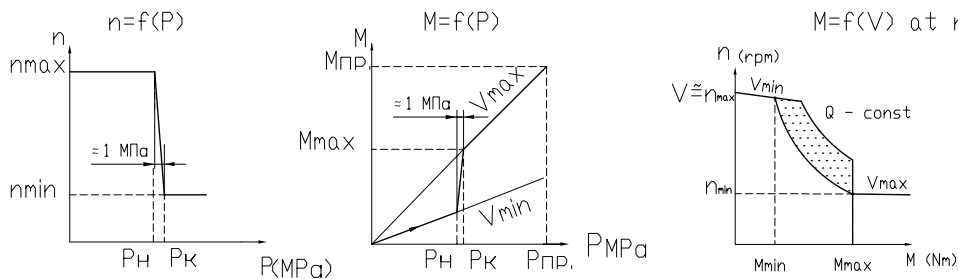
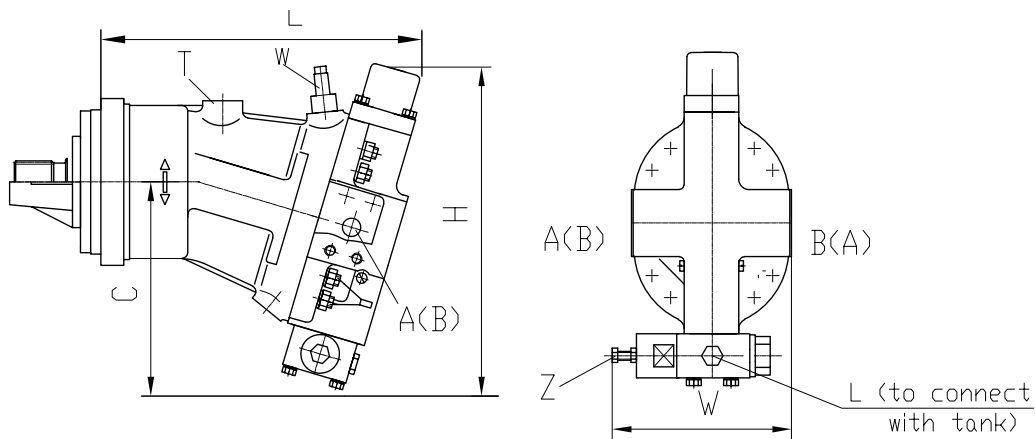
with limitations of V_{min} and V_{max}

at pressure regulation

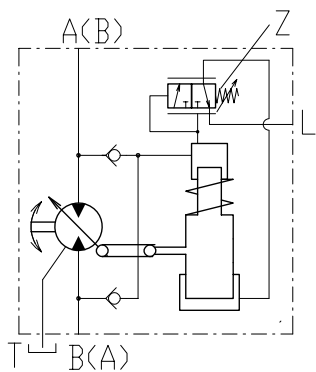
control absent



The hydraulic motor regulator ensures automatic step change of working displacement at constant pressure.



P_H = 5...25 MPa - regulation start pressure



Hydraulic motors	L	H	C	W
303...55.	290	323	198	179
303...80....	320	340	210	179
303...107. ...	335	342	212	184
303...160. ...	373	412	240	198

T - to connect with drain line (see section 1 Drain pipeline assembly diagram)
L - regulator outlet line (to connect with tank) M12x1,5-7H



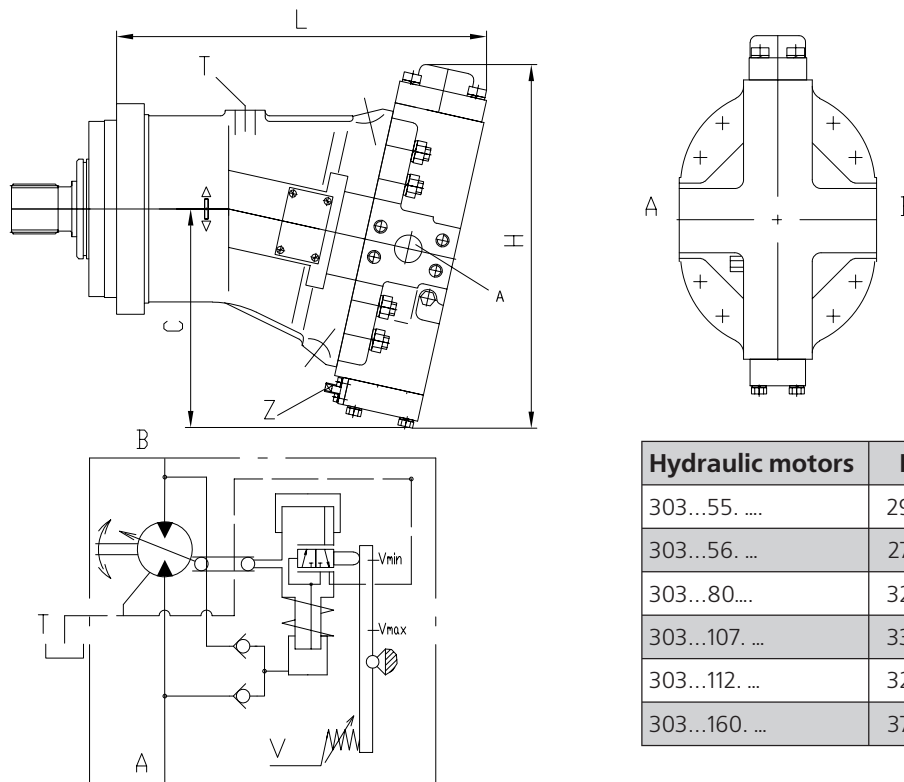
Hydraulic motor with pressure regulator with hyperbolic characteristic Delivery sets of hydraulic motors with above mentioned regulation type:

303 . 3 . 55 . 1 4 0

Hydraulic motors

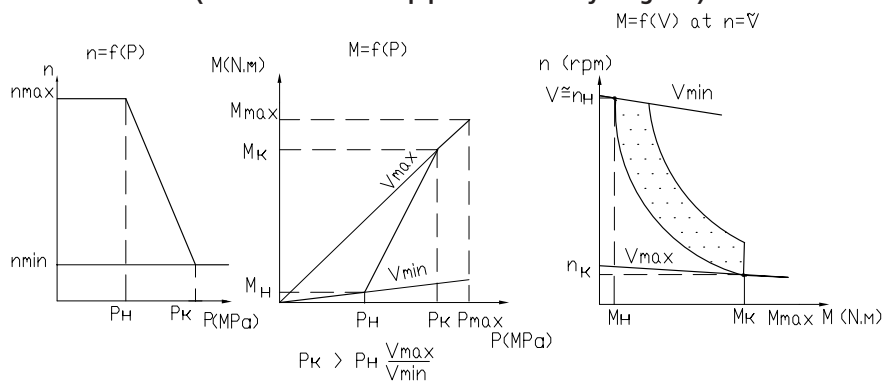
with roller conical bearings	3
or with bimetal cylinder block	4
with working displacement: 55 or 56, 80, 107, 112, 160 cm ³	
regulation mounting - 180°	
without limitation	1
with limitation of V _{min}	2
with limitation of V _{max}	3
with limitations of V _{min} и V _{max}	4
pressure regulator with hyperbolic characteristic	
no regulation	

The regulator ensures the automatic change of the torque M_{kp} and rotational speed n on variation of the output shaft load.



Hydraulic motors	L	H	C
303...55.	290	307	182
303...56. ...	270	258	180
303...80....	320	323	194
303...107. ...	336	328	198
303...112. ...	320	284	192
303...160. ...	374	397	225

T – to connect with drain line (see section 1 Drain pipeline assembly diagram)





Hydraulic motor with pressure regulator with hyperbolic characteristic and hydraulic negative control
Delivery sets of hydraulic motors with above mentioned regulation type:

303 . 3 . 55 . 1 4 1

Hydraulic motors

with roller conical bearings

or with bimetal cylinder block

with working displacement: 55 or 56, 80, 107, 112, 160 cm³

regulation mounting - 180°

without limitation

with limitation of V_{min}

with limitation of V_{max}

with limitations of V_{min} and V_{max}

pressure regulator with hyperbolic characteristic

hydraulic negative adjustment

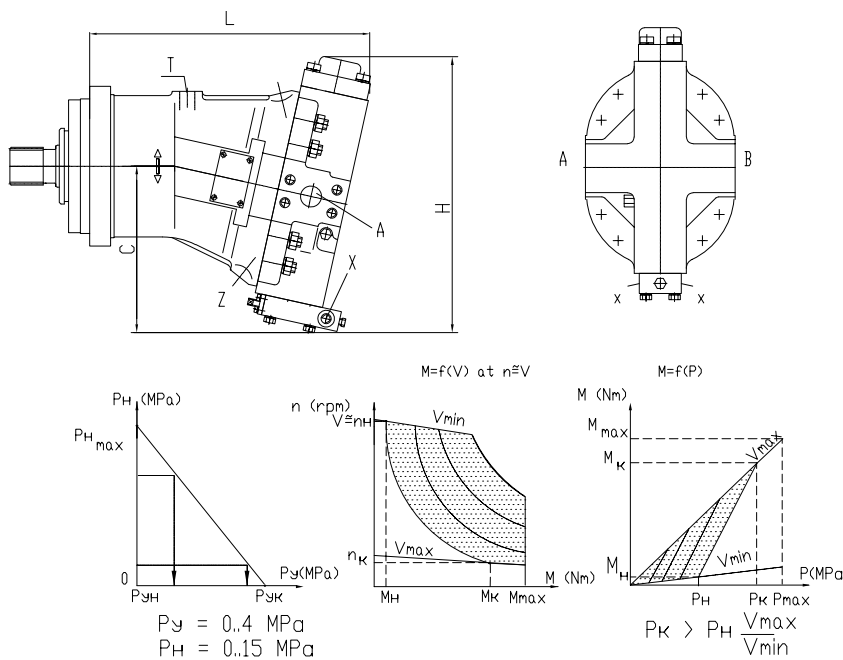
3
4

1
2
3
4

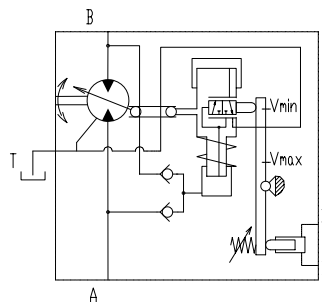
The motor regulator:

- ensures the automatic change of the torque M_{kr} and rotational speed n on variation of the output shaft load;

- changes over the hydraulic motor to operation at the maximal torque M_{kr} and minimal rotational speed n by the control signal independent of pressure in hydraulic system.



Hydraulic motors	L	H	C
303...55.	290	303	181
303...56. ...	269	259	181
303...80....	320	323	194
303...107. ...	336	327	197
303...112.	320	285	194
303...160. ...	374	396	225



T – to connect with drain line (see section 1 Drain pipeline assembly diagram)

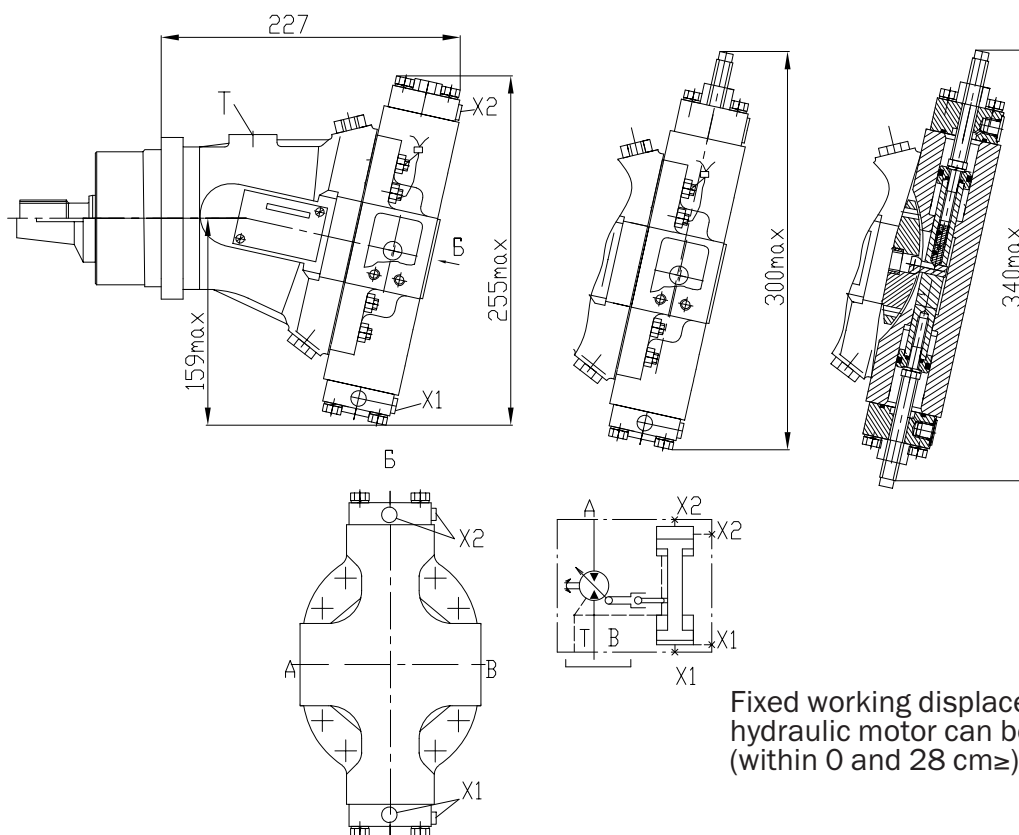


Hydraulic motor with direct displacement control
Delivery sets of hydraulic motors with above mentioned regulation type:

		303	.	2	.	28	.	0	7	.	0	.	0
Hydraulic motors													
version													
with working displacement: 28 cm ³													
regulation mounting 0°													
without working displacement limitation screw		0											
or with V _{min} limitation screw		5											
or with V _{max} limitation screw		7											
or with V _{min} and V _{max} limitation screws		9											
with direct displacement control													
Absent control		0											
Direct control:												AB	
multi-sided double-chambered piston												C	
multi-sided one chamber piston													
equilateral double-chambered piston													
Reversible rotation, splined shaft												0	
keyed shaft												1	

The hydraulic motor 303.2.28. 7 is intended to change the hydraulic motor displacement by applying pressure into one of the regulator piston chambers (line X1) and releasing pressure in another chamber

The hydraulic motor can be adjusted to constant working displacement (within the range between 0 and 28 cm³) as a fixed displacement motor.



Fixed working displacement of the hydraulic motor can be set by screws (within 0 and 28 cm³)

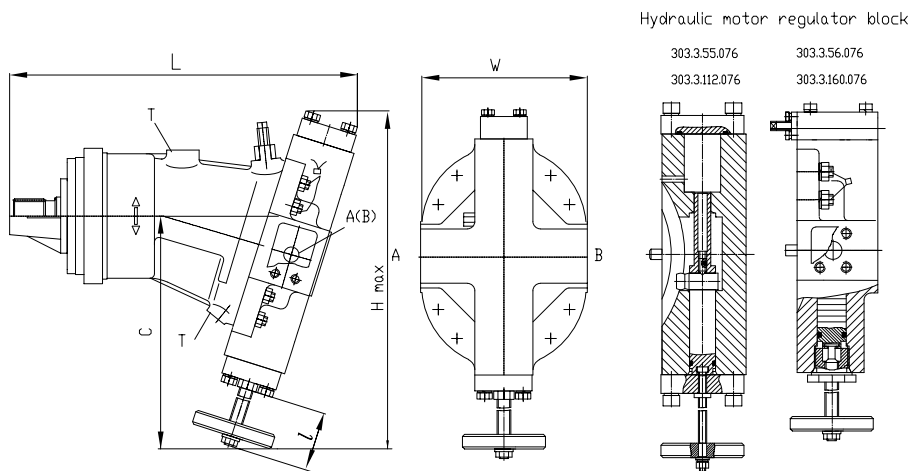
T – to connect with drain line (see section 1 Drain pipeline assembly diagram)



Hydraulic motor with mechanical displacement control
Delivery sets of hydraulic motors with above mentioned regulation type:

303	.	3	.	55	.	0	7	6
Hydraulic motors								
with roller conical bearings		3						
or with bimetal cylinder block		4						
with roller bearings (only with 12 and 28 cm ³ displacement)		2						
with working displacement: 12, 28, 55 or 56, 107, 112, 160 cm ³								
regulation mounting 0°								
without working displacement limitation screw							0	
or with V _{min} limitation screw							5	
or with V _{max} limitation screw							7	
or with V _{min} and V _{max} limitation screws							9	
regulation mounting 180°								
without working displacement limitation screw							1	
or with V _{min} limitation screw							2	
or with V _{max} limitation screw							3	
or with V _{min} and V _{max} limitation screws							4	
no regulation								
mechanical regulation – shift by rotary movement								

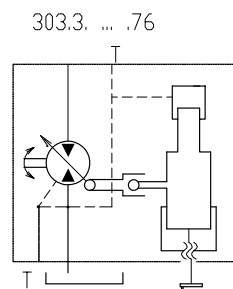
The regulator of the hydraulic motor with direct rearrangement changes the effective torque and motor rotational speed by an external mechanical action.



T – to connect with drain line (see section 1 Drain pipeline assembly diagram)

Hydraulic motors	L	H	C	W	I
303.2.12	252	230	155	90	31,5
303.2.28	322	320	217	132	42
303...55.	280	374	256	155	55
303...56.	370	300	210	154	40
303...107. ...	432	420	298	178	65
303...112. ...	430	358	256	186	65
303...160. ...	470	475	320	206	80

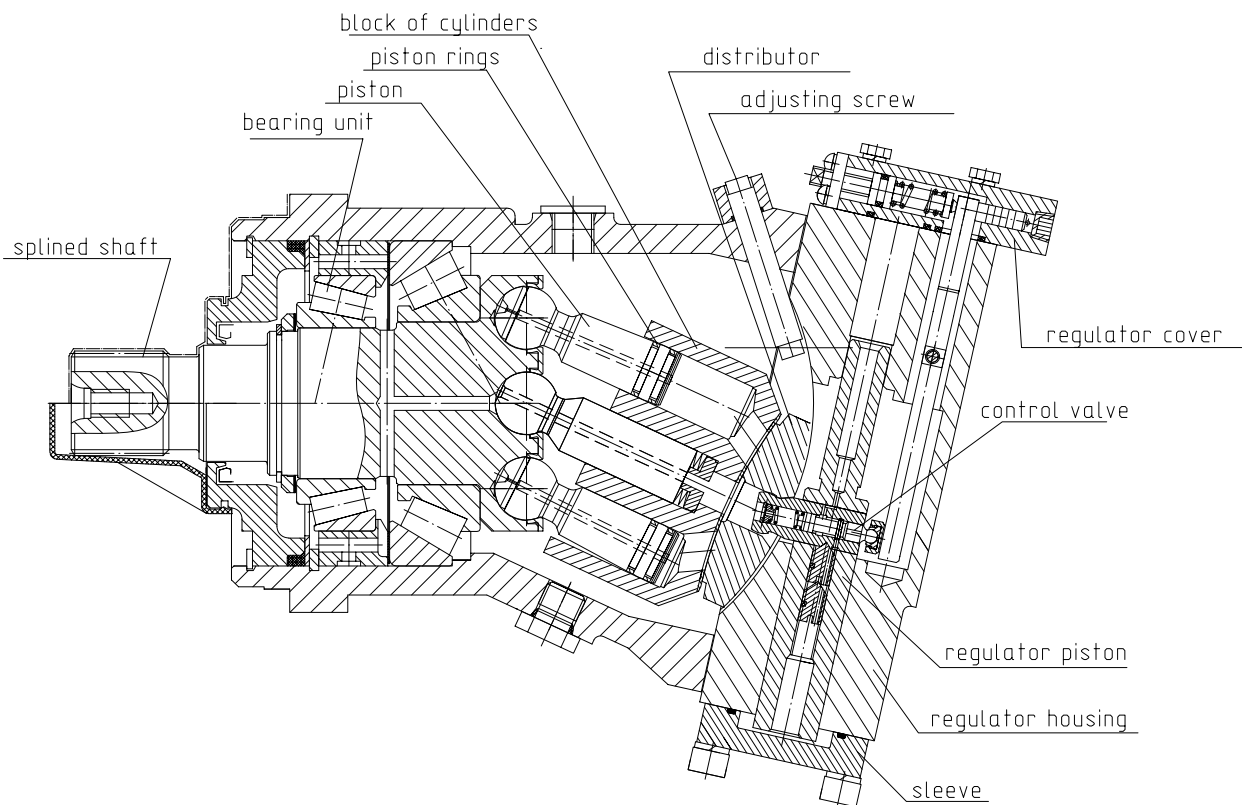
Hydraulic circuit





Design and operation principle of variable displacement axial-piston motor 403 series is similar to motor 303 series, except the design of rod-piston unit of the pump rotary group. The piston is conical with two spherical heads. With one spherical head rod rests on shaft, the second spherical head of the

shaft is in the block of cylinders moving progressively in block of cylinders. Sealing is ensured by two piston rings of compression type. The present design of piston unit allows to decrease weight and pump dimensions, to increase max working pressure and rotation speed of drive shaft.



Technical characteristics

Max working pressure:

- continuous 400 bar
- peak 450 bar

Parameter	403.0.107		
Working displacement	Vg_{max} Vg_{min}	cm ³	107 0
Rotation speed	n_{min} n_{max}	min ⁻¹	3550 5600 6300
max at Vg_{max} max at $Vg < 68 \text{ cm}^3$ max at Vg_n			
Input pressure	Dp_{max}	bar	450
Max total input and output pressure	p	bar	700
Max feed	Q_{Vmax}	l/min	380
Max power	N_{max}	kW	100
Max torque at $Dp_{max} = 450 \text{ bar}$	M_{max}	NMm	750
Weight (without working fluid)	m_{max}	kg	45



Designation structure diagram of variable displacement hydraulic motor 403 series

403			
Variable displacement hydraulic motor 403 = series		Climatic version and category of disposition	55 107
		NBR	M M
		FKM	F F
Hydraulic motor version 0 = basic 1 = mounted in 1)		Special functions NN = absent*	55 107 M M
Working displacement 055 = 55 cm /revolution 107 = 107 cm /revolution		Regulation type	55 107
Rotation sense W = reversible		B - absent, fixed working displacement	F F
Shaft version	55 107	H1 - = hydraulic direct equilateral two-chambered piston	F F
A1 = splined W30x2x30x14x9g DIN5480	F -	H2 - = hydraulic direct versatile two-chambered piston	F F
A2 = splined W35x2x30x16x9g DIN5480	M -	H3 P = hydraulic direct, one-chambered	F F
A3 = splined W40x2x30x18x9g DIN5480	- F	H3 N = hydraulic direct, one-chambered	F F
A4 = splined W45x2x30x21x9g DIN5480	- M	H4 P = hydraulic 2-positional	F F
A5		H4 N = hydraulic 2-positional	M M
A6		H5 P = hydraulic proportional	F F
Z1 = keyed 30k6 A8x7x50 DIN 6885	F -	H5 N = hydraulic proportional	F F
Z2 = keyed 40k6 A12x8x63DIN 6885	- F	HA1 = automatic, with pressure regulator	F F
Connection of working lines	55 107	HA2 = automatic, with pressure regulator on hyper-bola	F F
F1 0 = 2 flanges on end	M M	E1 P = electric, 2-positional, 12V	F F
F1 1 = 2 flanges on end	F F	E1 N = electric, 2-positional, 12V	F F
F2 0 = 2 flanges on each side	F F	E2 P = electric, 2-positional, 24V	F F
F3 0 = 2 flanges sideways	F F	E2 N = electric, 2-positional, 24V	F F
F3 1 = 2 flanges sideways	F F	E3 P = electric proportional (by voltage)3)	F F
F3 2 = 2 flanges sideways	F F	E3 N = electric proportional (by voltage)3)	F F
Mounted in hydraulic valve equipment		E4 P = electric proportional (by voltage)3)	F F
0 = absent		E4 N = electric proportional (by voltage)3)	F F
1 = rinsing block		M1 P = mechanical, proportional to pushers motion	F F
2 = check-safety valves		M1 N = mechanical, proportional to pushers motion	F F
Mechanical limitation of working displacement 2)	55 107	M2 P = mechanical, proportional to arm turn	F F
VN = absent	M M	M2 N = mechanical, proportional to arm turn	F F
V1 = limitation of Vmin	M M	N P = shift by progressive motion	F F
V2 = limitation of Vmax	F F	P1 N = shift by progressive motion	F F
V3 = limitation of Vmin and Vmax	F F	P2 P = shift by rotary motion	F F
		P2 N = shift by rotary motion	F F
Regulation		Additional regulation	55 107
P - positive		G1 = regulator feed from outer source	F F
N - negative		T1 = additional hydraulic regulation (only for HA1, HA2)	F F
		U1 = additional electric regulation 12V (only for HA1, HA2, HA5)	F F
		U1 = additional electric regulation 24V (only for HA1, HA2, HA5)	F F
		Cut-off valve	55 107
		C1 = pressure cut-off valve	F F
		C2 = cut-off valve in regulation line	F F
		C3 = cut-off valve (for hydraulic motor without regulation)	F F

M – basic version

F – possible version

- – not manufactured version

* - not to be filled in at order of these versions

1) – cartridge type hydraulic motor

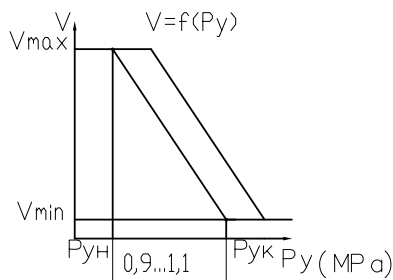
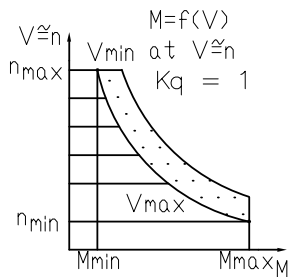
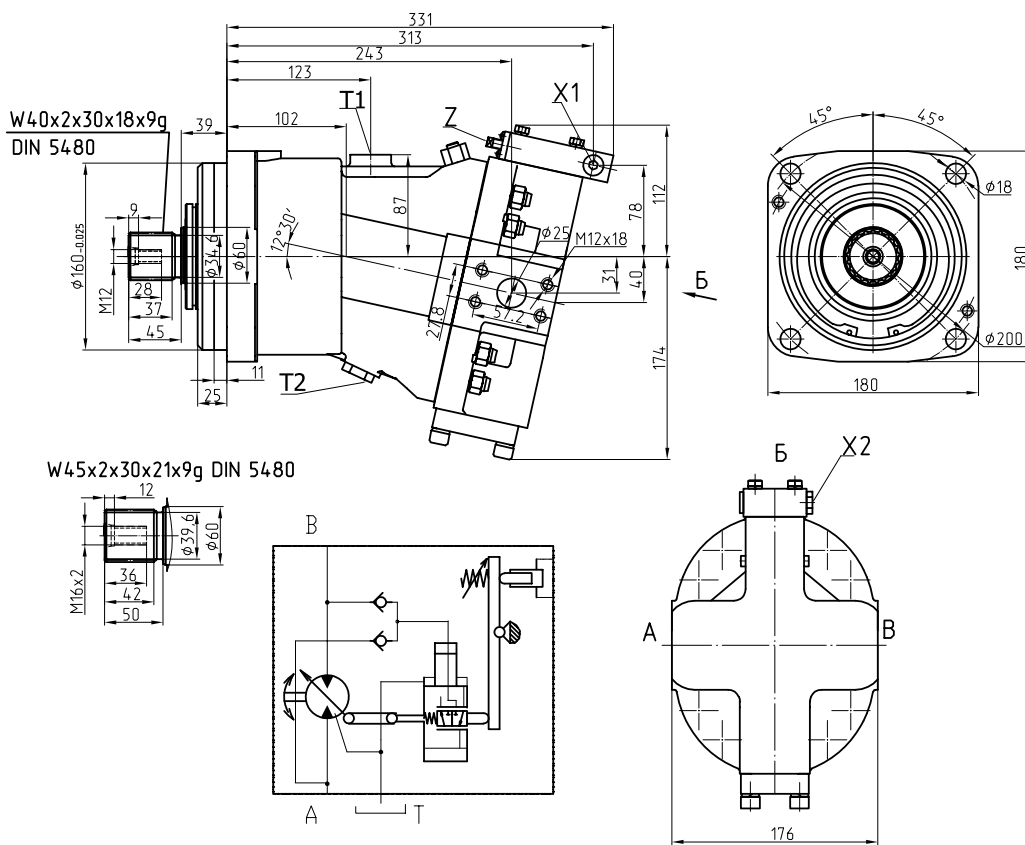
2) – limitation value of Vmin and Vmax is agreed in Delivery Contract

3) – voltage of electric block 12...30V



Variable displacement axial-piston hydraulic motor with proportional regulation and hydraulic negative adjustment

	403	.	0.	107.	W.	A3.	F2	0.	V1.	H5	N.	
hydraulic motor – series												
basic hydraulic motor												
working displacement												
reversible												
shaft version = splined W40x2x30x18x9g DIN5480							A3					
= splined W45x2x30x21x9g DIN5480							A4					
connection of working lines - 2 flanges on each side												
mounted in hydraulic valve equipment - absent												
limitation of working displacement Vmin												
regulation type – hydraulic proportional												
negative												



$P_{yH} = 0,6..1,0 \text{ MPa}$
 $P_{yK} = 1,6..2,0 \text{ MPa}$



Variable displacement axial-piston hydraulic motor with proportional regulator, hydraulic negative adjustment, with safety-charge valves and possibility to dock brake valve

	403	0	107	W	A3	F2	2	V1	H5	N
hydraulic motor – series										
basic hydraulic motor										
working displacement										
reversible										
shaft version = splined W40x2x30x18x9g DIN5480					A3					
= splined W45x2x30x21x9g DIN5480					A4					
connection of working lines - 2 flanges on each side										
mounted in check-safety valve										
limitation of working displacement V_{min}										
regulation type – hydraulic proportional										
negative										

