Black Bruin

Product Manual
S series

Contents

1 General Instructions

1.1 About the manual

This manual contains the technical instructions for the Black Bruin S series hydraulic motors. Take these instructions into consideration when planning the use of the product.

All information given in this manual is current and valid according to the information available at the time of publication. The manufacturer reserves the rights to implement changes without prior notice.

Please visit www.blackbruin.com for the most recent version of this manual. The product datasheets and the 3D-models are available from the manufacturer by request.

1.2 Intended use

Black Bruin S series hydraulic motors are designed for industrial use. They can also be used in other applications that use torque for rotary motion.

1.3 Warranty

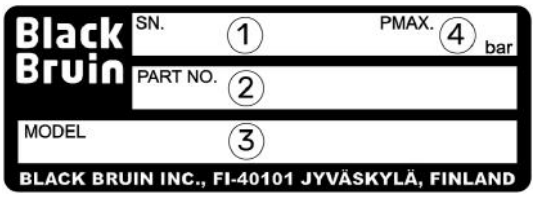
Check the package and the product for transport damage when receiving goods. The package is not meant for long term storage; protect the product appropriately.

Do not dismantle the product. The warranty is void if the product has been disassembled.

The manufacturer is not responsible for damages resulting from misinterpreted, non-compliance, incorrect, or improper use of the product that goes against the instructions given in this document.

1.4 Product identification

The product identification data can be found on the identification plate attached to the motor.



1. Serial number
2. Part number
3. Model
4. Maximum allowed operating pressure

Figure 1. Identification plate of the motor.

Note:

The serial number is also stamped on the motor. All manufacturing data can be found with the serial number.

1.5 Publication date

08.08.2023 - This manual is published.

1.6 Declaration of incorporation

Black Bruin

DECLARATION OF INCORPORATION 1(1)

2022-01-13

Black Bruin Inc.

DECLARATION OF INCORPORATION (in accordance with EC Machinery Directive 2006/42/EC, Annex II B)

Manufacturer	Black Bruin Inc.
Address	Valmetintie 9 FI-40420 Jyskä, FINLAND
Product description	Black Bruin hydraulic motor series: ▪ **BBC** ▪ **BB** ▪ **B100** ▪ **B200** ▪ **C200** ▪ **S** We hereby declare that the product(s) specified above is intended to be incorporated into machinery or to be assembled with other machinery to constitute machinery covered by EC Machinery Directive 2006/42/EC, as amended. And that the following harmonised standards have been applied: ▪ **EN ISO 4413:2010** (Hydraulic fluid power - General rules and safety requirements for systems and their components) ▪ **EN ISO 12100:2010** (Safety of machinery – General principles for design – Risk assessment and risk reduction) And furthermore declares that the product(s) covered by this declaration must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of EC Machinery Directive 2006/42/EC. The product(s) must be applied and installed in accordance with all the technical documents applicable to the product(s). This document supersedes all previous releases to this subject.
Place and date	Jyväskylä, 2022-01-13 On behalf of Black Bruin Inc.
Name Title	Tero Ylä-Mononen R&D Manager

BLACK BRUIN INC.
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2 Safety Instructions

The following instructions apply to all procedures associated with the motor. Read these instructions carefully and follow them closely.

- Use necessary personal protective equipment when working with the motor.
- Support the motor properly. Make sure the motor cannot fall over or turn around by accident.
- Use only appropriate equipment and attachments for lifting and transferring the motor.
- Do not use magnetic lifting devices.
- Always use the lifting equipment properly and check the load-bearing capacity.
- Prevent unintended use of the motor during installation and maintenance procedures by preventing pressurization of the hydraulic lines.
- The operating temperature of the motor may be over 60 °C (140 °F), which is hot enough to cause severe burns. Beware of hot hydraulic fluid when disconnecting the hydraulic connections.

2.1 Warning symbols

The following symbols are used in this manual:

Note:

Useful information.

Danger:

Danger of death or injury.

Attention:

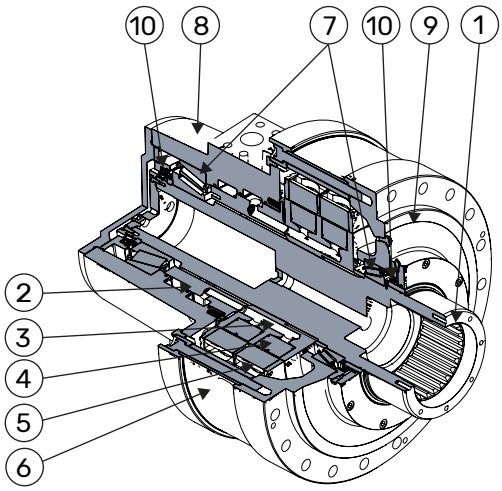
May cause damage to the product.

3 Motor Description

3.1 Working principle

S series motors are rotating shaft motors. This means the motor shaft and the cylinder block rotates while the motor is running.

S series motors can be equipped with a holding brake.



1. Shaft
2. Distribution valve
3. Cylinder block
4. Piston
5. Cam roll
6. Cam ring
7. Bearings
8. Housing
9. Cover
10. Shaft sealing

Figure 2. The main components of the S series motor.

The rotation of the motor is achieved by feeding pressurized hydraulic fluid through the working lines to the distribution valve. The distribution valve directs the flow to the pistons which are on a power stroke. Pressure pushes the pistons and cam rolls outwards against the cam ring on the housing. The waveform of the cam ring transforms the force into torque. When the pistons reach the end of the power stroke, the distribution valve closes the flow to the pistons and switches the pistons to a return stroke. The cam ring pushes the pistons back into the cylinder block preparing them for the next power stroke.

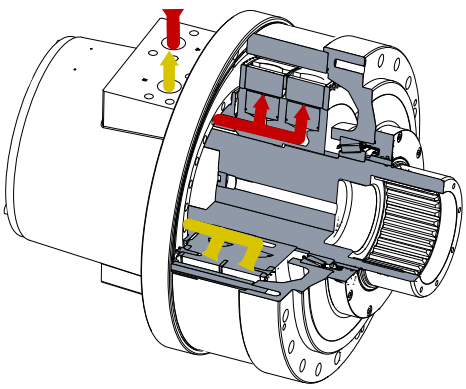


Figure 3. Flow to and from the pistons.

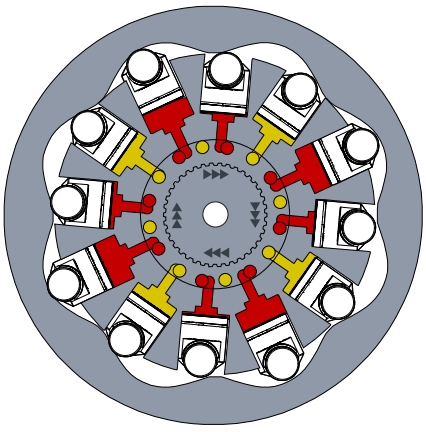


Figure 4. Cylinder block, cam ring and pistons.

3.2 Product identification code

Black Bruin product identification code consists of motor model code and processing ID.

S2100-1000-2N0L-4A-0	-	**1 1 0 0 0 0**
Motor model code	-	Processing ID

3.2.1 Motor model code

MODEL CODE	**AAAAA - BBBB - CCCC - DD - E**
Rotating shaft motors	

A: Frame	**AAAAA -BBBB-CCCC-DD-E**	**S1000**	**S2000**	**S3000**	**S3010**
S series frames	S1000	●			
	S2000		●		
	S3000			●	
	S3010				●

B: Displacement	**AAAAA-BBBB-CCCC-DD-E**	**S1000**	**S2000**	**S3000**	**S3010**
S1000 displacements	0440 : 4400 ccm/rev	●			
	0630 : 6300 ccm/rev	●			
S2000 displacements	0880 : 8800 ccm/rev		●		
	0990 : 9900(/6300) ccm/rev (asymmetrical)		●		
	1100 : 11000 ccm/rev		●		
S2000/S3000/S3010 displacements	1320 : 13200 ccm/rev		●	●	●
	1500 : 15000 ccm/rev		●	●	●
S3000/S3010 displacements	1485 : 14850(/9450) ccm/rev (asymmetrical)			●	●
	1760 : 17600 ccm/rev			●	●
	1890 : 18900 ccm/rev			●	●
	2250 : 22500 ccm/rev			●	●

C: Displacement control	**AAAAA-BBBB-CCCC-DD-E**	**S1000**	**S2000**	**S3000**	**S3010**
1-speed	1N00 : Fixed displacement	●	●	●	●
2-speed valve	2N0R : Right side - CW preferred	●	●	●	●
	2N0L : Left side - CCW preferred	●	●	●	●

D: Shaft type	**AAAAA-BBBB-CCCC-DD-E**	**S1000**	**S2000**	**S3000**	**S3010**
Internal splines	1A: DIN5480-N140	●			
	1B: DIN5480-N140		●		
	1C: DIN5480-N150		●	●	

D: Shaft type	AAAAA-BBBB-CCCC-DD-E	S1000	S2000	S3000	S3010
	1D: DIN5480-N150		●	●	
	1E: DIN5480-N200				●
Internal splines, through shaft	2A: DIN5480-N150		●	●	
External splines, through shaft	3A: DIN5480-W150		●		
	3B: DIN5480-W180			●	
External splines, solid shaft	4A: DIN5480-W150		●	●	
	4B: DIN5480-W180			●	
Shrink disc	5A		●	●	
	5B				●

E: Housing type	AAAAA-BBBB-CCCC-DD-E	S1000	S2000	S3000	S3010
Mounting threads	0: M24 threads (standard)	●	●	●	●
	1: 1-8 UNC threads	○	○	○	

MODEL CODE	AAAAA - BBBB - CCCC - DD - E
Rotating shaft motors with holding brake	

A: Frame	AAAAA -BBBB-CCCC-DD-E	S1100	S2100	S3100
S series frames	S1100	●		
	S2100		●	
	S3100			●

B: Displacement	AAAAA-BBBB-CCCC-DD-E	S1100	S2100	S3100
S1100 displacements	0440 : 4400 ccm/rev	●		
	0630 : 6300 ccm/rev	●		
S2100 displacements	0880 : 8800 ccm/rev		●	
	0990 : 9900(/6300) ccm/rev (asymmetrical)		●	
	1100 : 11000 ccm/rev		●	
S2100/S3100 displacements	1320 : 13200 ccm/rev		●	●
	1500 : 15000 ccm/rev		●	●
S3100 displacements	1485 : 14850(/9450) ccm/rev (asymmetrical)			●
	1760 : 17600 ccm/rev			●
	1890 : 18900 ccm/rev			●
	2250 : 22500 ccm/rev			●

C: Displacement control	AAAAA-BBBB-CCCC-DD-E	S1100	S2100	S3100
1-speed	1N00 : Fixed displacement	●	●	●
2-speed valve	2N0R : Right side - CW preferred	●	●	●
	2N0L : Left side - CCW preferred	●	●	●

D: Shaft type	AAAAA-BBBB-CCCC-DD-E	S1100	S2100	S3100
External splines, solid shaft	4A: DIN5480-W150	●	●	●

E: Housing type	AAAAA-BBBB-CCCC-DD-E	S1100	S2100	S3100
Mounting threads	0: M24 threads (standard)	●	●	●
	1: 1-8 UNC threads	○	○	○

Code example	S2100 - 1000 - 2N0L - 4A - 0
	A - B - C - D - E
A =	The frame of the motor is "S2100".
B =	The displacement of the motor is 10000 ccm/rev.
C =	In-built 2-speed valve for displacement control. The motor is CCW preferred in 2-speed mode.
D =	The shaft of the motor is solid and it has external slines. Spline type W150.
E =	The thread type for the mounting holes in the housing is M24.

3.2.2 Processing ID

S SERIES PROCESSING ID	R M S P D T

R M S P D T	Lubrication	Definition of factory lubrication
0	= Seal protector is not filled with lubricant. [1]	
1	= Seal protector is filled with lubricant.	

R M S P D T	Painting	Definition of the painted surfaces
0	= No painting	-Motors are protected from corrosion.
1	= Painted	- [2]

R M S P D T	Protection	Definition of the protection for storage/transportation
0	= Default / Not defined [3]	

R M S P D T	Packaging	Definition of the motor package
0	= Default / Not defined [4]	

R M S P D T	Documents	Definition of the printouts to be attached to the delivery
0	= Default / Not defined	

R M S P D T	Testing	Definition of the testing and reporting
0	= Default / Not defined [5]	

Code example	1 1 0 0 0 0
	R M S P D T
R =	The seal protector of the motor is filled with lubricant.
M =	Prime coating. The shaft and hub interfaces of the motor are unpainted.

Code example	**1**	**1**	**0**	**0**	**0**	**0**
S =	Pressure openings and threaded holes of the motor are protected according to general practices of the manufacturer.					
P =	The motor is packaged according to general practices of the manufacturer.					
D =	The documentation delivered with the motor is according to general practices of the manufacturer.					
T =	The motor is tested according to general practices of the manufacturer.					

[1] If necessary, the seal protector is not filled with lubricant at the factory.
[2] Prime coating: HEMPATHANE HS 55610 or equivalent. Tint: glossy black.
[3] Working lines are plugged with metal covers. Other pressure openings and threaded holes are capped with plastic fittings. Hydraulic fluid is drained out.
[4] Delivery on wooden pellet or in plywood box.
[5] The manufacturer keeps test records of every manufactured motor.

3.3 Technical data

TECHNICAL DATA		**S1000**		**S2000**				
Displacement [ccm]								
	at full displacement	4400	6300	8800	9900	11000	13200	15000
	at partial displacement	2200	3150	4400	6300	5500	6600	7500
Maximum torque [Nm] [1]								
	theoretical	31500	45100	63000	70900	78700	94500	107400
	with 100 bar	7000	10000	14000	15900	17500	21000	23900
Max. operating power [kW]								
	at full displacement	175				350		
	at partial displacement	118				235		
Max. rotating speed [rpm] [1]								
	at full displacement	180		130	115	103	86	75
	at partial displacement	180		130	90	103	86	75
	at freewheeling	180				180		
Min. rotating speed [rpm]		3 [3]				3 [3]		
Max. working pressure [bar]								
	peak pressure	450				450		
	intermittent [2]	400				400		
Max. case pressure [bar]								
	average	2				2		
	intermittent [2]	10				10		
Flushing flow [l/min]								
	recommended	3,8 - 5,7				5,7 - 7,6		
	maximum	15				15		
Recommended pilot pressures for 2-speed valve [bar]								

TECHNICAL DATA		S1000	S2000
	at full displacement Y1	0 - 2	0 - 2
	Y2	0 - 50	0 - 50
	at partial displacement Y1	10 - 20	10 - 20
	Y2	0 - 2	0 - 2
Weight [kg]		430 - 448	540 - 618

TECHNICAL DATA		S3000/S3010					
Displacement [ccm]							
	at full displacement	13200	14850	15000	17600	18900	22500
	at partial displacement	6600	9450	7500	8800	9450	11250
Maximum torque [Nm] [1)]							
	theoretical	94500	106300	107400	12600	135300	136000/ 161100 (S3010)
	with 100 bar	21000	23600	23900	28000	30100	35800
Max. operating power [kW]							
	at full displacement	500					
	at partial displacement	335					
Max. rotating speed [rpm] [1)]							
	at full displacement	86	75	75	64	60	50
	at partial displacement	86	60	75	64	60	50
	at freewheeling	180					
Min. rotating speed [rpm]		3 [3)]					
Max. working pressure [bar] [1)]							
	peak pressure	450	450	450	450	450	380/ 450 (S3010)
	intermittent [2)]	400	400	400	400	400	350/ 400 (S3010)
Max. case pressure [bar]							
	average	2					
	intermittent [2)]	10					
Flushing flow [l/min]							
	recommended	7,6 - 9,5					
	maximum	15					
Recommended pilot pressures for 2-speed valve [bar]							
	at full displacement Y1	0 - 2					
	Y2	0 - 50					
	at partial displacement Y1	10 - 20					
	Y2	0 - 2					
Weight [kg]		648 - 738					

TECHNICAL DATA	S1100		S2100				
Displacement [ccm]							
at full displacement	4400	6300	8800	9900	11000	13200	15000
at partial displacement	2200	3150	4400	6300	5500	6600	7500
Maximum torque [Nm] 1)							
theoretical	31500	45100	63000	70900	78700	94500	107400
with 100 bar	7000	10000	14000	15900	17500	21000	23900
Brake torque [Nm]	55000		95000				
Max. operating power [kW]							
at full displacement	175		350				
at partial displacement	118		235				
Max. rotating speed [rpm] 1)							
at full displacement	180		130	115	103	86	75
at partial displacement	180		130	90	103	86	75
at freewheeling	180		180				
Min. rotating speed [rpm]	3 3)		3 3)				
Max. working pressure [bar]							
peak pressure	450		450				
intermittent 2)	400		400				
Max. case pressure [bar]							
average	2		2				
intermittent 2)	10		10				
Flushing flow [l/min]							
recommended	3,8 - 5,7		5,7 - 7,6				
maximum	15		15				
Recommended pilot pressures for 2-speed valve [bar]							
at full displacement Y1	0 - 2		0 - 2				
Y2	0 - 50		0 - 50				
at partial displacement Y1	10 - 20		10 - 20				
Y2	0 - 2		0 - 2				
Brake opening pressure [bar]							
minimum	20		20				
maximum	30		30				
Max. brake releasing displacement [ccm]	1000		1000				
Brake opening pressure leakage [l/min]	< 0,1		< 0,1				
Weight [kg]	748 - 766		850 - 868				

TECHNICAL DATA	S3100
Displacement [ccm]	

TECHNICAL DATA		S3100					
	at full displacement	13200	14850	15000	17600	18900	22500
	at partial displacement	6600	9450	7500	8800	9450	11250
Maximum torque [Nm] [1)]							
	theoretical	94500	106300	107400	12600	135300	136000
	with 100 bar	21000	23600	23900	28000	30100	35800
Brake torque [Nm]		95000					
Max. operating power [kW]							
	at full displacement	500					
	at partial displacement	335					
Max. rotating speed [rpm] [1)]							
	at full displacement	86	75	75	64	60	50
	at partial displacement	86	60	75	64	60	50
	at freewheeling	180					
Min. rotating speed [rpm]		3 [3)]					
Max. working pressure [bar][1)]							
	peak pressure	450	450	450	450	450	380
	intermittent [2)]	400	400	400	400	400	350
Max. case pressure [bar]							
	average	2					
	intermittent [2)]	10					
Flushing flow [l/min]							
	recommended	7,6 - 9,5					
	maximum	15					
Recommended pilot pressures for 2-speed valve [bar]							
	at full displacement Y1	0 - 2					
	Y2	0 - 50					
	at partial displacement Y1	10 - 20					
	Y2	0 - 2					
Brake opening pressure [bar]							
	minimum	20					
	maximum	30					
Max. brake releasing displacement [ccm]		1000					
Brake opening pressure leakage [l/min]		< 0,1					
Weight [kg]		957 - 975					

[1)] These values correspond to the displacement values in the same column.
[2)] Intermittent operation: permissible values for maximum of 10% of every minute.
[3)] Special consideration of the work pressure and the oil properties under 3 rpm is necessary.

3.4 Motor interfaces

3.4.1 Main dimensions

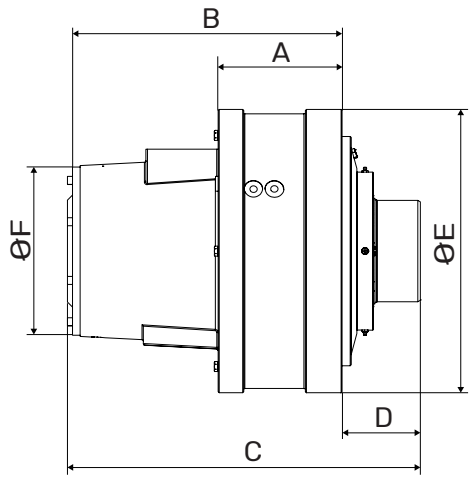


Figure 5. Shaft types 1A, 1B, 1C, 1D, 1E, 4A, 4B and 5A.

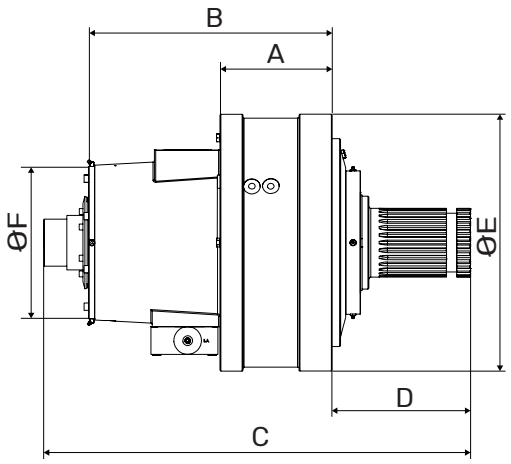


Figure 6. Shaft types 2A, 3A and 3B.

MOTOR TYPE	SHAFT TYPE	MAIN DIMENSIONS [mm]					
		A	B	C	D	E	F
S1000	1A	172	458	552	84	556	330
S2000	1B	243	529	693	154	556	330
	1C	243	529	693	154	556	330
	1D	243	529	740	201	556	330
	2A	243	529	702	154	556	330
	3A	243	529	924	299,5	556	330
	4A	243	529	773	234	556	330
	5A	243	529	769	230	556	330
S3000	1C	314	600	764	154	556	330
	1D	314	600	811	201	556	330
	2A	314	600	773	154	556	330
	3B	314	600	995	299,5	556	330
	4A	314	600	844	234	556	330
	4B	314	600	844	234	556	330
	5A	314	600	840	230	556	330
S3010	1E	314	600	838	228	556	330
	5B	314	600	847	237	556	330

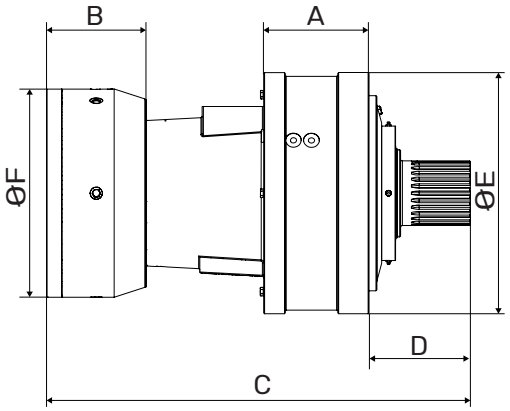


Figure 7. Main dimensions of the motor with brake.

MOTOR TYPE	SHAFT TYPE	MAIN DIMENSIONS [mm]					
		A	B	C	D	E	F
S1100	4A	172	230	907	234	556	480
S2100	4A	243	230	978	234	556	480
S3100	4A	314	230	1049	234	556	480

3.4.2 Dimensions of the 2-speed motors

The 2-speed valve increases the main dimensions of the S series motors.

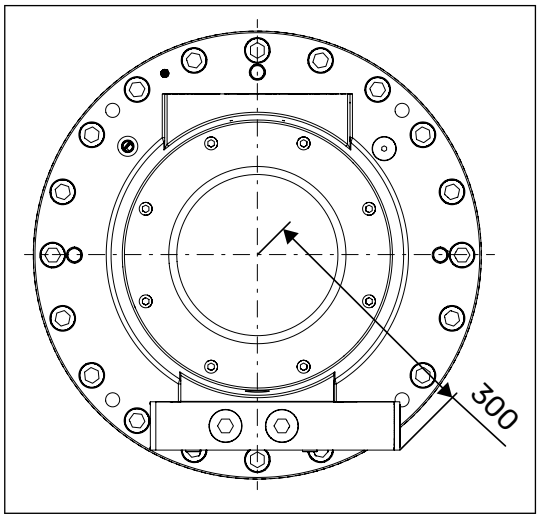


Figure 8. Dimensioning of the 2-speed valve.

3.4.3 Shaft connection

S1000: 1A

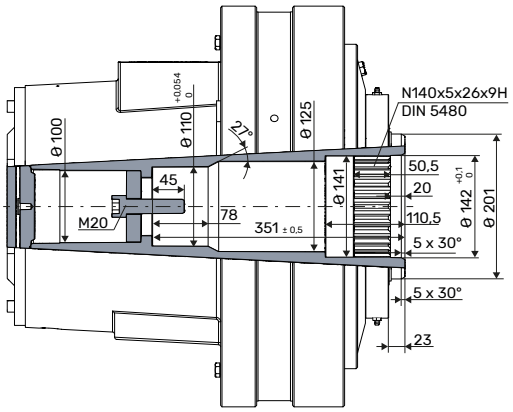


Figure 9. Dimensions of the shaft type 1A: Splines N140.

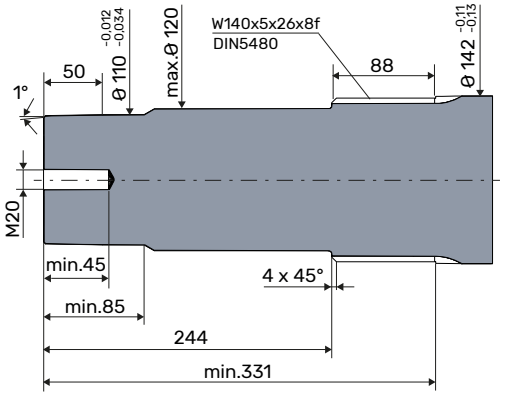


Figure 10. Dimensions of the recommended shaft design for type 1A. Material ex. 42CrMo4.

S2000 / S3000: 1B and 1C

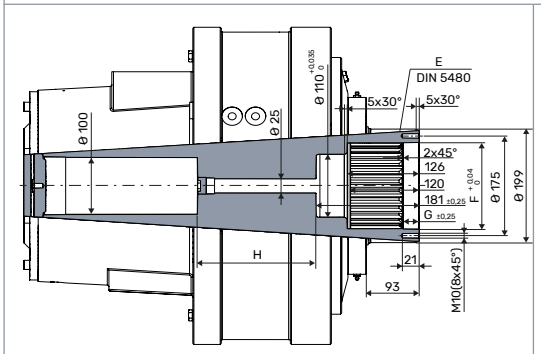


Figure 11. Dimensions of the shaft types 1B and 1C.

S2000 / S3000: 2A

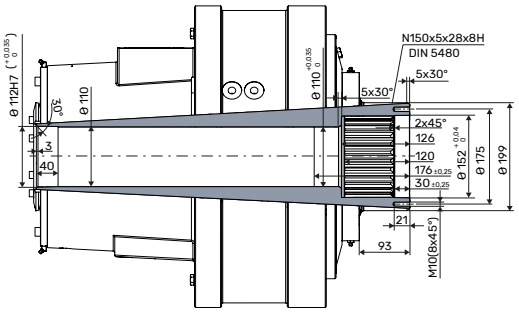


Figure 12. Dimensions of the shaft type 2A: Spline N150.

S2000 / S3000: 1B, 1C and 2A

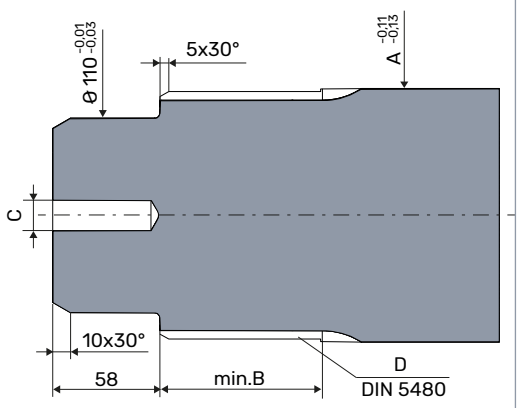


Figure 13. Dimensions of the recommended shaft design for types 1B, 1C and 2A. Material ex. 42CrMo4.

		1B	1C,2A
A	[mm]	ø142	ø152
B min (spline length)	[mm]	89	99
C		Threaded hole for mounting bolt	
D	[mm]	W140x5x26x8f	W150x5x28x8f
E	[mm]	N140x5x26x9H	N150x5x28x8H
F	[mm]	ø142	ø152
G	[mm]	40	30
H	[mm]	207,5	207,5 (S2000) 278,5 (S3000)

S2000 / S3000: 1D

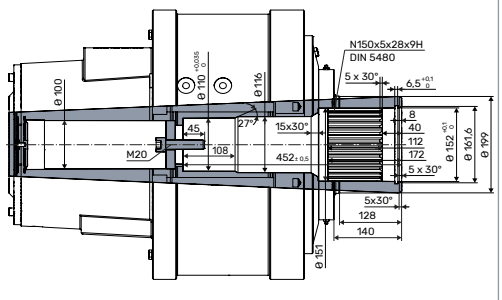


Figure 14. Dimensions of the shaft type 1D. Spline N150.

S2000 / S3000: 1D

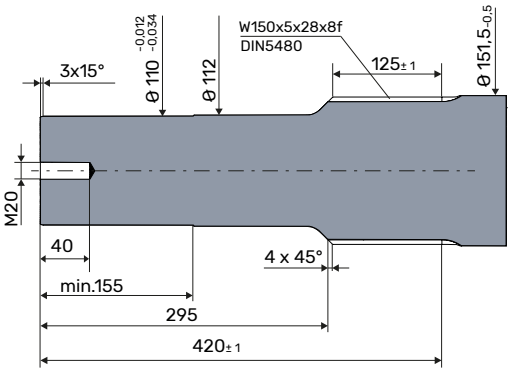


Figure 15. Dimensions of the recommended shaft design for type 1D. Material ex. 42CrMo4.

S3010: 1E

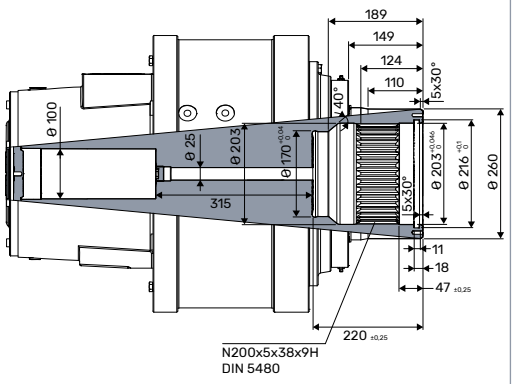


Figure 16. Dimensions of the shaft type 1E.

S3010: 1E

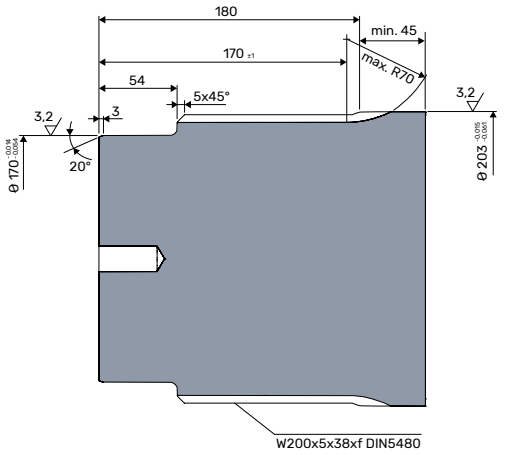


Figure 17. Dimensions of the recommended shaft design for type 1E.

S2000: 3A

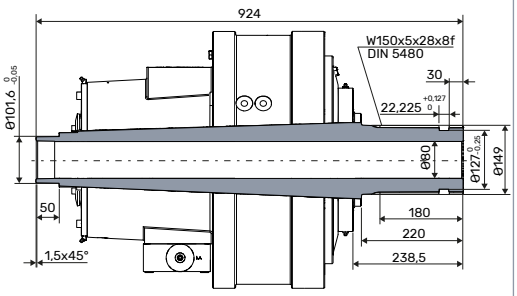


Figure 18. Dimensions of the shaft type 3A, spline W150.

S2000 / S3000: 4A, 4B

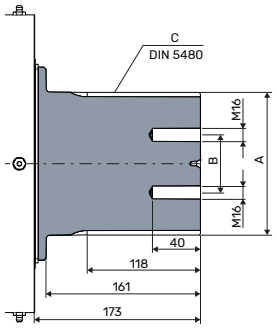


Figure 19. Dimensions of the shaft types 4A and 4B. Shaft W150 / W180.

		S2000 / S3000: 4A	S3000: 4B
A	[mm]	ø 149	ø 179
B	[mm]	60	90
C	[mm]	W150x5x28x8f	W180x5x34x8f

S3000: 3B

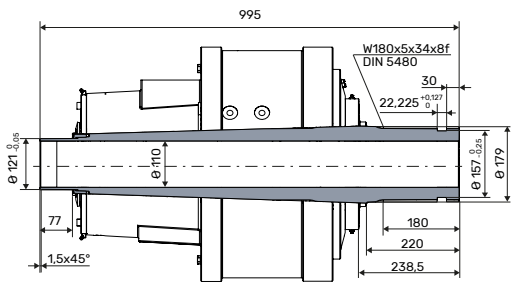


Figure 20. Dimensions of the shaft type 3B, spline W180.

S2000 / S3000: 5A

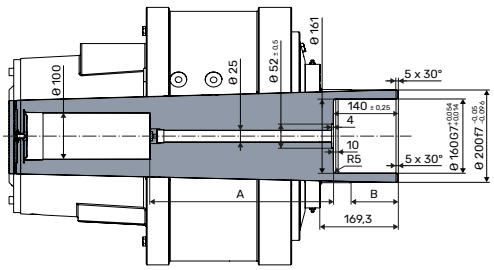


Figure 21. Dimensions of the shaft type 5A, shrink disc.

S2000 / S3000: 5A

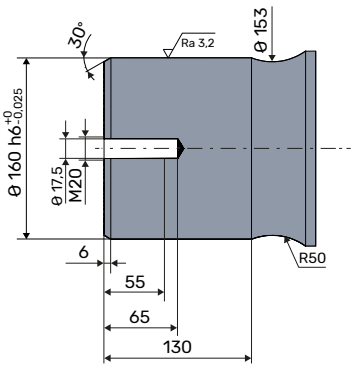


Figure 22. Dimensions of the recommended customer shaft design for type 5A. Material ex. 42CrMo4.

		S2000: 5A	S3000: 5A
A	[mm]	325,15	396,15
B	[mm]	102	123

S3010: 5B	**S3010: 5B**

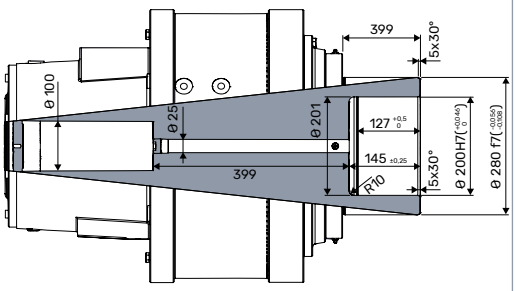
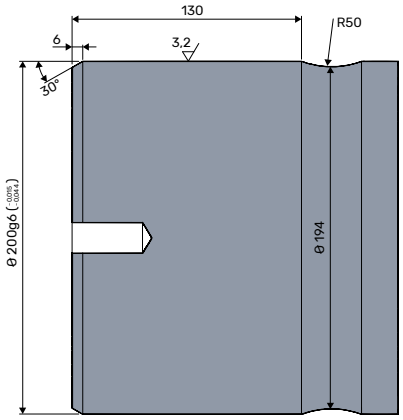

	

Figure 23. Dimensions of the shaft type 5B.	Figure 24. Dimensions of the recommended customer shaft design for type 5B.

3.4.4 Housing interface

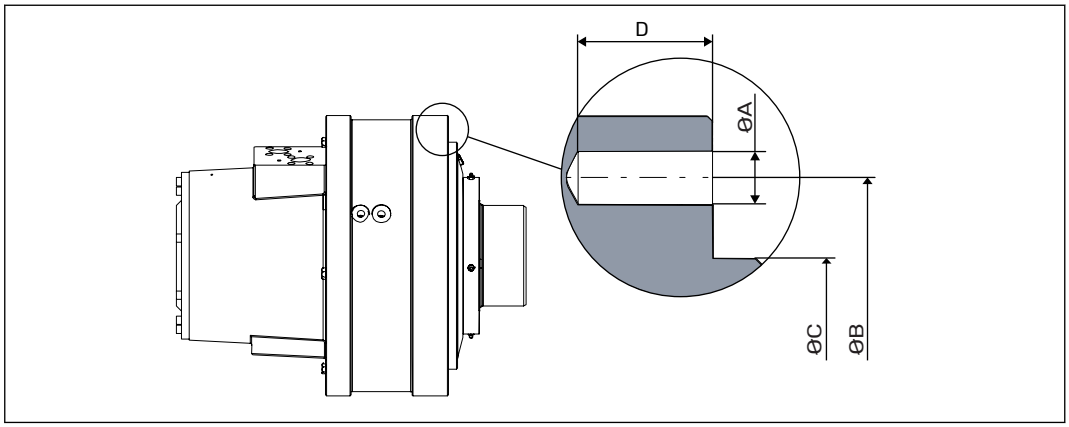


Figure 25. Dimensions of the housing interface.

INTERFACE DIMENSIONS		
Housing interface		
A	size	M24[1)]
	pattern	20x18°
	strength class [2)]	10,9
	tightening torque [3)] [Nm]	930
B	[mm]	510
C	[mm]	450
	tolerance [mm]	0 / -0,15
D	(thread) [mm]	45

[1] M24 thread can be replaced with UNC 1"-8 thread, see model code E.
[2] Strength class as in ISO898-1. If using lower strength class, check interface load capacity and tightening torque.
[3] Declared values are for reference only. Always use application specific tightening torques when given.

Note:

The attachment screws are not included in the motor delivery. Ensure correct dimensioning and availability of the fastening screws.

3.4.5 Torque arm

The motor can be mounted to the application with the torque arm.

The length of the torque arm affects the radial force applied to the motor and thus the service lifetime of the bearings.

Shaft types used for torque arm mounting; 1A, 1B, 1C, 1D, 1E, 2A and 5A. For torque arm mounting, the splines of the shaft connection must be greased or in oil.

When using a double ended torque arm there would not be a radial load applied to the motor due the torque.

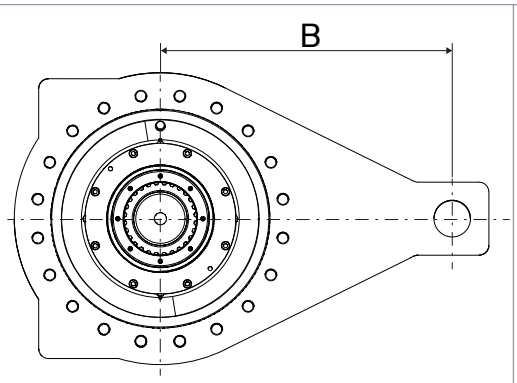


Figure 26. Torque arm length.

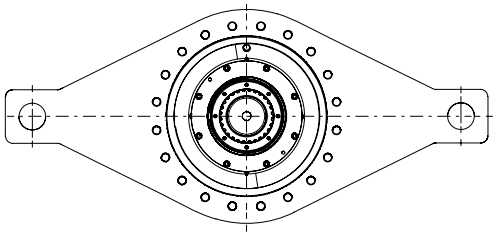


Figure 27. Double ended torque arm.

The minimum length of the torque arm, B:	S1000 = 600 mm S2000 = 800 mm S3000 = 1000 mm

3.5 Rotating direction

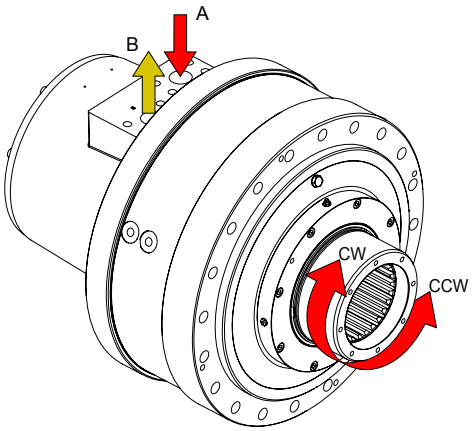


Figure 28. Rotating direction of the motor.

The rotating direction of the motor is defined as the rotating direction of the shaft viewed from the front of the motor.

The rotating direction of the motor and the flow direction in the working lines is given in the table below.

Table 1: Rotating direction and flow direction.

ROTATING DIRECTION	Flow direction	
	A → B	B → A
1N00	CW	CCW
2N0R	CW	CCW
2N0L	CCW	CW

Preferred operating direction

AAAAA	-	BBBB	-	**2N0R**	-	DD	-	E
AAAAA	-	BBBB	-	**2N0L**	-	DD	-	E

The preferred operating direction applies to motors with 2-speed valve block (see *3.8 2-speed valve : 2N0R / 2N0L*).

The preferred operating direction is the rotating direction of the motor when the flow direction is from port A to B.

- **2N0R** = CW motor.
- **2N0L** = CCW motor.

3.6 Freewheeling function

Freewheeling of the S series motors can be done by pressurizing the casing, when the case pressure pushes the pistons into the cylinder block. The case pressure must be at least 0.5 bar higher than the pressure on the working lines (A and B). The maximum case pressure must not be exceeded. The permissible freewheeling

speed and the maximum case pressure can be found in the technical data (see *3.3 Technical data*).

Attention:

Any pressure in the working lines (A and B) or loss of case pressure during the freewheeling pushes the pistons out of the freewheeling position. This causes a clattering noise when the pistons hit the cam ring.

Constant clattering of the pistons may cause premature wear or failure of the motor.

ENGAGING THE MOTOR

Make sure that the motor is not running when engaging the motor. When engaging the motor, the pressure in the working lines must be less than 100 bar to prevent excessive pressure peak in casing, which may damage the shaft seals.

3.7 1-speed : 1N00

AAAAA - BBBB - **1N00** - DD - E

Displacement control selection 1-speed means the motor has a fixed displacement. These motors are known as 1-speed motors and are always in full displacement during operation.

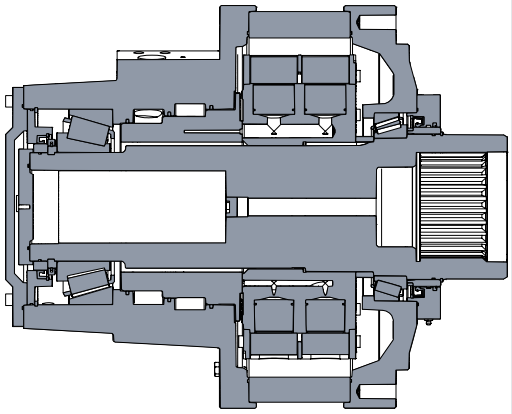


Figure 29. 1-speed motor.

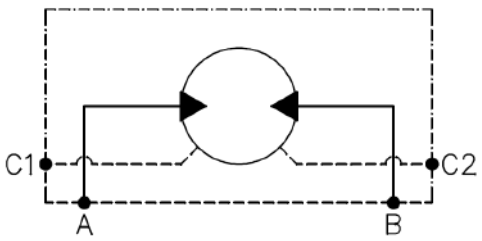


Figure 30. Hydraulic circuit, 1-speed motor.

3.8 2-speed valve : 2N0R / 2N0L

AAAAA - BBBB - **2N0R** - DD - E
AAAAA - BBBB - **2N0L** - DD - E

The 2-speed valve enables change of displacement during operation. The benefit of this function is a more extensive speed range with the same hydraulic system capacity. The motors are also known as 2-speed motors.

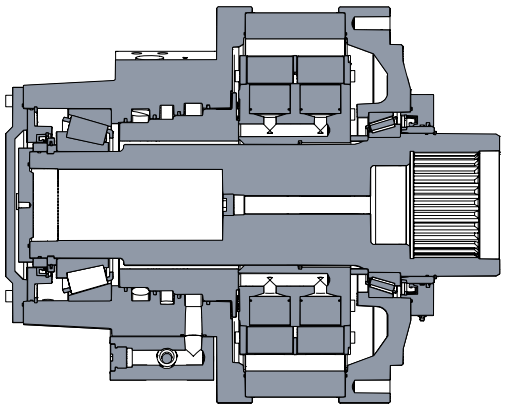


Figure 31. 2-speed motor.

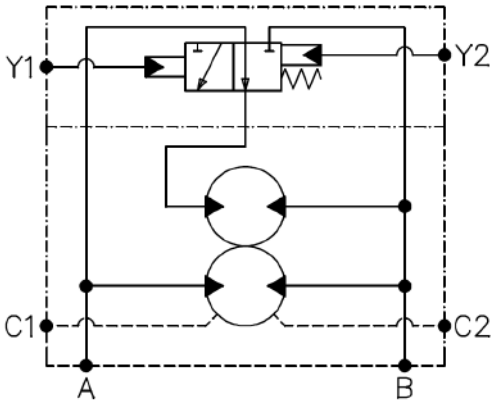


Figure 32. Hydraulic circuit, 2-speed motor.

The change of displacement works by switching the piston to idle on every second stroke. This is done with the in-built 2-speed valve, which changes the fluid circulation in the motor.

USING THE 2-SPEED VALVE

Using the 2-speed valve works in the same manner as gear shifting. In S series there are available symmetrical and asymmetrical camrings. With symmetrical camring the partial displacement in the 2-speed motor is always half of the full displacement. With asymmetrical camring the partial displacement's ratio is something else than 50% of the full displacement. For example with the camring 14850/9450 ccm the full displacement is 14850 ccm and partial displacement is 9450 ccm, cirka 64% from full displacement.

- SHIFTING TO PARTIAL DISPLACEMENT

  The motor is switched to partial displacement by applying the pilot pressure (see *4.4.2 Pilot pressure*) to the pilot line Y1.

  The recommended pressure difference over the pilot lines Y1 and Y2 is 20 bar.

  When the motor is not rotated, pressure difference of 10 bar is enough to engage the 2-speed valve.

  When the motor, with symmetrical 2-speed operates at half displacement, it rotates twice as fast and generates half of the torque when compared to a motor on full displacement with the same flow rate and pressure.

  The working pressure should be primarily applied into the working line A. The motor operates at lower efficiency and the operating temperature may rise if working pressure is applied into the working line B. The motor starting may also be blocked.

- SHIFTING TO FULL DISPLACEMENT

  The motor is switched back to full displacement by releasing the pressure in the pilot line Y1.

  When switching to full displacement during operation, it is recommended to engage the pilot pressure to pilot line Y2 at the same time as the pressure is released from pilot line Y1.

The required pressure difference over the pilot lines Y2 and Y1 can be up to 50 bar depending on the flow rate of the working lines and the hydraulic fluid viscosity.

When switching to full displacement while the motor is stopped, the switching can be done by releasing the pilot pressure from the pilot line Y1. In this case the pilot line Y2 can be connected directly to the drain line.

When the motor operates at full displacement, it works like the 1-speed motor and it may be operated normally on both directions.

Attention:

Take the following things into consideration, when changing the speed range during motion.

- Hydraulic system supply must adjust to the rapid change of flow rate.
- The rapid change in flow rate may cause momentary jerk. This may be avoided by throttling the working lines lightly.
- Prevent operating conditions, in which the permissible performance values could be exceeded.

The permissible performance values are in the technical data (see *3.3 Technical data*).

Attention:

Continuous use of high working pressure in the working line B at half displacement may cause premature wear or failure of the motor.

3.9 Holding brake

The brake used with the S series motors is static brake. Type of the brake is SAHR (Spring Applied, Hydraulics Release) wet multi-disc brake.

Mechanical brake release

- Remove the plug from the center of the brake end.
- Tight the screw (M24) with nut and washer to the bottom of the thread in the piston.
- Then tighten the nut until the motor shaft turns freely, needed torque about 750 Nm.

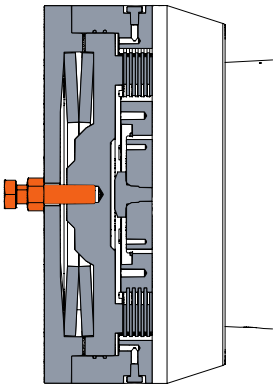


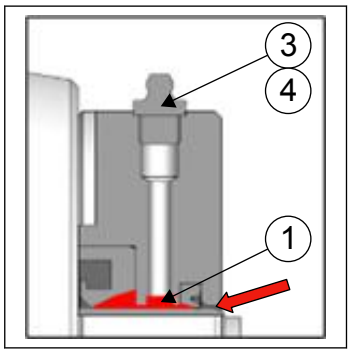
Figure 33. Mechanical brake release.

3.10 Seal protector

The seal protector provides protection for the motor's seal against outside impurities.

- In dirty environment lubricant is needed to add regularly.
- Lubricate the seal protector as part of the vehicle lubrication routine.
- Observe lubrication adequacy during use and increase or decrease lubrication as needed. In clean and dry environment there is no need to add lubrication.
- Add lubricant from both nipples during operation. Add lubricant when the motor is warm.

The lubricant pocket is filled with NLGI-1 lubricant (e.g. Microlube GL 261). Use only compatible lubricants. The lubricant is mineral oil-based grease which is precipitated with lithium-soap.



- Lubricant pocket (1)
- Grease nipple (3)
- Check valve (4): depending on motor model the seal protector may have check valve. Possible drainage of lubricant.
- Possible drainage of lubricant (red arrow)

3.11 Flushing of the motor case

All the S series motors are equipped with the case flushing line port (C1). The flushing line is an extra case line for cooling the motor.

The motor must be cooled to avoid high temperature in the motor case. High temperature can reduce the performance and the lifetime of the motor.

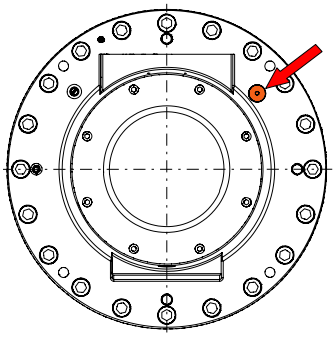
The motor case must be flushed (see recommended flushing flow rate in *3.3 Technical data*) in all continuous duty applications where the output power is over the 50% of maximum power of the motor. The motor case must be flushed also if in application the motor oil temperature exceed the maximum operating temperature (see *7.3 Operating temperature*).

3.12 Accessories

3.12.1 Speed sensor

It is possible to use the speed sensor with all S series motors. The speed sensor and the cable can be ordered separately.

The speed sensor of the S series motors has directional detection and the pulse rate is 100ppr. Technical data of the speed sensor and the cable can be found from the table below.

Sensor item number	0954100800
Pulses per revolution	100
Reading range	0,5-2 mm
Supply voltage	8-32 V
Electrical protection	Reverse polarity
Current consumption	20mA max.
Output type	2 push-pull shifted square frequency signals (phase shift minimum 20°)
Frequency range	0 to 15 kHz
Protection rating	IP68
Material	Stainless steel
Cable length	6 m
Cable item number	0954100801
Cable type	Straight: 
Sensor position	

More detailed sensor installation instructions; see the installation manual of the speed sensor.

3.12.2 Shrink discs

These shrink discs are accessories to motors with shaft type 5A and 5B.

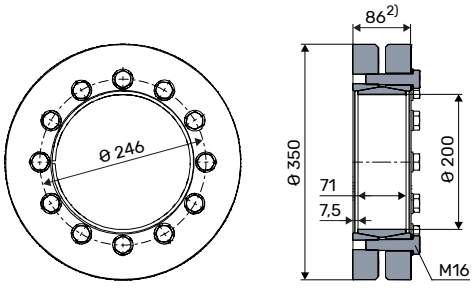


Figure 34. Shrink disc 0908000001 for shaft type 5A

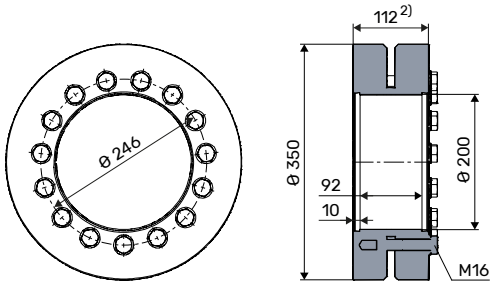


Figure 35. Shrink disc 0908000010 for shaft type 5A

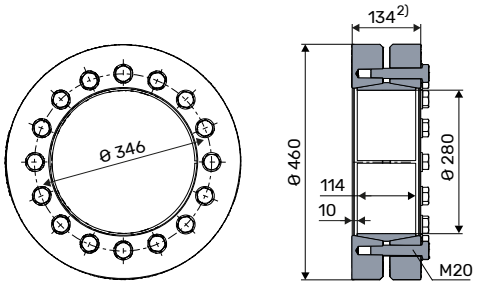


Figure 36. Shrink disc 0908000110 for shaft type 5B

		0908000001	0908000010	0908000110
Locking screws	type	M16 x 70 - strength class 10.9 - DIN 931	M16 x 80 - strength class 12.9 - DIN 931	M20 x 100 - strength class 12.9 - DIN 931
	amount	12 pcs	15 pcs	16 pcs
	max. torque 1)	250 Nm	290 Nm	570 Nm
Shrink disc	max. transmittable torque 1)	88400 Nm	131000 Nm	266000 Nm
	weight	39 kg	51 kg	99 kg
	coating	painted	painted	painted
1) Max. transmittable torque is obtained when locking screws are at max. torque.				
2) Dimension in unlocked position.				

3.12.3 Torque arms

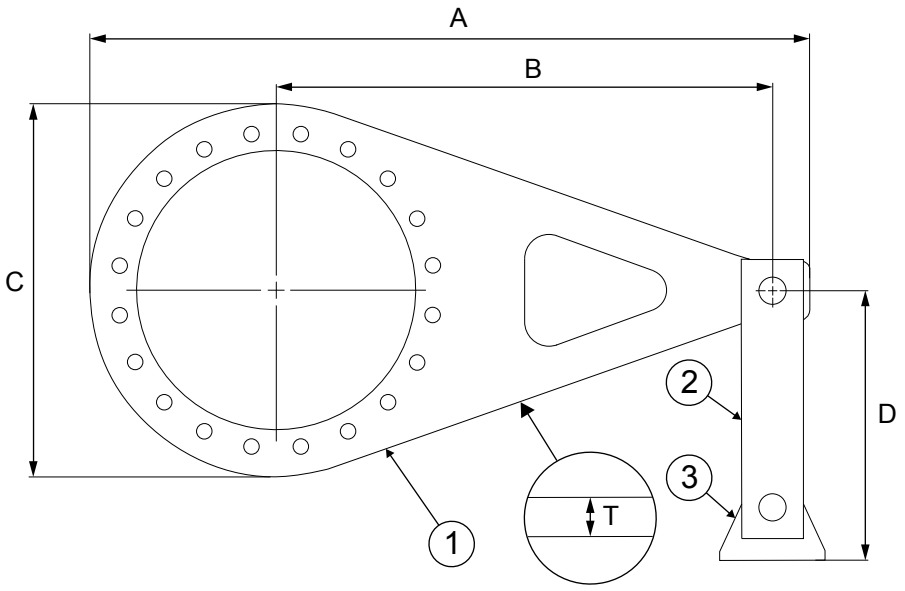


Figure 37. Torque arms L800 and L1000

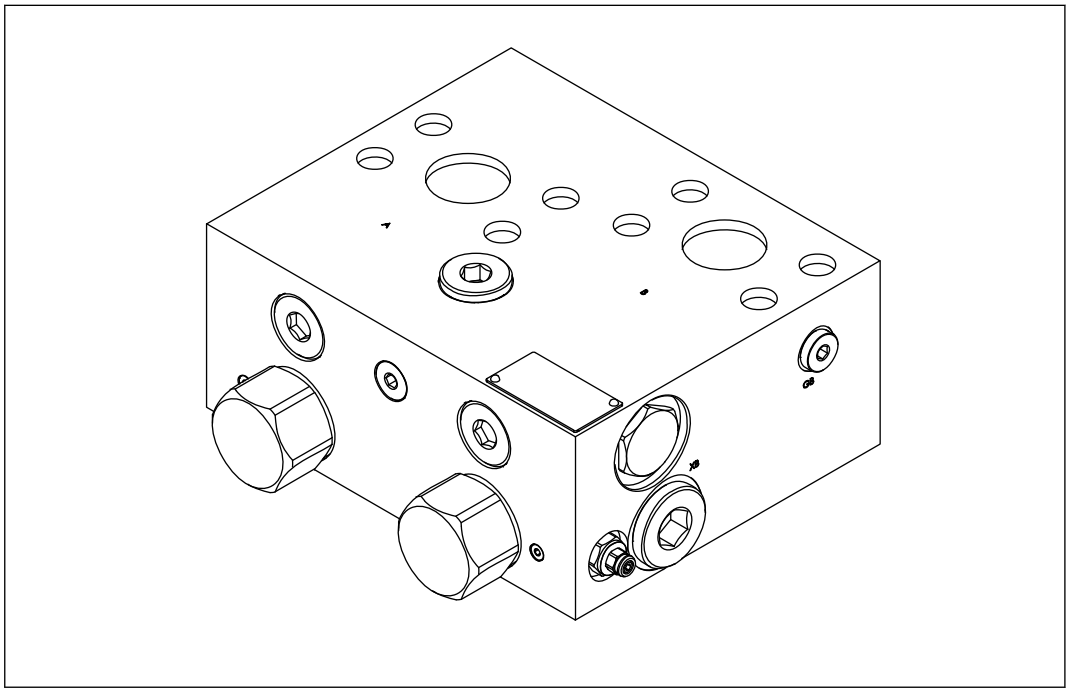
	L800	L1000
A	1160 mm	1360 mm
B	800 mm	1000 mm
C	600 mm	600 mm
D	435 mm	435 mm
T	40 mm	40 mm

Item numbers		
	L800	**L1000**
1	Torque arm N11928	Torque arm N11937
2	Link N11929	
3	Anchor N11930	

Fixing screw set	
Item number	1779000300
Type	M24x80 10.9 ISO 4762
Amount	20 pcs

Washers		
Item number	1779000310	1779000400
Type	24-300HV-ZN ISO 7089	M24 DELTA DIN 25201
Amount	20 pcs	20 pcs

3.12.4 Cross-over relief valve CPV500



CPV500 valve provides cross line relief and cavitation protection.

Features:

- rated flow 500 lpm
- standard pressure setting 320 bar

- mounted directly on motor's work ports
- protects the motor from high pressure peaks.

For more information, refer to the datasheet.

4 System Design

4.1 Motor hydraulic circuit

4.1.1 Simple connection

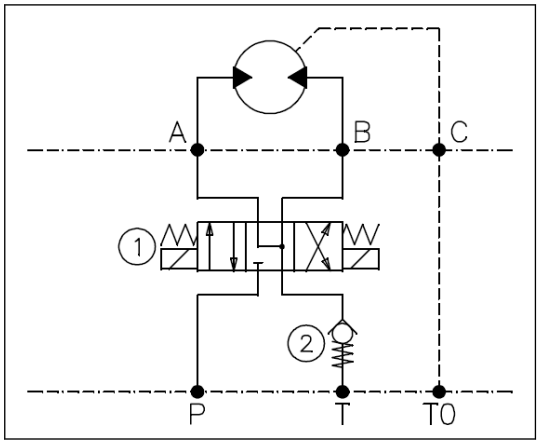


Figure 38. A simple motor hydraulic circuit in an open loop hydraulic system.

In an open loop hydraulic system the hydraulic circuit of the motor is usually implemented roughly as in the figure above.

- Select the operating direction with the directional control valve (1) by applying the working pressure (P) to the other working line (A or B).
- The minimum pressure (see *4.4.3 Working line pressure*) required in the return line (T) is created with the cracking pressure of the check valve (2).
- The case drain line port (C) is connected to the system reservoir (T0) as directly as possible.

Attention:

The case drain line of the motor must always be connected to a reservoir, even during freewheeling. The case pressure of the motor may rise significantly, if the motor is completely plugged during use.

Note:

Using the motor on a closed loop hydraulic system is different from the open loop system. The closed loop system is more complex, but enables more functions, such as hydrostatic braking, series connection and counter pressure operation.

4.1.2 Counter pressure operation

Counter pressure operation means using the motor with high back pressure in the return line.

The counter pressure operation affects the torque output of the motor due to decreased pressure difference over the working lines.

High counter pressure affects also to the motor efficiency.

Attention:

Make sure the combined pressure in the working lines does not exceed the permissible values of the working pressure during counter pressure operation.

Counter pressure operation is not recommended for S series motors, because high back pressure stresses the motor more than usual operation.

4.1.3 Hydrostatic braking

Hydrostatic braking means using the output torque of the motor to decelerate the speed. The output torque is generated by closing the return line of the motor, in which case a working pressure will form in the return line. The minimum pressure and feed flow must be maintained in the feed line of the motor during hydrostatic braking.

Note:

The hydrostatic braking requires an active hydraulic fluid supply.

Danger:

Do not use the hydrostatic braking without relief valves in the working lines. When an external load is rotating the motor, the hydraulic pressure may increase indefinitely. This leads to danger if a hydraulic hose or component brakes under high pressure.

4.1.4 Short circuit operation

Short circuit operation means connecting the return flow of the motor directly to the feed line of the motor.

Short circuit operation is needed, if the motor must be rotated faster than the hydraulic system can supply and freewheeling the motor is not possible (see *3.6 Freewheeling function*).

Make sure the minimum pressure is maintained in both working lines of the motor during short circuit operation.

Note:

The short circuit operation requires an active hydraulic fluid supply.

Attention:

Make sure the motor does not overheat during short circuit operation.

4.2 Hydraulic connections

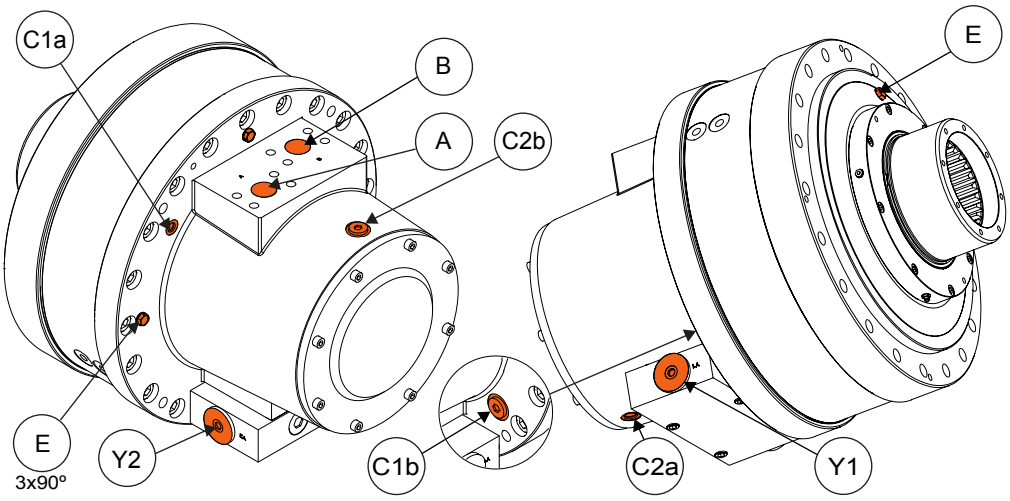


Figure 39. The hydraulic connections of the 2-speed motor.

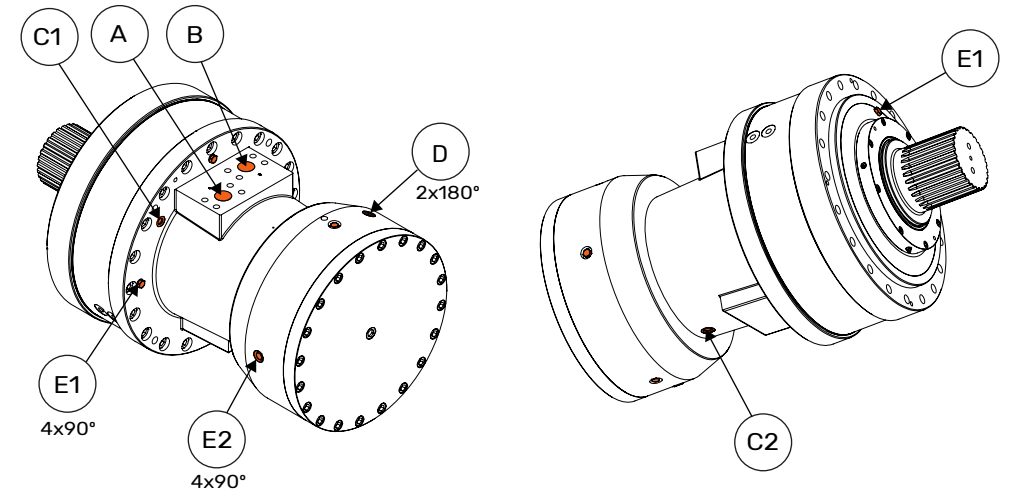


Figure 40. The hydraulic connections of the 1-speed motor with brake.

- WORKING LINE PORTS (A and B)

  The working lines, aka the feed and return lines of the motor are the high pressure lines meant for running the motor.

- FLUSHING LINE PORT (C1, C1a and C1b)

  The flushing line is the motor housing flushing inlet line.

- CASE DRAIN LINE PORT (C2, C2a and C2b)

  The case drain line is the return line from the housing cavity.

- BRAKE LINE PORTS (D)

  The brake lines are ment for the brake releasing pressure.

There are two ports for the brake so you can choose one of them and plug the other one.

- AIR BLEEDING SCREWS (E/E1)

  The air bleed screws are meant for removing the air inside the housing during air bleeding procedure (see *6.3 Air bleeding procedure*).

- AIR BLEEDING SCREWS (E2)

  The air bleed screws are meant for removing the air inside the brake during air bleeding procedure (see *6.3 Air bleeding procedure*).

- PILOT LINE PORTS (Y1 and Y2)

  The pilot lines are meant for controlling the 2-speed valve of the motor (see *3.8 2-speed valve : 2N0R / 2N0L*).

Note:

More detailed information and dimensioning can be foundon the product datasheet.

4.3 Hydraulic fluid

4.3.1 Hydraulic fluid type

Black Bruin hydraulic motors are designed to work with hydraulic fluids based on mineral oil. Consider the following requirements when choosing hydraulic fluid:

- Hydraulic oils in accordance with ISO 6743-4 are recommended to be used.
- Motor oils in accordance with API-grades SF, SG, SH and SL may also be used.
- Fire resistant hydraulic fluids HFB and HFC or similar may be used under certain circumstances.

4.3.2 Hydraulic fluid properties

Requirements concerning the hydraulic fluid properties:

- The recommended fluid viscosity range for constant use is 25 - 50 cSt.
- The minimum permissible intermittent viscosity is 15 cSt.
- The maximum permissible viscosity during motor startup is 1000 cSt.
- The viscosity index must be at least 100.
- The water content of hydraulic oil should be less than 500 ppm (0,05 %).
- The hydraulic fluid must reach score 10 on a wear protection test FZG A/8,3/90 in accordance with ISO 14635-1 (DIN 51354)
- The effect of the additives improving the viscosity index can decrease during operation.

Note:

Temperature has a significant effect on the viscosity and the lubricating capability of the hydraulic fluid. Take into consideration the real operating temperature when defining the fluid viscosity.

The need for service and the overall service life may be improved by using hydraulic fluids with higher viscosity. In addition higher viscosity may improve the running smoothness.

4.3.3 Hydraulic fluid cleanliness

Hydraulic fluid must fulfill cleanliness level 18/16/13 in accordance with ISO 4406 (NAS 1638 grade 7).

Note:

The purity of the hydraulic fluid has a significant effect on the need for service and the overall service life of the motor.

4.4 Operating pressures

4.4.1 Case pressure

The case pressure of the motor affects the lifetime of the sealing. It is recommended to maintain as low case pressure as possible.

When the motor is running, the permissible average case pressure is 2 bar and the highest permissible intermittent case pressure is 10 bar.

When the motor is not running, the highest permissible constant case pressure is 10 bar.

Attention:

Running the motor with higher than allowed case pressure shortens the service life of the motor.

Note:

The lifetime of the sealing may be improved with an accumulator, which cuts the pressure peaks that are higher than the pre-charge pressure of the accumulator.

Recommended pre-charge pressure is 2 bar and the displacement should be about 25 % of the motor displacement. The accumulator should be connected to the case drain line port as close to the motor as possible.

4.4.2 Pilot pressure

AAAAA	-	BBBB	-	**2N0R**	-	DD	-	E
AAAAA	-	BBBB	-	**2N0L**	-	DD	-	E

The pilot pressure is used to engage the 2-speed function of the motor and it may be applied to pilot lines Y1 and Y2.

The recommended pilot pressure is 20 to 50 bar and the maximum allowed pilot pressure is 350 bar (see *3.8 2-speed valve : 2N0R / 2N0L*).

Note:

When using over 50 bar pilot pressure, it is recommended to lightly throttle the pilot lines.

4.4.3 Working line pressure

WORKING PRESSURE

The working pressure is the high pressure that generates the output torque of the motor. The following values for the working pressure are in the technical data (see *3.3 Technical data*):

- PEAK PRESSURE

  The value of the peak pressure is the maximum allowed value of the working pressure. Make sure the working pressure does not exceed this value under any circumstances.

- INTERMITTENT PRESSURE

  The value of the intermittent pressure is a permissible value of the working pressure for a reference period of one minute (1 min). The working pressure may exceed this value for 10 % of the time during the reference period (for 6 seconds).

MINIMUM PRESSURE

The minimum pressure is a low pressure required in the working lines, which ensures the motor stays engaged when running. The motor is engaged when the pistons of the motor stay constantly connected to the cam ring.

The required minimum pressure depends mainly on the flow rate in the working lines.

The minimum pressure is maintained with back pressure or charge pressure. Type of the hydraulic system affects the implementation.

- BACK PRESSURE

  In open loop hydraulic system the minimum pressure may be done with back pressure. The back pressure is usually generated by a suitable check valve with cracking pressure.

- CHARGE PRESSURE

  In closed loop hydraulic system the charge pressure is usually used as the minimum pressure.

  In open loop hydraulic system the charge pressure may be done by a suitable pressure reducing valve.

When the motor is used in braking mode, value for required minimum pressure can be found in the following figure. Required minimum pressure is 50% of this value, if motor works in driving mode only. In this case pressure may not be lower than 2 bar.

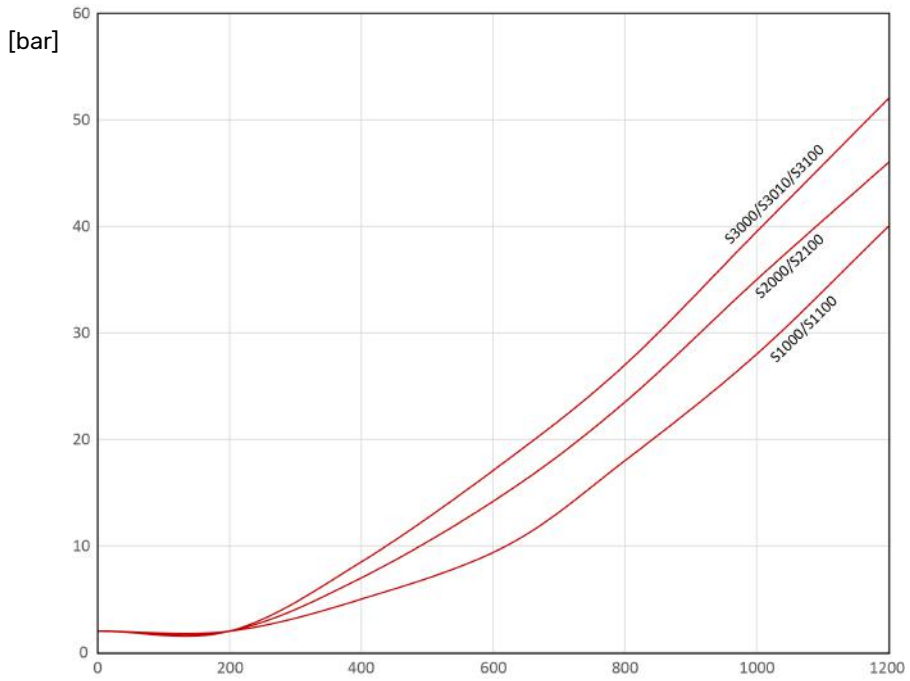


Figure 41. The minimum pressure at full displacement (fluid viscosity 35 cSt).

The required minimum pressure of the 2-speed motor in all applications can be found in the following figure.

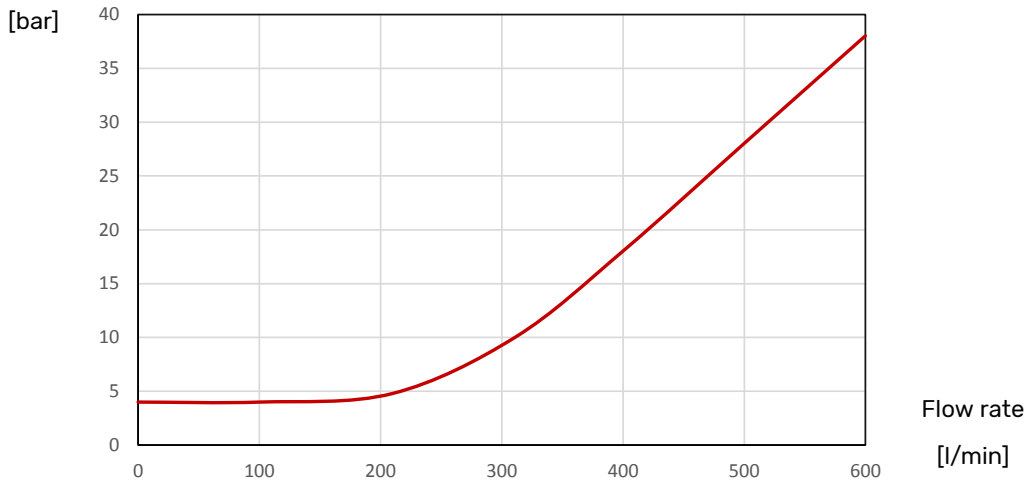


Figure 42. The minimum pressure at half displacement (fluid viscosity 35 cSt).

Attention:

Too low pressure in the working lines causes the pistons to disconnect from the cam ring when the motor is running. The effect of this is a clattering noise when the pistons hit the cam ring again.

Constant use with too low working line pressure may cause premature wear or failure of the motor.

5 Motor Sizing

5.1 Performance

5.1.1 Rotating speed and flow rate

Rotating speed of the motor and required flow rate may be calculated with the following equations:

ROTATING SPEED

$$RPM = 1000 \cdot \frac{Q}{V}$$

RPM = rotating speed [rpm]
V = displacement [ccm]
Q = flow rate in working lines [l/min]

FLOW RATE

$$Q = \frac{RPM \cdot V}{1000}$$

Note:

Due to motor dynamics, a constant smooth operating speed of under 1 rpm may be difficult to achieve.

5.1.2 Torque and power

Torque

The output torque of the motor is generated by the pressure difference of the working lines (pressure difference between ports A and B)

The output torque of the motor may be estimated with the following equations:

MAXIMUM TORQUE

$$T_{max} = 0{,}01592 \cdot V \cdot \Delta p$$

T = torque [Nm]
V = displacement [ccm]
Δp = pressure difference [bar]

Power

The operating power of the motor should be determined for all operating conditions. The operating power may be calculated with the following equation:

$$P = \frac{Q \cdot p_w}{600}$$

or

$$P = \frac{V \cdot RPM \cdot p_w}{600\,000}$$

P = power [kW]
Q = flow rate in working lines [l/min]
RPM = rotating speed [rpm]
V = displacement [ccm]
p_w = working pressure [bar]

Note:

Rough estimate of the operating power may be checked by dividing the available hydraulic power between the motors.

The allowed performance values can be found in the tecnical data (see *3.3 Technical data*) and performance charts (see *5.2 Performance charts*).

5.2 Performance charts

5.2.1 Performance curves

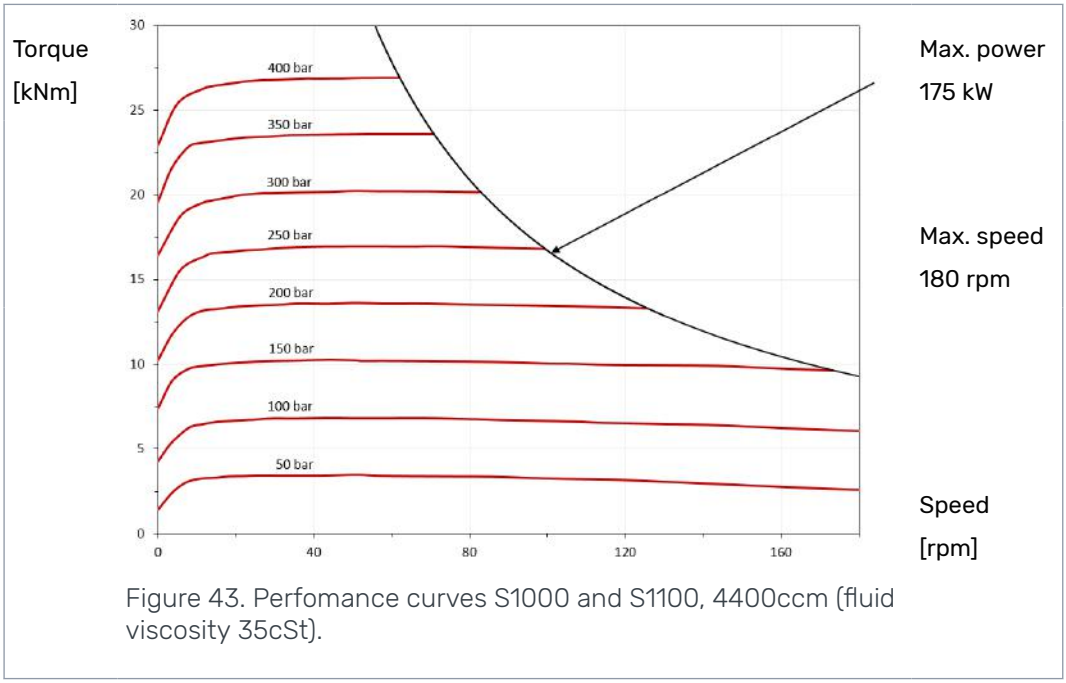


Figure 43. Perfomance curves S1000 and S1100, 4400ccm (fluid viscosity 35cSt).

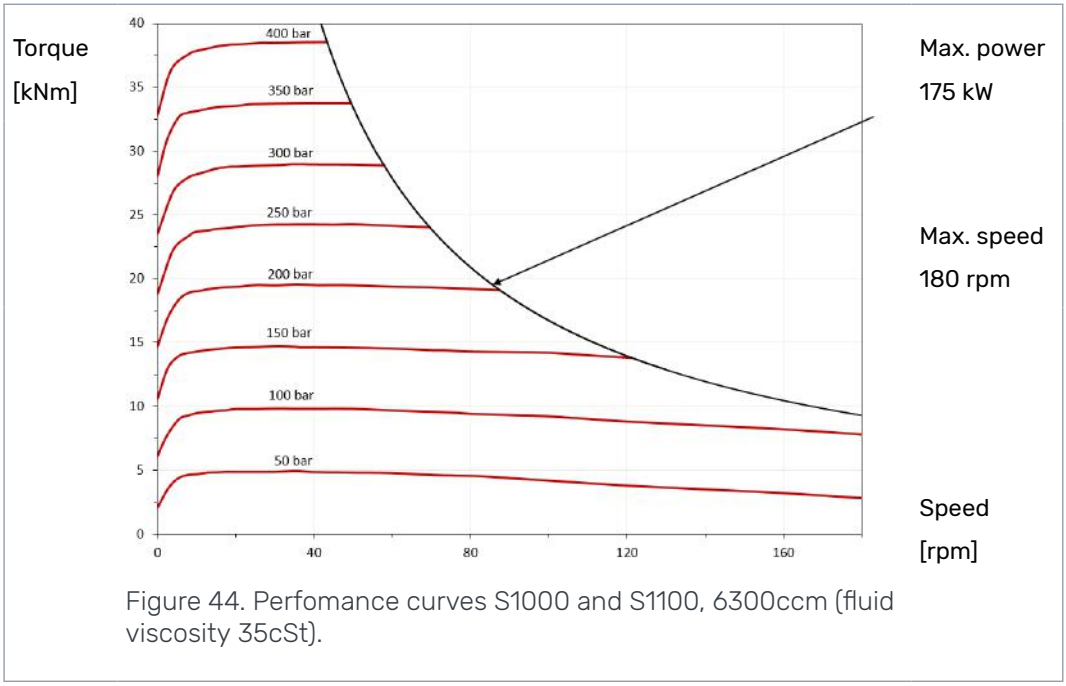


Figure 44. Perfomance curves S1000 and S1100, 6300ccm (fluid viscosity 35cSt).

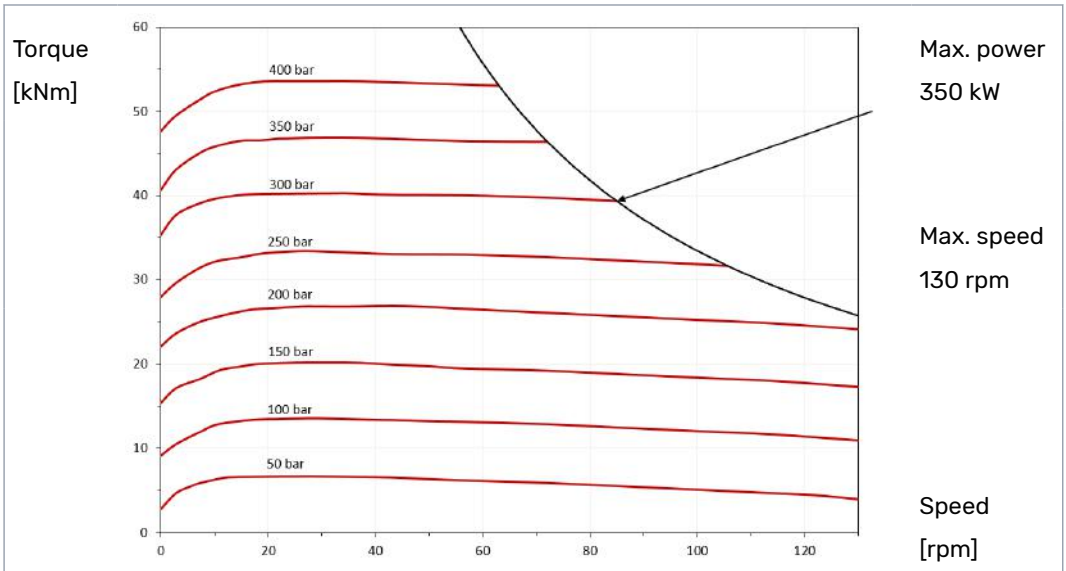


Figure 45. Perfomance curves S2000 and S2100, 8800ccm (fluid viscosity 35cSt).

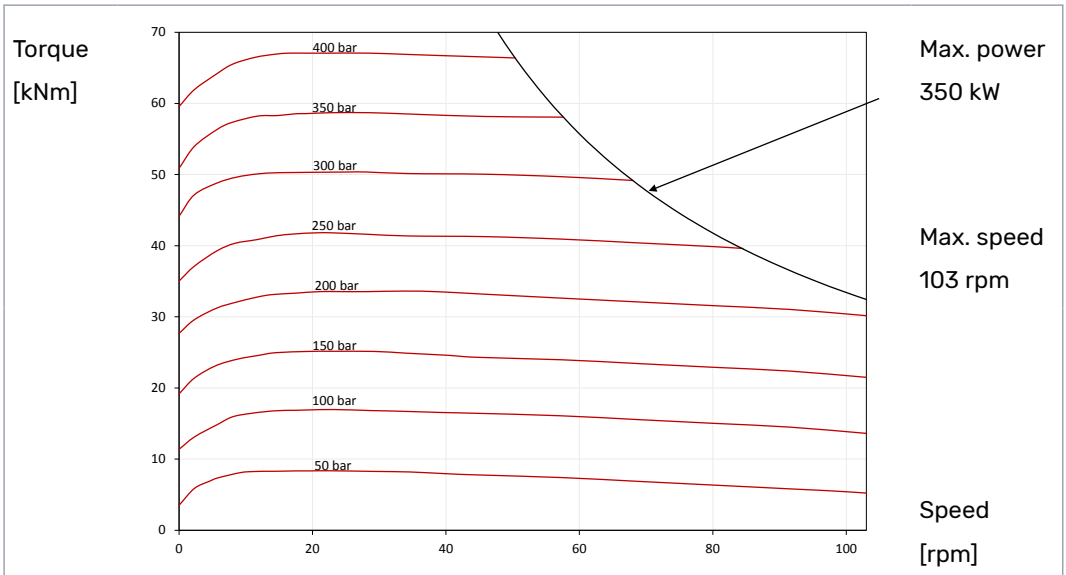


Figure 46. Perfomance curves S2000 and S2100, 11000ccm (fluid viscosity 35cSt).

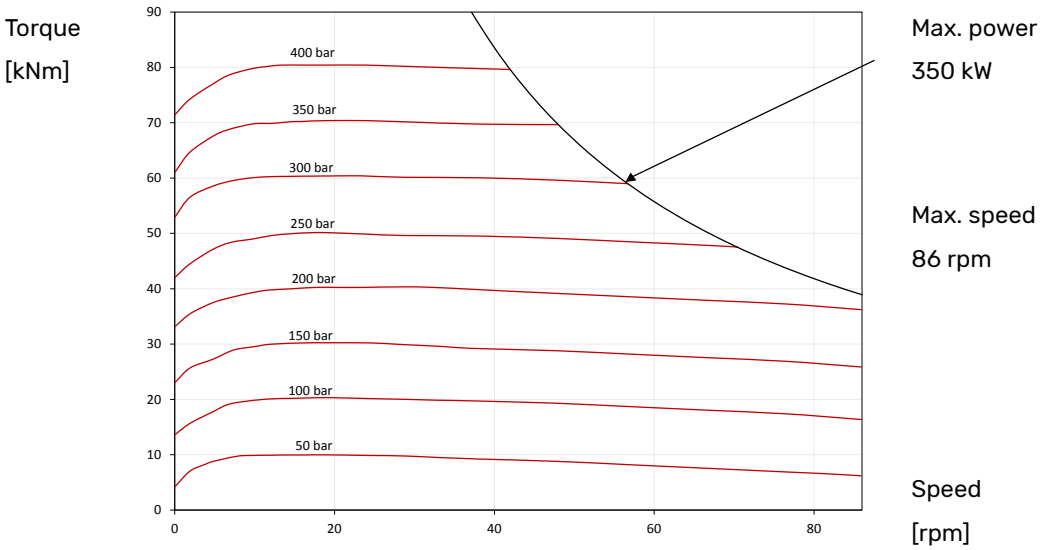


Figure 47. Perfomance curves S2000 and S2100, 13200ccm (fluid viscosity 35cSt).

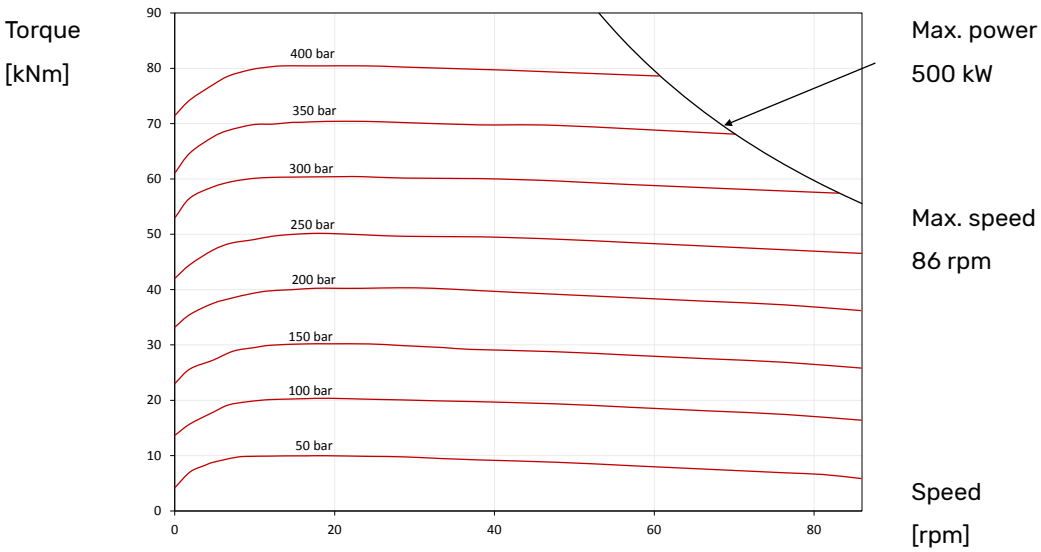


Figure 48. Perfomance curves S3000, S3010 and S3100, 13200ccm (fluid viscosity 35cSt).

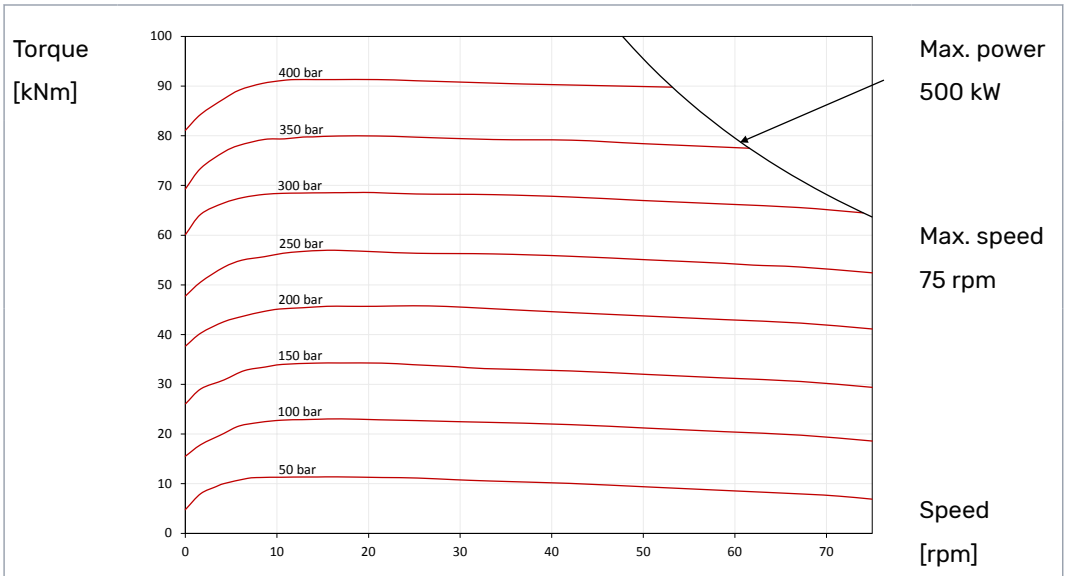


Figure 49. Perfomance curves S3000, S3010 and S3100, 15000ccm (fluid viscosity 35cSt).

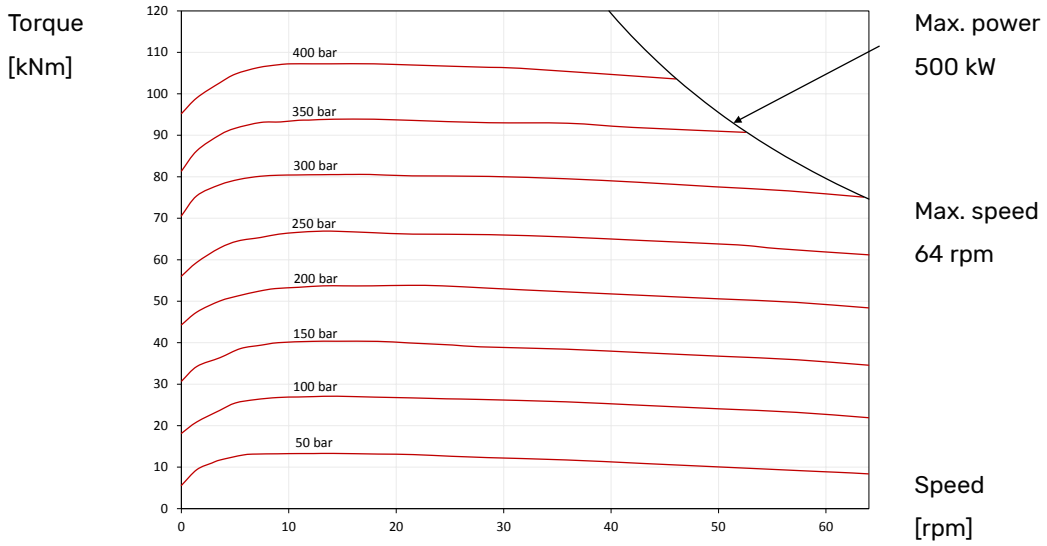


Figure 50. Perfomance curves S3000, S3010 and S3100, 17600ccm (fluid viscosity 35cSt).

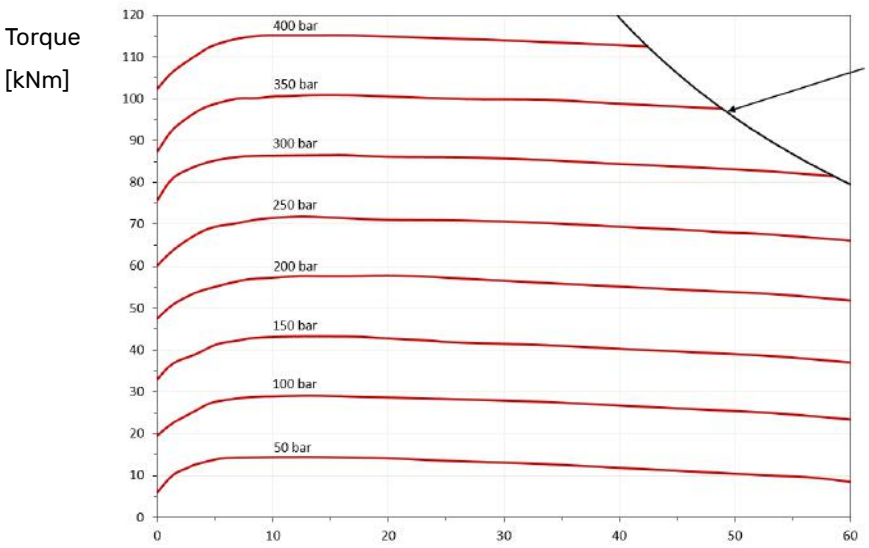


Figure 51. Perfomance curves S3000, S3010 and S3100, 18900ccm (fluid viscosity 35cSt).

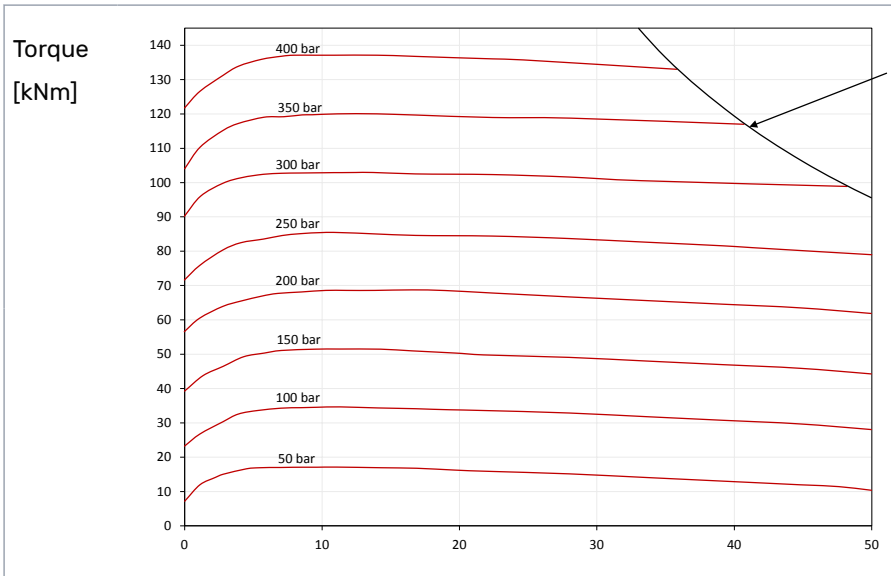


Figure 52. Perfomance curves S3000, S3010 and S3100, 22500ccm (fluid viscosity 35cSt).

5.2.2 Pressure loss

The figures below apply to all S series motors.

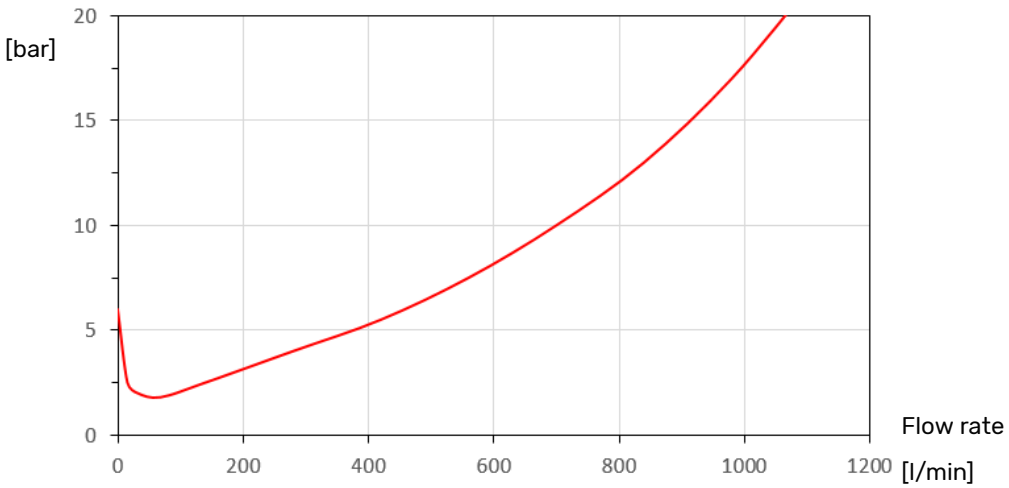


Figure 53. Pressure loss A-B, 1-speed motor (fluid viscosity 35cSt).

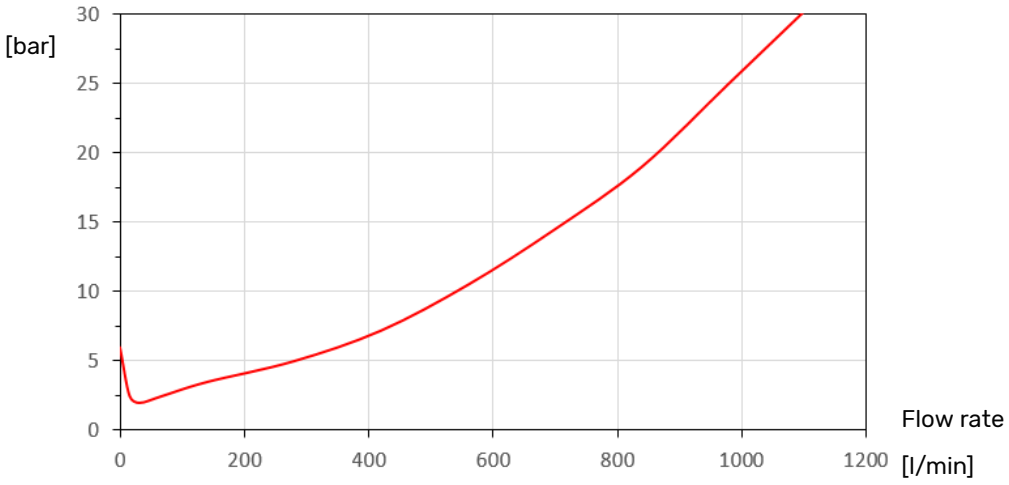


Figure 54. Pressure loss A-B at full displacement, 2-speed motor (fluid viscosity 35cSt).

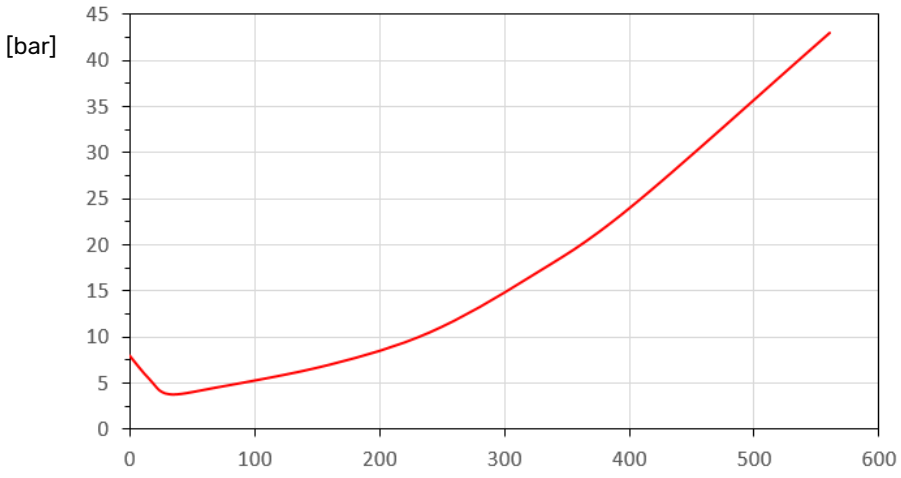


Figure 55. Pressure loss A-B at half displacement, 2-speed motor (fluid viscosity 35cSt).

5.2.3 Case leakage

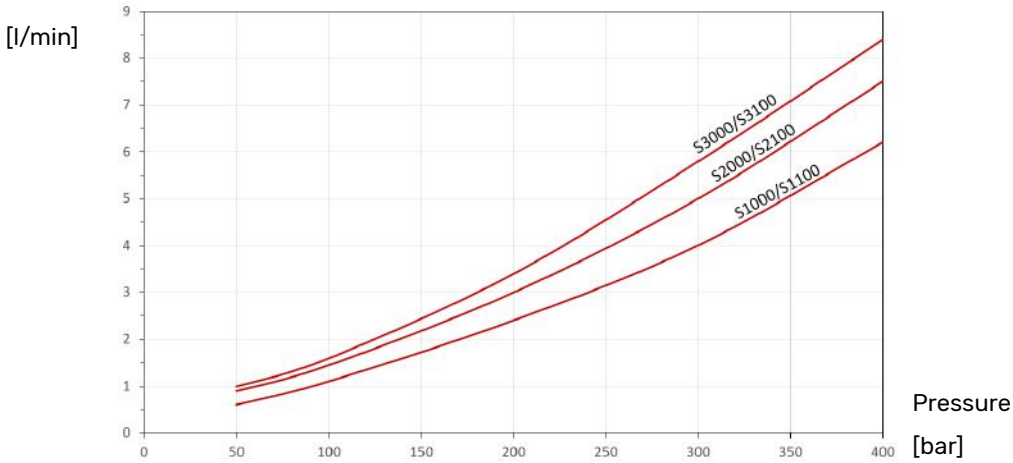


Figure 56. Case leakage curves (fluid viscosity 35cSt).

5.2.4 Brake torque

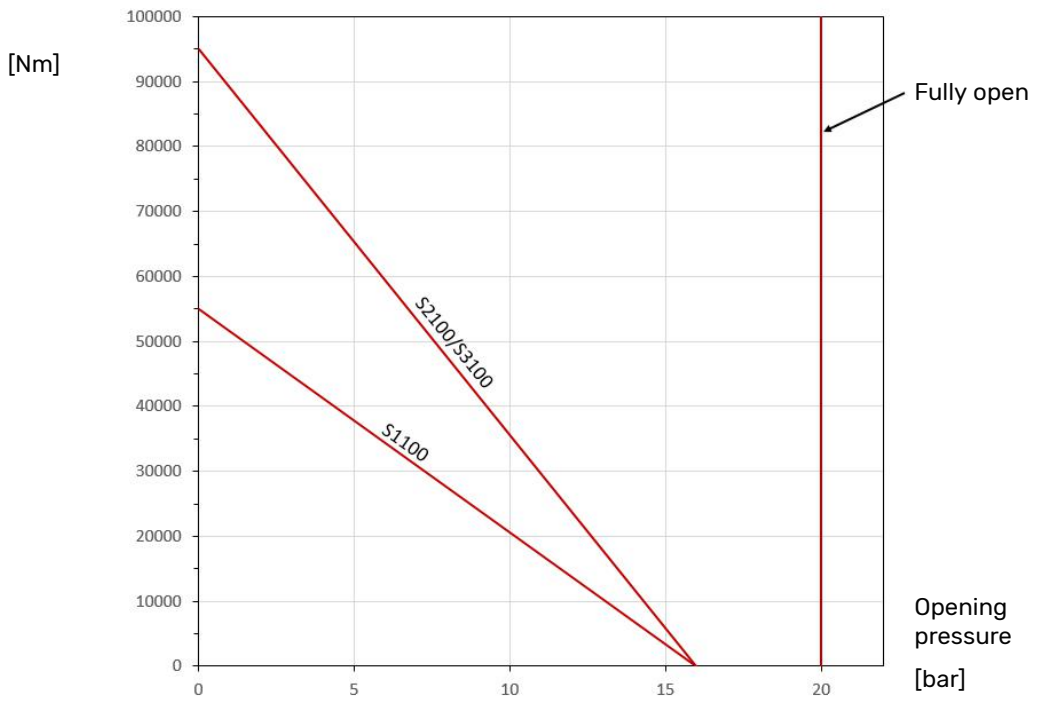


Figure 57. Holding brake torque.

5.3 Service life

The service life of the motor is based on the rated life of its bearings. The bearings load curve gives the radial load value, which the motors endures for 10 million rotations with 90 % reliability.

L = millions B10 revolutions at 150 bar (average pressure)

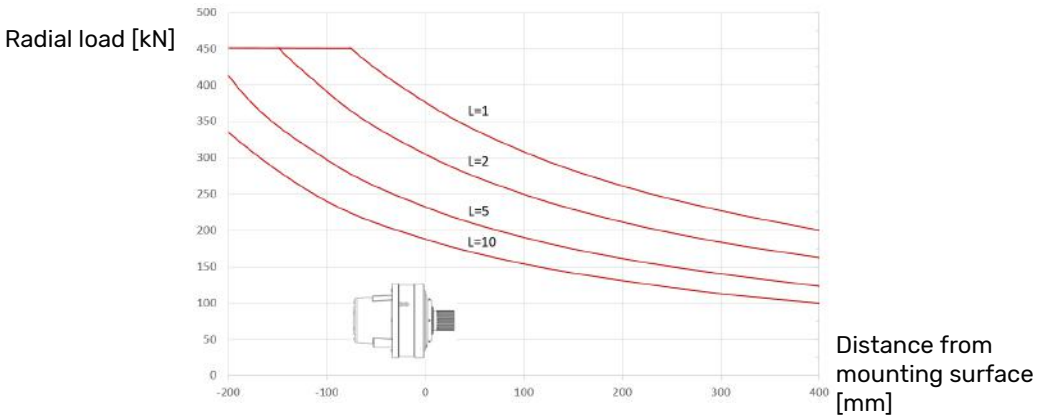
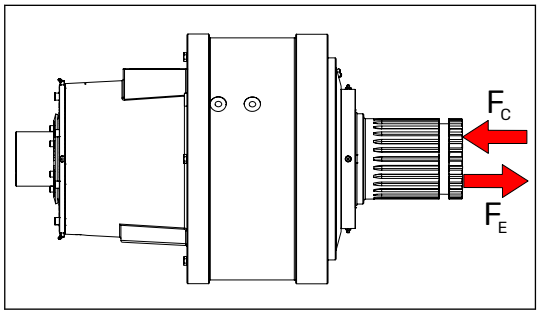


Figure 58. Service life of bearings, without axial load.



Max. axial load, without radial load (work pressure 0 bar)		
Compression (F_C)	225	kN
S3010 compression (F_C)	330	kN
Expansion (F_E)	460	kN

The service life of the bearings and maximum axial load is influenced by the work pressure. For an accurate calculations, consult your Black Bruin application engineer.

6 Installation Instructions

6.1 Mounting the motor

The installation dimensions and tightening torques are given in the product datasheet.

Check the following things before installing the motor:

- The counter surfaces must be clean and even.
- Make sure that the strength class (grade) of the fastening screws is sufficient.
- Make sure that the fastening screws are of suitable size and length.
- The fastening screws should be cleaned and oiled lightly before installing them.
- Use threadlocker only if necessary, removing the old threadlocker may be difficult.
- Remove any old threadlocker before mounting the motor.

Note:

When replacing fastening screws with new ones, renew all of the screws.

6.2 Flushing the hydraulic system

Prior to connecting the motor as part of the hydraulic system, the hydraulic circuit of the motor must always be flushed by circulating hydraulic fluid through a filter installed in place of the motor.

The flushing is carried out by circulating hydraulic fluid through the entire system with a minimum pressure for at least an hour.

- After flushing, renew all filters.

Note:

Flushing the hydraulic system should also be performed after every system modification or repair.

6.3 Air bleeding procedure

For the motor

Air bleeding procedure is carried out to fill the housing of the motor completely with hydraulic fluid. Air is removed from the housing with air bleeding screws as follows:

- Locate the topmost air bleeding screw (E/E1).
- Make sure the drain line (C2) of the motor is connected.
- Feed hydraulic fluid into the motor with low pressure throughout the procedure.
- Unscrew the air bleeding screw by half a turn and let air escape from the housing.
- Close the screw when only hydraulic fluid is pouring through it.
- Tighten the screw to a torque of 39 ± 3 Nm.

For the holding brake

Before using the brake the air bleeding procedure must be taken care of. Air bleeding procedure is carried out to fill the housing of the brake completely with hydraulic fluid. Brake housing is separate from the motor housing so the air bleeding procedure

must be made separately for motor and brake. Air is removed from the brake housing with air bleeding screws as follows:

- Feed hydraulic fluid into the brake via port D throughout the air bleeding procedure.
- Locate the topmost air bleed screw of the housing (E2).
- Unscrew the air bleeding screw by half a turn and let air escape from the housing.
- Close the screw when only hydraulic fluid is pouring through it.
- Tighten the screw to a torque of 39 ± 3 Nm.

Note:

The location of the air bleed screws can be found in *4.2 Hydraulic connections*.

If feed pressure is not available, fill the housing manually by pouring hydraulic fluid in the motor through the topmost opening of the housing.

6.4 Commissioning procedure

Ensure that the following things are in order before starting a new or replaced motor:

- The hydraulic circuit of the motor is flushed.
- Motor is installed appropriately.
- Air bleeding procedure is carried out.
- The reservoir of the hydraulic system is full.

During the initial stages of use, also take the following things into consideration:

- Do not run the motor immediately with full power. Increase the load and speed of rotation gradually.
- Observe the motor and the hydraulic system for external leaks or abnormal noises during the commissioning procedure.
- Start the motor break-in.

Note:

During all installation and service procedures, plug any open ports and hoses.

When filling the reservoir, add hydraulic fluid through a filter.

Attention:

Do not start the motor, if the air bleeding procedure has not been carried out.

Stressing an unused motor with full power may cause premature wear or failure of the motor.

7 Operating Instructions

7.1 Break-in period

The motor achieves its final properties during the first hours of use. Therefore all new and reconditioned motors should go through an initial break-in period.

Things to be considered during break-in period:

- The break-in period should last for at least first eight hours (8 h) of use.
- The power output should remain under 50 % of the maximum power capacity of the motor.
- The power output is limited by limiting the working pressure, the speed of rotation or both.
- The working pressure should be limited so, that pressure peaks which last over two seconds (2 s) remain under 75 % of the permissible values.

Note:

During the break-in period, the moving parts of the motor wear against each other so, that the wear of the parts sets to a stable state for the entire service life of the motor.

7.2 Use

Things to be considered during use of motors:

- Check the screw connections tightening torque and hydraulic connections regularly.
- Do not use pressure cleaning directly between the shaft and housing of the motor (the shaft seal area).
- Avoid situations in which the motors are completely submerged in water or mud.

7.3 Operating temperature

The operating temperature means the internal temperature of the motor. Take into considerations the following requirements for the operating temperature:

- For improved service life, avoid over 70 °C (158 °F) operating temperature.
- The highest permissible intermittent operating temperature is 85 °C (185 °F).
- The lowest permissible operating temperature is -35 °C (-31 °F).
- The temperature difference between the motor and the hydraulic fluid should be under 60 °C (140 °F).

The operating temperature may be measured from the hydraulic fluid returning from the motor. Take into account the temperature of hydraulic fluid returning from the drain line and from the return line (A or B).

7.4 Demounting the motor

Take into consideration the following things when demounting the motor for service or replacement:

- Release the pressure in the hydraulic lines and let the motor cool down.
- Disconnect all the hydraulic lines from the motor and plug all openings and hoses.
- Demount the motor and lift it away from its position.

- Clean the outside of the motor thoroughly, but do not use any solvents.
- Protect the cleaned motor from corrosion.
- If possible, drain all the hydraulic fluid from the motor.

Note:

Dispose of hydraulic fluid should be done appropriately.

8 Special Instructions

8.1 Storing the motor

During short term storage of the motor, the following should be taken into consideration:

- Cover any pressure openings and open threaded holes with suitable caps.
- Protect the unpainted surfaces from dirt and moisture.
- Store the motor in a dry place with relatively stable temperature.
- The motor should not be stored in a same place as substances with aggressive corrosive nature (solvents, acids, alkalis and salts).
- The motor should not be exposed to strong magnetic fields.
- The motor should not be exposed to strong vibration.

Note:

For long-term storage (over 9 months) the following additional actions are recommended:

- Damages to surface paint must be repaired.
- Protect the unpainted surfaces with suitable anti-corrosion treatment.
- Fill the motor completely with hydraulic fluid.

If these instructions are followed, the motor may be stored for approximately two years. However, as storage conditions do have a significant effect, these times should only be considered as guide values.

No POWER like it.

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EN 20230808