Black Bruin

Product Manual
C200 series

Contents

1 General Instructions

1.1 About the manual

This manual contains the technical instructions for the Black Bruin C200 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 C200 series hydraulic motors are designed to be used as hub motors on hydrostatic transmission on vehicles. They can also be used in other applications that need torque for rotary movement.

1.3 Warranty

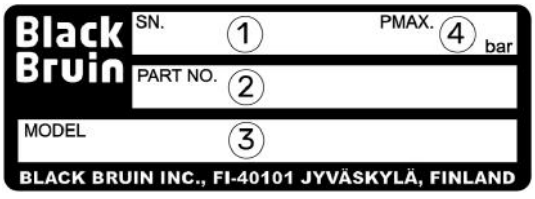
Check the package and the product for transport damage when receiving goods. The package is not meant for long term storage; protect the product appropriately.

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

06.06.2023 - 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	Tero Ylä-Mononen
Title	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.

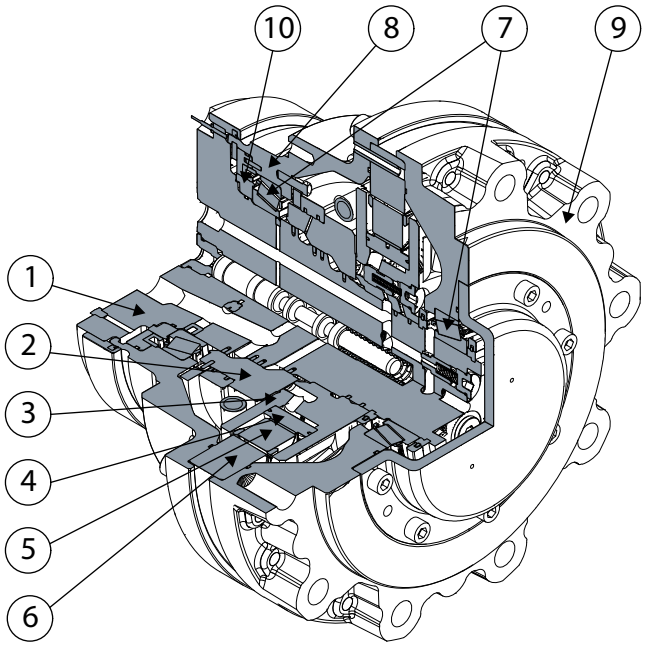
Attention:

May cause damage to the product.

3 Motor Description

3.1 Working principle

C200 series motors are rotary-housing. This means the motor shaft and the cylinder block remain in place while the motor is running.



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

Figure 2. The main components of the motor.

The rotation of the motor is achieved by feeding pressurized hydraulic fluid through the motor shaft 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.

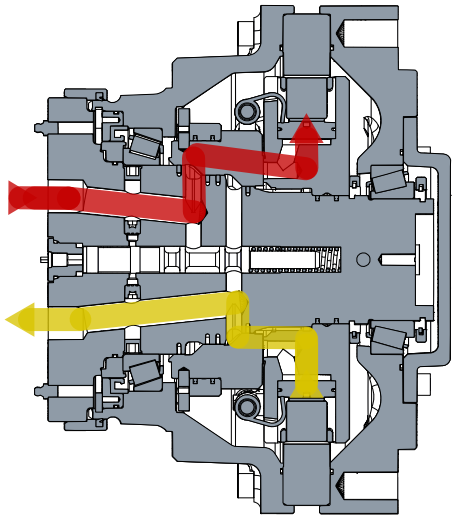


Figure 3. Flow to and from the pistons.

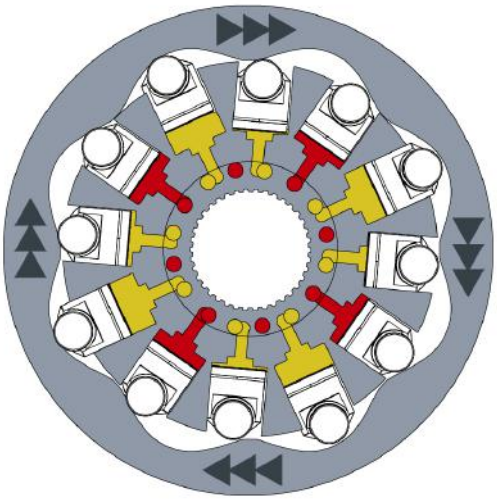


Figure 4. Cylinder block, cam ring and pistons.

3.2 Product identification code

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

C200 SERIES PRODUCT IDENTIFICATION CODE		
C250 - 0227 - 1N00 / 0	-	**1 1 0 0 0 0**
Motor model code	-	Processing ID

3.2.1 Motor model code, C200 series

SERIES MODEL CODE	**AAAA - BBBB - CCCC / D**
AAAA	Motor series standard code
AAAA	Motor frame size
AAAA	Motor brake type
BBBB	Motor displacement (ccm/rev)
CCCC	Motor speed and displacement control
CCCC	Mechanical freewheeling
D	Speed sensor

A: Series standard code	**AAAA - BBBB - CCCC / D**
C200	C2

Code example	**C250 - 0192 - 2N01 / 1**
	AAAA - BBBB - CCCC / D
A =	The motor is a C200 series frame size 5 motor without brake.
B =	The displacement of the motor is 1922 ccm/rev.
C =	The motor is equipped with an internal 2-speed valve for displacement control. The motor is equipped with mechanical freewheeling.
D =	The motor is equipped with a speed sensor.

3.2.2 Motor model code, C2x0 and C2x1 series

C2x0: Motor without brake

C2x1: Motor with parking brake

A: Motor frame size	**AAAA - BBBB - CCCC / D**	**C210/ C211**	**C220/ C221**	**C230/ C231**	**C250/ C251**
C21x: 462-667 ccm	C210 / C211	●			
C22x: 705-1018 ccm	C220 / C221		●		
C23x: 909-1313 ccm	C230 / C231			●	
C25x: 1572-2271 ccm	C250 / C251				●

B: Motor displacement	**AAAA - BBBB - CCCC / D**	**C210/ C211**	**C220/ C221**	**C230/ C231**	**C250/ C251**
C21x	0046 : 462 ccm/rev	●			
	0051 : 513 ccm/rev	●			
	0056 : 564 ccm/rev	●			
	0061 : 615 ccm/rev	●			
	0066 : 667 ccm/rev	●			
C22x	0070 : 705 ccm/rev		●		
	0078 : 783 ccm/rev		●		
	0086 : 862 ccm/rev		●		
	0094 : 940 ccm/rev		●		
	0101 : 1018 ccm/rev		●		
C23x	0090 : 909 ccm/rev			●	
	0101 : 1010 ccm/rev			●	
	0111 : 1111 ccm/rev			●	
	0121 : 1212 ccm/rev			●	
	0131 : 1313 ccm/rev			●	
C25x	0157 : 1572 ccm/rev				●
	0174 : 1747 ccm/rev				●
	0192 : 1922 ccm/rev				●
	0209 : 2096 ccm/rev				●
	0227 : 2271 ccm/rev				●

C: Displacement control	**AAAA - BBBB - CCCC / D**	**C210/ C211**	**C220/ C221**	**C230/ C231**	**C250/ C251**
1-speed	1N00 : Fixed	●	●	●	●
2-speed valve	2N00 : 100 / 50%	●	●	●	●
2-speed valve	2N10 : 100/ 25%				●
1-speed	1N01 : Fixed, with mechanical freewheeling		●	●	●
2-speed valve	2N01 : 100 / 50%, with mechanical freewheeling		●	●	●

C: Displacement control	AAAA - BBBB - CCCC / D	C210/ C211	C220/ C221	C230/ C231	C250/ C251
2-speed valve	2N11 : 100/ 25%, with mechanical freewheeling				•

D: Accessory	AAAA - BBBB - CCCC / D	C210/ C211	C220/ C221	C230/ C231	C250/ C251
Without speed sensor	0	•	•	•	•
With speed sensor	1	•	•	•	•

3.2.3 Motor model code, C2x2 and C2x3 series

C2x2: Motor with service brake

C2x3: Motor with double brake

A: Motor frame size	AAAA - BBBB - CCCC / D	C222/C223	C232/C233
C22x: 705-1018 ccm	C222 / C223	•	
C23x: 909-1313 ccm	C232 / C233		•

B: Motor displacement	AAAA - BBBB - CCCC / D	C222/C223	C232/C233
C22x	0070 : 705 ccm/rev	•	
	0078 : 783 ccm/rev	•	
	0086 : 862 ccm/rev	•	
	0094 : 940 ccm/rev	•	
	0101 : 1018 ccm/rev	•	
C23x	0090 : 909 ccm/rev		•
	0101 : 1010 ccm/rev		•
	0111 : 1111 ccm/rev		•
	0121 : 1212 ccm/rev		•
	0131 : 1313 ccm/rev		•

C: Displacement control	AAAA - BBBB - CCCC / D	C222/C223	C232/C233
1-speed	1N00 : Fixed	•	•
2-speed valve	2N00 : 100 / 50%	•	•
2-speed valve	2N10 : 100/ 25%		
1-speed	1N01 : Fixed, with mechanical freewheeling	•	•
2-speed valve	2N01 : 100 / 50%, with mechanical freewheeling	•	•

D: Accessory	AAAA - BBBB - CCCC / D	C222/C223	C232/C233
Without speed sensor	0	•	•

3.2.4 Motor model code, C2x4 and C2x5 series

C2x4: 4-speed motor without brake

C2x5: 4-speed motor with parking brake

A: Motor frame size	AAAA - BBBB - CCCC / D	C254/C255	C264/C265
C25x: 1572-2271 ccm	C254 / C255	●	
C26x: 2000-3150 cm	C264 / C265		●

B: Motor displacement	AAAA - BBBB - CCCC / D	C254/C255	C264/C265
C25x	0157 : 1572 ccm/rev	●	
	0174 : 1747 ccm/rev	●	
	0192 : 1922 ccm/rev	●	
	0209 : 2096 ccm/rev	●	
	0227 : 2271 ccm/rev	●	
C26x	0200 : 2000 ccm/rev		●
	0250 : 2500 ccm/rev		●
	0315 : 3150 ccm/rev		●

C: Displacement control	AAAA - BBBB - CCCC / D	C254/C255	C264/C265
4-speed	4N00 : 100 / 75 / 50 / 25 %	●	●
4-speed	4N01 : 100 / 75 / 50 / 25 %, with mechanical freewheeling	●	●

D: Accessory	AAAA - BBBB - CCCC / D	C25x	C26x
Without speed sensor	0	●	●
With speed sensor	1	●	●

3.2.5 Processing ID

C200 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	= Painting type 1	- Unpainted interfaces: SHAFT, HUB [2)]
2	= Painting type 2	- Unpainted interfaces: SHAFT, HUB, HOUSING [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.
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] 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, C200 series

TECHNICAL DATA		C21x				
Displacement [ccm]		462	513	564	615	667
Maximum torque [Nm]						
	theoretical	3310	3670	4040	4160	4250
	with 100 bar	735	816	898	979	1060
Max. operating power [kW]						
	at full displacement			32		
	at partial displacement.			21		
Max. rotating speed [rpm]						
	at full displacement	260	234	213	195	180
	at partial displacement	364	328	298	278	252
	at freewheeling			500		
Min. rotating speed [rpm]				2		
Max. engaging speed [rpm]		130	117	107	98	90
Max. working pressure [bar]						
	peak pressure	450	450	450	425	400

TECHNICAL DATA		C21x				
	intermittent [1]	400	400	400	375	350
Max. case pressure [bar]						
	average	2				
	intermittent [1]	10				
Pilot pressure for internal valve [bar]						
	valve released	0-2				
	valve engaged	15-30 [2]				
Max. flow rate [l/min]						
	at full displacement	120				
	at partial displacement	84				
Spring operated wet multi-disc brake (parking brake), C211						
	brake torque (min.) [Nm] [3]	4300				
	releasing pressure [bar]	16				
	brake pressure (max.) [bar]	30				
	needed oil volume [ccm]	120				
Weight [kg]						
	without brake	46 **(C210)**				
	with parking brake	56 **(C211)**				

TECHNICAL DATA		C22x				
Displacement [ccm]		705	783	862	940	1018
Maximum torque [Nm]						
	theoretical	5050	5610	6170	6360	6480
	with 100 bar	1120	1250	1370	1500	1620
Max. operating power [kW]						
	at full displacement	42				
	at partial displacement	28				
Max. rotating speed [rpm]						
	at full displacement	223	201	182	167	154
	at partial displacement	318	286	260	238	220
	at freewheeling	450				
Min. rotating speed [rpm]		2				
Max. engaging speed [rpm]		112	101	91	84	77
Max. working pressure [bar]						
	peak pressure	450	450	450	425	400
	intermittent [1]	400	400	400	375	350
Max. case pressure [bar]						
	average	2				
	intermittent [1]	10				

TECHNICAL DATA		C22x
Pilot pressure for internal valve [bar]		
	valve released	0-2
	valve engaged	15-30 [2]
Max. flow rate [l/min]		
	at full displacement	157
	at partial displacement	112
Spring operated wet multi-disc brake (parking brake), C221/C223		
	brake torque (min.) [Nm] [3]	6560
	releasing pressure [bar]	16
	brake pressure (max.) [bar]	30
	needed oil volume [ccm]	120
Dynamic wet multi-disc brake (service brake), C222/C223		
	brake torque (min.) [Nm][3]	7800
	brake pressure (max.) [bar]	60
Weight [kg]		
	without brake	64 **(C220)**
	with parking brake	75 **(C221)**
	with service brake	111 **(C222)**
	with double brake	122 **(C223)**

TECHNICAL DATA		C23x				
Displacement [ccm]		909	1010	1111	1212	1313
Maximum torque [Nm]						
	theoretical	6510	7230	7960	8200	8360
	with 100 bar	1450	1610	1770	1930	2090
Max. operating power [kW]						
	at full displacement			50		
	at partial displacement			33		
Max. rotating speed [rpm]						
	at full displacement	206	186	169	155	143
	at partial displacement	290	261	238	218	201
	at freewheeling			425		
Min. rotating speed [rpm]				2		
Max. engaging speed [rpm]		103	93	85	78	72
Max. working pressure [bar]						
	peak pressure	450	450	450	425	400
	intermittent [1]	400	400	400	375	350

TECHNICAL DATA		C23x
Max. case pressure [bar]		
	average	2
	intermittent [1]	10
Pilot pressure for internal valve [bar]		
	valve released	0-2
	valve engaged	15-30 [2]
Max. flow rate [l/min]		
	at full displacement	187
	at partial displacement	132
Spring operated wet multi-disc brake (parking brake), C231/C233		
	brake torque (min.) [Nm] [3]	8470
	releasing pressure [bar]	16
	brake pressure (max.) [bar]	30
	needed oil volume [ccm]	150
Dynamic wet multi-disc brake (service brake), C232		
	brake torque (min.) [Nm][3]	10700
	brake pressure (max.) [bar]	60
Weight [kg]		
	without brake	81 **(C230)**
	with parking brake	97 **(C231)**
	with service brake	132 **(C232)**
	with double brake	148 **(C233)**

TECHNICAL DATA		C25x				
Displacement [ccm]		1572	1747	1922	2096	2271
Maximum torque [Nm]						
	theoretical	11300	12500	13800	14200	14500
	with 100 bar	2500	2780	3060	3340	3610
Max. operating power [kW]						
	at full displacement	72				
	at 3/4 displacement	60				
	at partial displacement	48				
	at 1/4 displacement	32				
Max. rotating speed [rpm]						
	at full displacement	172	155	141	129	119
	at 3/4 displacement	205	185	168	154	142
	at partial displacement	244	220	200	183	169

TECHNICAL DATA		**C25x**				
	at 1/4 displacement	326	293	266	244	226
	at freewheeling			400		
Min. rotating speed [rpm]				2		
Max. engaging speed [rpm]		86	78	71	65	60
Max. working pressure [bar]						
	peak pressure	450	450	450	425	400
	intermittent [1]	400	400	400	375	350
Max. case pressure [bar]						
	average			2		
	intermittent [1]			10		
Pilot pressure for internal valve [bar]						
	valve released			0-2		
	valve engaged			15-30 [2]		
Max. flow rate [l/min]						
	at full displacement			270		
	at 3/4 displacement			242		
	at partial displacement			192		
	at 1/4 displacement			128		
Spring operated wet multi-disc brake (parking brake), C251/C255						
	brake torque (min.) [Nm] [3]			20600		
	releasing pressure [bar]			16		
	brake pressure (max.) [bar]			30		
	needed oil volume [ccm]			260		
Weight [kg]						
	without brake			124 **(C250)**, 132 **(C254)**		
	with parking brake			158 **(C251)**, 164 **(C255)**		

TECHNICAL DATA		**C26x**		
Displacement [ccm]		2000	2500	3150
Maximum torque [Nm]				
	theoretical	14300	17900	22600
	with 100 bar	3180	3980	5010
Max. operating power [kW]				
	at full displacement		90	
	at 3/4 displacement		75	
	at partial displacement		60	
	at 1/4 displacement		40	
Max. rotating speed [rpm]				
	at full displacement	173	139	110

TECHNICAL DATA		**C26x**		
	at 3/4 displacement	205	164	130
	at partial displacement	228	183	145
	at 1/4 displacement	252	202	160
	at freewheeling		400	
Min. rotating speed [rpm]			2	
Max. engaging speed [rpm]		86	78	71
Max. working pressure [bar]				
	peak pressure	450	450	450
	intermittent [1]	400	400	400
Max. case pressure [bar]				
	average		2	
	intermittent [1]		10	
Pilot pressure for internal valve [bar]				
	valve released		0-2	
	valve engaged		15-30[2]	
Max. flow rate [l/min]				
	at full displacement		347	
	at 3/4 displacement		308	
	at partial displacement		229	
	at 1/4 displacement		126	
Spring operated wet multi-disc brake (parking brake), C265				
	brake torque (min.) [Nm] [3]		20600	
	releasing pressure [bar]		16	
	brake pressure (max.) [bar]		30	
	needed oil volume [ccm]		260	
Weight [kg]				
	without brake		157 **(C264)**	
	with parking brake		189 **(C265)**	

[1] Intermittent operation: permissible values for maximum of 10% of every minute.
[2] If pilot pressure over 30 bar is used, the pilot line should be throttled.
[3] Brake torque for new brake.

3.4 Motor interfaces

3.4.1 Main dimensions

C2x0 and C2x4 series motors without brake

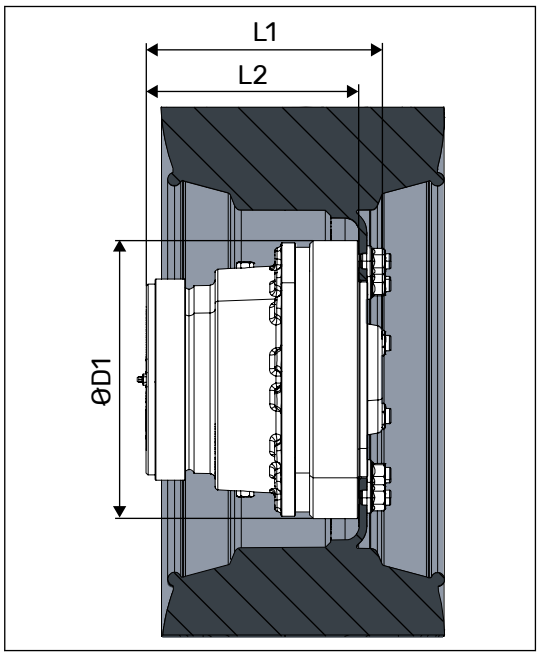


Figure 5. Main dimensions of the motor.

MAIN DIMENSIONS			C210	C220	C230	C250	C254	C264
Motor								
	L1	[mm]	234	254	268	298	312	355,5
	L2	[mm]	210	233	241	259	273	317
	D1	[mm]	263	282	315	376	376	408

C2x1 and C2x5 motors with parking brake

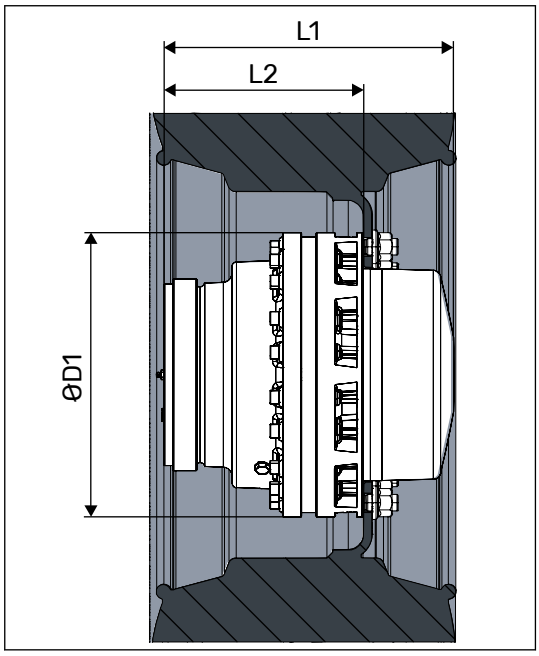


Figure 6. Main dimensions of the motor.

MAIN DIMENSIONS			C211	C221	C231	C251	C255	C265
Motor								
	L1	[mm]	299	322	331	383	397	439
	L2	[mm]	213	236	241	263	277	319
	D1	[mm]	263	282	315	376	376	408

C2x2 series motors with dynamic multi-disc brake

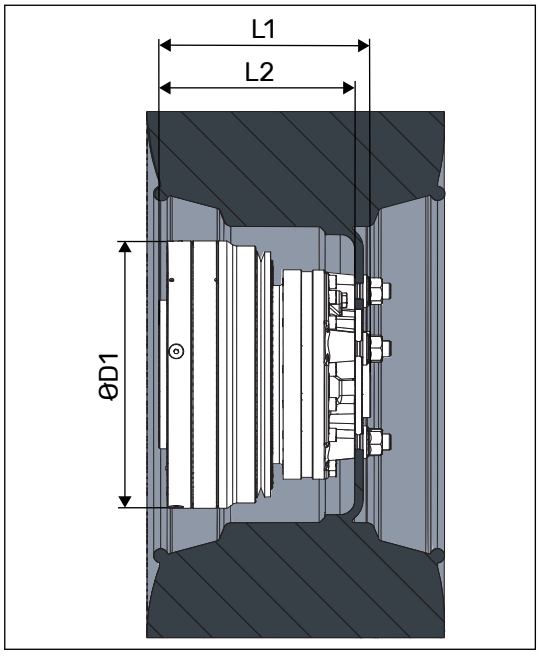


Figure 7. Main dimensions of the motor.

MAIN DIMENSIONS		C222	C232
Motor			
L1	[mm]	286	300
L2	[mm]	264	274
D1	[mm]	360	360

C2x3 series motors with double brake

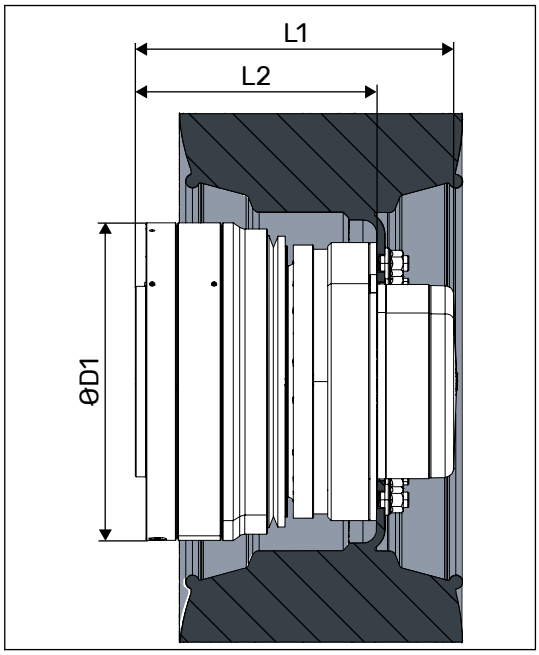


Figure 8. Main dimensions of the motor.

MAIN DIMENSIONS		C223	C233
Motor			
L1	[mm]	353	364
L2	[mm]	267	274
D1	[mm]	360	360

3.4.2 Shaft interfaces

The motor is attached to the body of the vehicle or device from the shaft flange. The hydraulic connections of the motor are located on the plane surface of the shaft flange.

C200 series motors

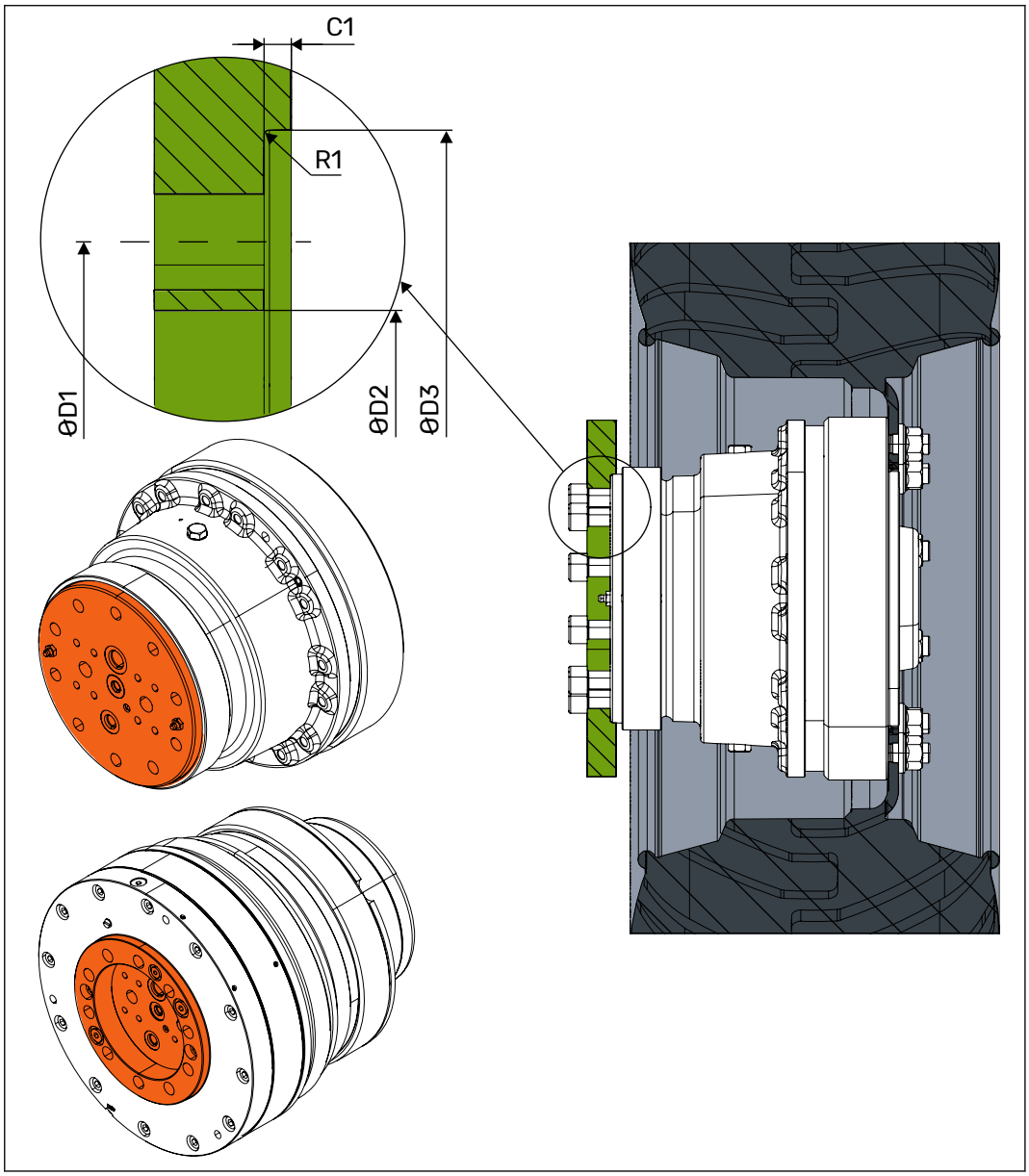


Figure 9. Dimensions of the shaft interfaces.

INTERFACE DIMENSIONS		C21x	C22x	C23X	C25x	C26x
Shaft interface						
D1	[mm]	140	160	175	200	200
	pattern	12x30°	8x45°	10x36°	12x30°	12x30°
	size	M12x1,75	M16x2,0	M16x2,0	M20x1,5	M20x1,5
	strength class [1]	12,9	12,9	12,9	12,9	12,9
	tightening torque [2] [Nm]	135	330	330	650	650
D2	min. [3] [mm]	117	135	150	166	170
D3	min. [4] [mm]	172	200	216	240	240

INTERFACE DIMENSIONS		C21x	C22x	C23X	C25x	C26x
R1	max. [mm]	1	1	1	1	1
C1	[mm]	4-10	4-10	4-10	4-10	4-10

[1] Strength class as in ISO898-1. If using lower strength class, check interface load capacity and tightening torque.
[2] Declared values are for reference only. Always use application specific tightening torques when given.
[3] Free space for hydraulic connections.
[4] Recommended feature to support and center the motor.

3.4.3 Housing interface (excluding C2x2 and C2x3 motors)

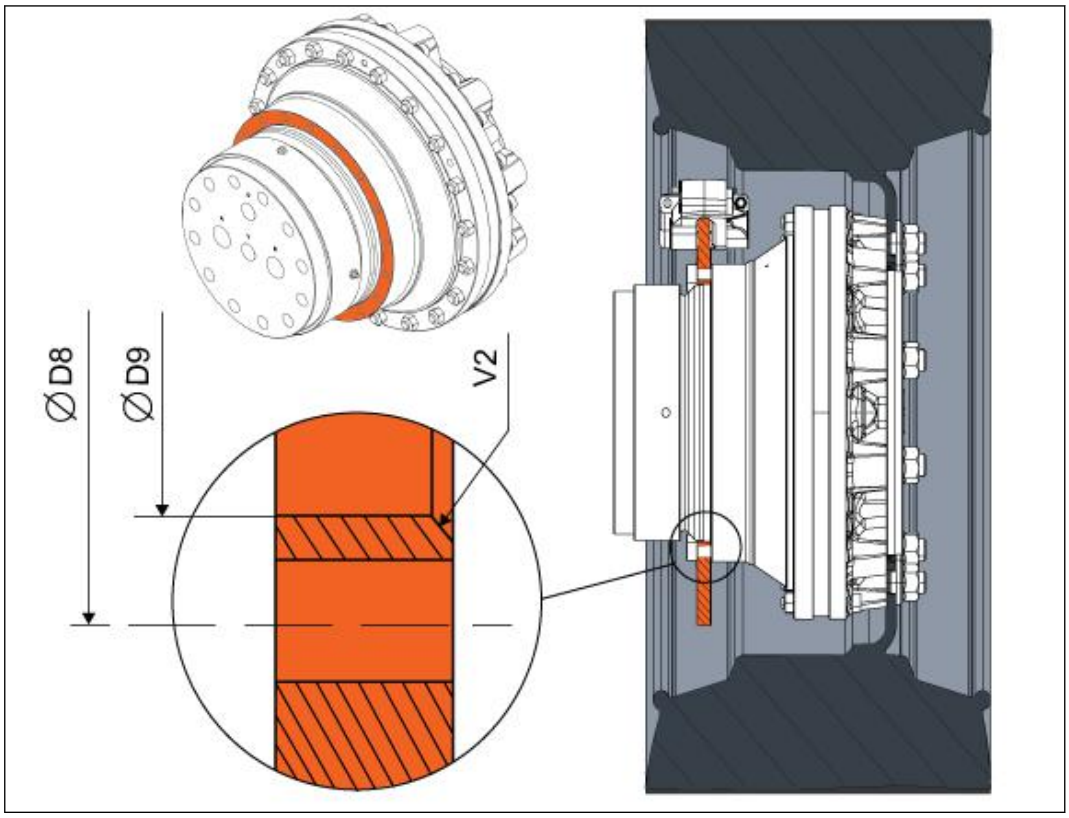


Figure 10. Dimensions of the housing interface.

INTERFACE DIMENSIONS		C21x	C22x	C23x	C25x	C26x
Housing interface						
D8	[mm]	184	212	228	254	254
	pattern	12x30°	20x18°	20x18°	18x20°	18x20°
	size	M10x1,5	M10x1,5	M10x1,5	M12x1,75	M12x1,75
	strength class[1]	10,9	10,9	10,9	10,9	10,9
	tightening torque [2] [Nm]	64	64	64	110	110
D9	min. [mm]	204	230	246	274	274
V2	min. [mm]	1x45°	1x45°	1x45°	1x45°	1x45°

[1] Strength class as in ISO898-1. If using lower strength class, check interface load capacity and tightening torque.
[2] Declared values are for reference only. Always use application specific tightening torques when given.

The necessary accessories can be attached to the housing interface. The interface can be used, for example, to attach a brake disc of a disc brake.

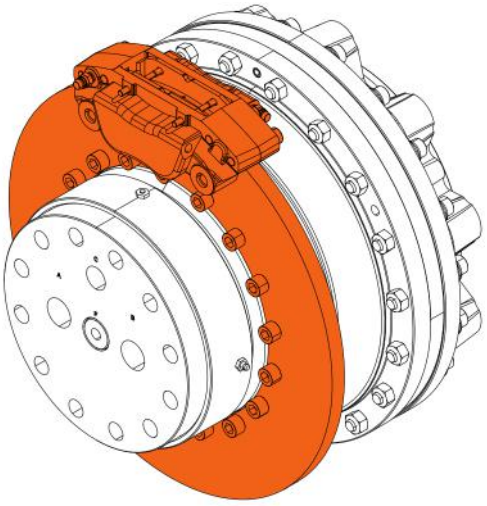


Figure 11. The motor with a disc brake.

Note:

If necessary, the grease nipples and plugs of the seal protector can be removed temporarily when attaching accessories to the housing interface.

Note:

Surface roughness (Ra) of the counterparts must be 12,5µm or better.

More detailed interface dimensions and tolerances are indicated on the product datasheet.

3.4.4 Hydraulic connections

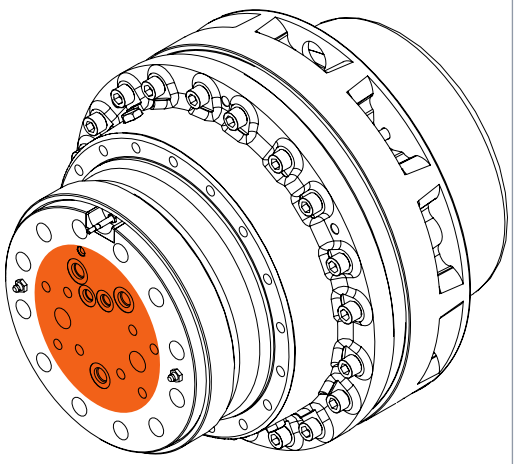


Figure 12. The interface of the motor hydraulics with parking brake.

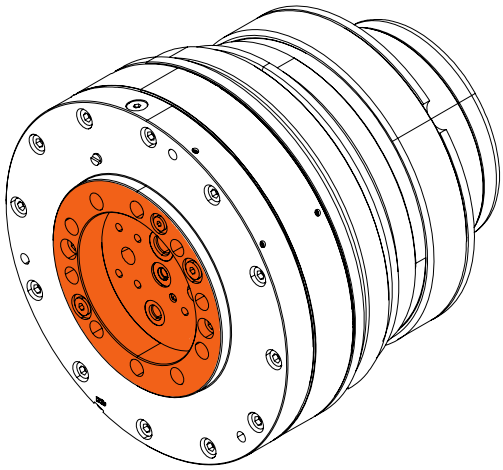


Figure 13. The interface of the motor hydraulics with double brake.

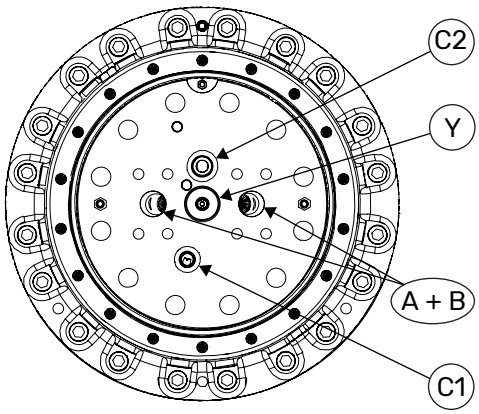


Figure 14. The hydraulic connections of a 2-speed C200 motor without brake.

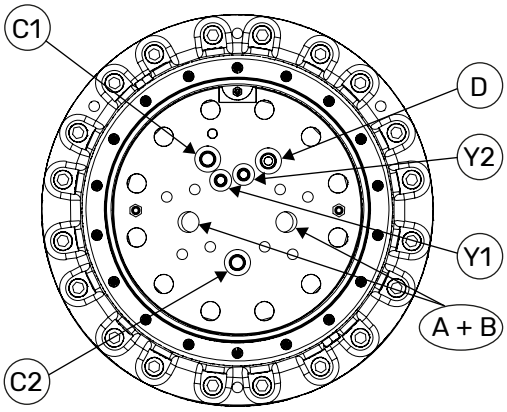


Figure 15. The hydraulic connections of a 4-speed C255 motor with parking brake.

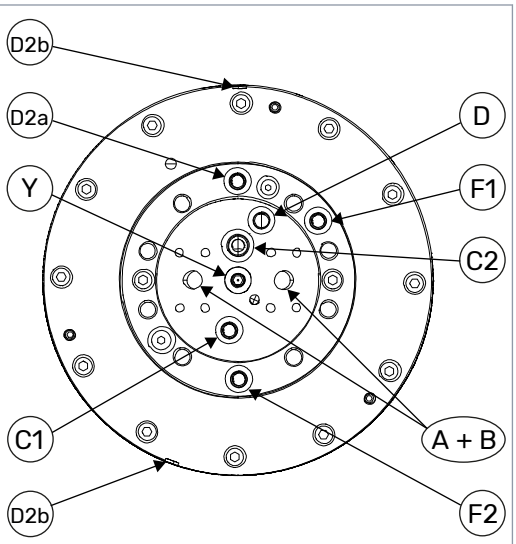


Figure 16. The hydraulic connections of a 2-speed C223 motor with a double brake.

Table 1: Sizes of the hydraulic connections (C200 series motors).

	Work ports A/B	Pilot port (s) Y, Y1/Y2	Case flushing port C1	Case drain port C2	Parking brake port D
C21x	1 1/16"-12 UNF	7/16"-20 UNF	9/16"-18 UNF	3/4"-16 UNF	9/16"-18 UNF
C22x	1 1/16"-12 UNF	7/16"-20 UNF	9/16"-18 UNF	3/4"-16 UNF	9/16"-18 UNF
C23x	SAE 3/4"	7/16"-20 UNF	9/16"-18 UNF	3/4"-16 UNF	9/16"-18 UNF
C250/C251	SAE 1" & G3/4"	7/16"-20 UNF	9/16"-18 UNF	3/4"-16 UNF	9/16"-18 UNF
C254/C255	SAE 1"	7/16"-20 UNF	9/16"-18 UNF	3/4"-16 UNF	9/16"-18 UNF
C26x	SAE 1"	7/16"-20 UNF	9/16"-18 UNF	3/4"-16 UNF	9/16"-18 UNF

Table 2: Sizes of the service brake and brake flushing connections (C22x and C23x motors).

	Service brake port D2a	Service brake port D2b	Brake flushing ports F1/F2
C22x	9/16"-18 UNF	7/16"-20 UNF	7/16"-20 UNF
C23x	7/16"-20 UNF	7/16"-20 UNF	9/16"-18 UNF

- 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.
- CASE DRAIN LINE PORT (C2) and CASE FLUSHING LINE PORT (C1)

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

  C200 motors are equipped with a case flushing line (C1). The flushing line is an extra case line. From a charge pump, or an alternative source, cool oil from reservoir is fed into motor housing through the flushing line (C1).

The case drain line is marked with C2. The case drain line is used for case drain and returning flush oil. To ensure motor functionality, C1 line has to be either plugged or used for flush flow in. C2 is always used for case drain flow out. Do not use C1 as case drain line.

- BRAKE PRESSURE PORTS (D, D2a and D2b)

  The motors with parking brake have brake release line marked with D.

  C2x2 and C2x3 series motors with service brake have service brake pilot lines marked with D2a and D2b.
- BRAKE FLUSHING LINE PORTS (F1 and F2)

  C2x2 and C2x3 series motors with service brake have service brake flushing lines marked with F1 and F2.
- PILOT LINE PORTS (Y or Y1 and Y2)

  The pilot line is meant for controlling a 2-speed or 4-speed motor (see *3.8 Multi-speed motors*).

Note:

The figures represent motor connections of specific models and are therefore only suggestive. For detailed information consult the motor manufacturer or its representatives.

3.4.5 Hub interfaces

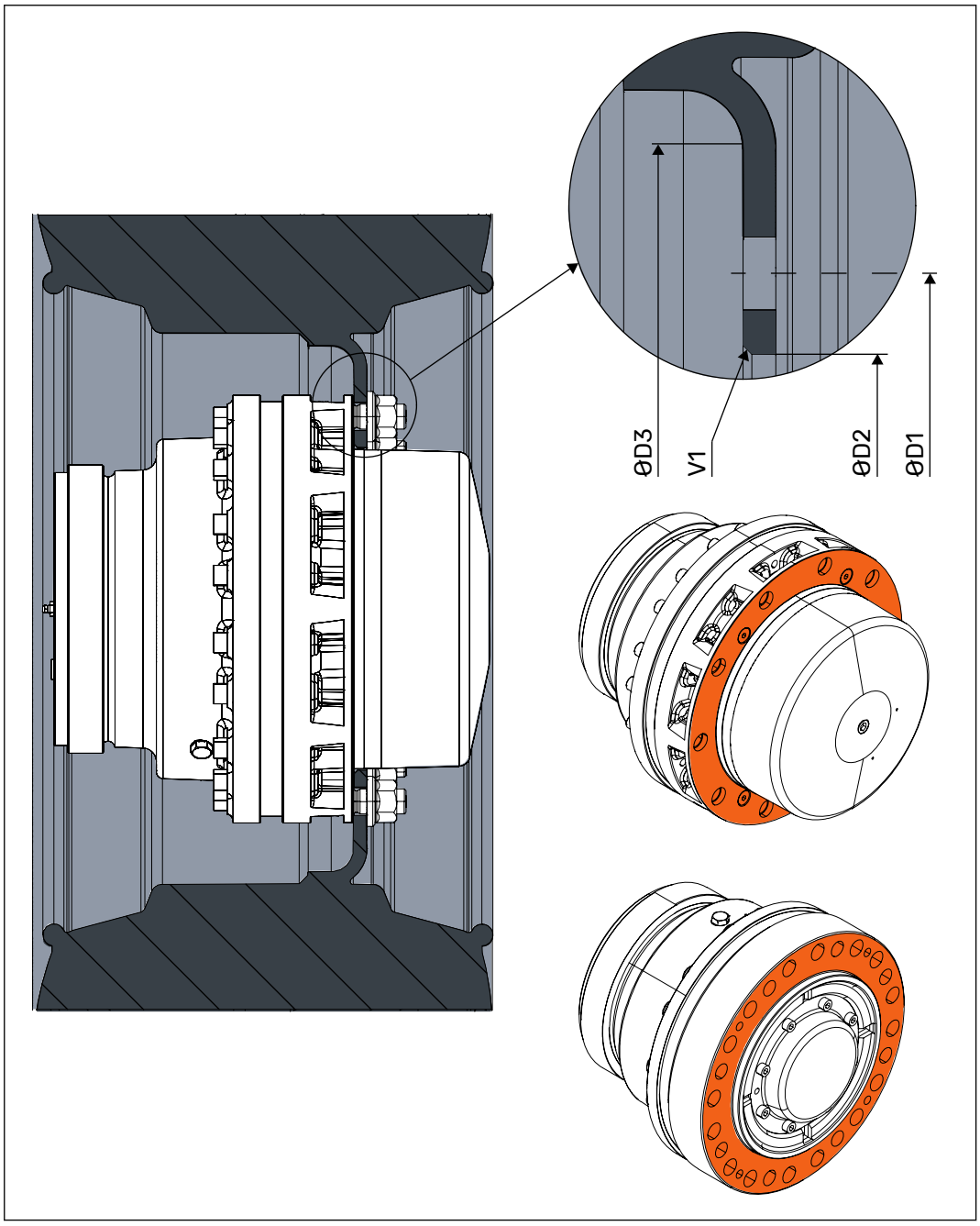


Figure 17. Dimensions of the hub interfaces.

INTERFACE DIMENSIONS		C21x	C22x	C23x	C25x	C26x
Hub interface						
D1	[mm]	225	225	275	335	335
	pattern	5x72°	5x72°	8x45°	10x36°	10x36°
	size	M22x1,5	M22x1,5	M20x1,5	M22x1,5	M22x1,5
	strength class [1]	10,9	10,9	10,9	10,9	10,9
	tightening torque [2] [Nm]	728	728	540	728	728

INTERFACE DIMENSIONS		C21x	C22x	C23x	C25x	C26x
D2	min. [mm]	176	176	221	281	281
V1	min. [mm]	1x45°	1x45°	1x45°	1x45°	1x45°
D3	min. [mm]	263	282	315	376	408

[1] Strength class as in ISO898-1. If using lower strength class, check interface load capacity and tightening torque.
[2] Declared values are for reference only. Always use application specific tightening torques when given.

The wheel rim or the rotatable device is attached to the motor hub.

Note:

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

There are multiple different type of fastening screws for hub interface. Select the hub screws according to the wheel rim design.

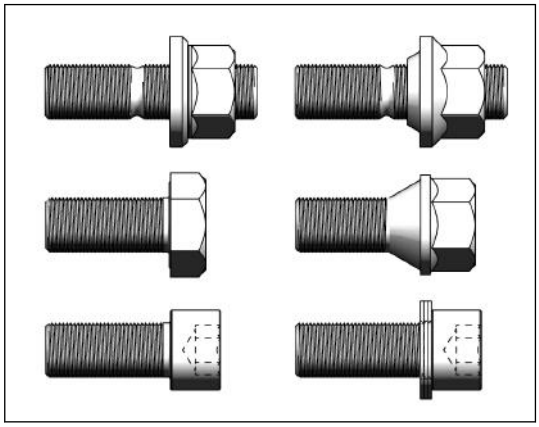


Figure 18. Hub fastening screw variants

3.5 Rotating direction

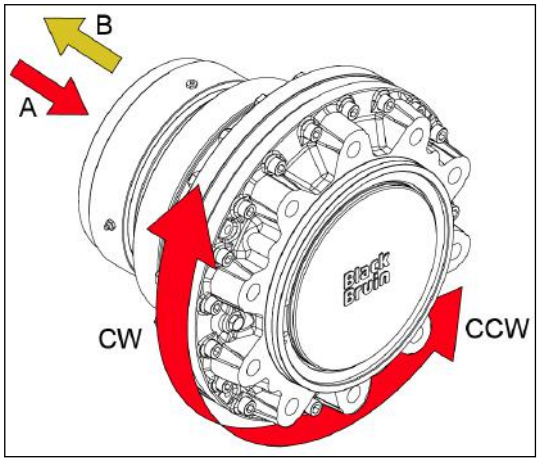


Figure 19. Rotating direction of the motor.

The rotating direction of the motor is defined as the rotating direction of the housing viewed from the hub to the shaft.

The rotating direction of the C200 series motor and the flow direction in the working lines is given in the table below.

Table 3: Rotating direction and flow direction of C200 motors.

ROTATING DIRECTION	flow direction	
	A → B	B → A
No preferred rotating direction	CW	CCW

3.6 Freewheeling

Hydrostatic freewheeling and mechanical freewheeling are options for C200 series motors. Mechanical freewheeling is not available for the C21x motor frames.

Black Bruin motors can be freewheeled without energy loss or overheating problems (stationary cylinder block - no centrifugal forces), even at high speeds. The motors can be re-engaged or disengaged during movement.

3.6.1 Hydrostatic freewheeling

Hydrostatic freewheeling requires a drain line check valve with 0.5 bar (8 psi) opening pressure and active feed between the check valve and the drain port of the motor.

A check valve in the drain line regulates the pressure in the case. To limit the pressure spikes in the case, the drain line and its check valve have to be sized to correspond with the maximum flow rate at the time of engagement.

In order to create the freewheeling pressure into the case, fluid must be supplied to flush port C1 between the motor and the check valve.

Hydrostatic freewheeling of a multispeed C200 series motor

In a multispeed (2- and 4-speed) C200 series motor without freewheeling springs, the freewheeling pressure is supplied to the motor case through case flushing line C1. A multispeed C200 series motor has an in-built check valve and thus no external check valve in case drain line is required.

The freewheeling valve should be positioned as close to the motor as possible to ensure smooth and rapid mode change.

3.6.2 Mechanical freewheeling

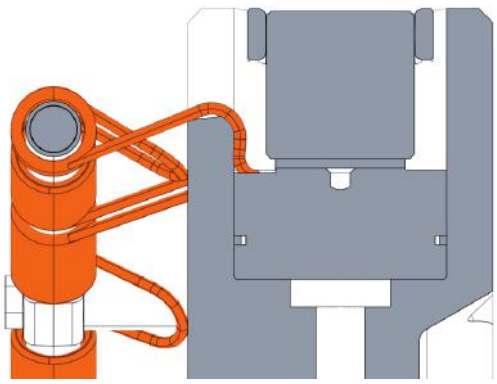


Figure 20. A piston with the freewheeling spring.

The motors can be equipped with mechanical freewheeling springs, which enable the motor disengagement. When there is no pressure in the working lines of the motor, the springs push the pistons down into the cylinders and hold them there. When disengaged the motor may be used without active fluid supply from the hydraulic system.

In systems using mechanical freewheeling, the drain line should be connected directly to the reservoir to ensure the lowest possible case pressure.

To ensure there is no pressure differential between the work lines A and B (acting under the pistons) and case drain line C (over the pistons), the three (3) lines are to be connected together in freewheel mode.

The external freewheeling valve should be positioned as close to the motor as possible to ensure smooth and rapid mode change.

USING THE FREEWHEELING

When the motor is depressurized and not rotating, the motor will disengage automatically. The motor disengagement during motion is done with a freewheeling valve.

The freewheeling valve can be a separate external valve, which connects the working lines (A and B) and the case drain line (C2) together. The purpose of the valve is to remove pressure difference over the motor pistons. This allows the pistons to retract with aid of mechanical springs.

- DISENGAGING THE MOTOR

  Open the freewheeling valve and depressurize the motor with the directional control valve to disengage the motor.

- ENGAGING THE MOTOR

  Close the freewheeling valve and pressurize the motor with the directional control valve to engage the motor.

The directional control valve and the freewheeling valve are usually activated simultaneously.

Attention:

Any pressure in the working lines (A and B) 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.

Note:

Another use of the freewheeling is a more extensive speed range for vehicles having several hydraulic motors. Hydraulic system capacity may be divided between fewer motors, when some of the motors are disengaged.

ROTATING SPEED

The rotating speed of the motor should be taken into account when implementing freewheeling.

- FREEWHEELING SPEED

  The freewheeling speed is the highest permissible rotating speed of the motor during freewheeling.

The permissible freewheeling speeds can be found on the technical data (see *3.3 Technical data, C200 series*).

DISENGAGING DELAY

While the pistons are retracting, there is a momentary flow of hydraulic fluid from the working lines to the casing of the motor. This causes always a small delay when disengaging the motor. Normal delay is about 1 - 2 seconds.

To minimize the disengaging delay, the hydraulic fluid should have as open channel as possible:

- The external freewheeling valve should be positioned as close to the motor as possible.
- All components and lines, which connect the working lines to the case drain line, should be sized for highest feasible flow rate.

Attention:

Without a freewheeling valve, the delay is considerably longer as the fluid must seep through the motor. Disengaging the motor during motion without a freewheeling valve may cause premature wear or failure of the motor.

3.7 1-speed motors

C2XX - BBBB - **1N0X** / D

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.

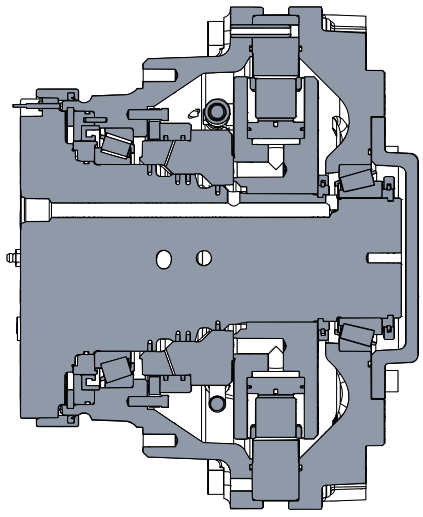


Figure 21. 1-speed motor.

3.8 Multi-speed motors

C2XX - BBBB - **2N0X** / D
C2XX - BBBB - **4N0X** / D

2- and 4-speed C200 motors do not have preferred rotational direction and can be operated at maximum rated power in both directions.

In 2-speed C200 motors, a 15-30 bar control pressure to Y port is required to activate 2-speed (partial displacement of a 2-speed motor).

Depressurizing the Y port will return the motor to full displacement. Do not use work/high pressure in Y port to control a standard 2-speed C200 motor.

C2x4 and C2x5 4-speed motors have high pressure shift ports (Y1 and Y2). To shift such motor, the highest available system pressure has to be applied to the shift port. Typically this highest system pressure is taken from motor work lines A and B by a shuttle valve.

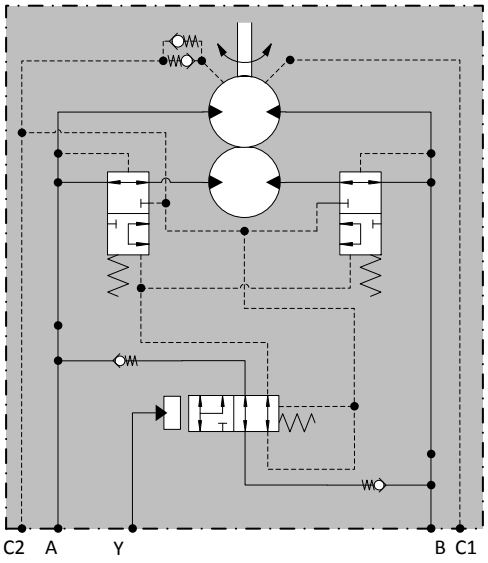


Figure 22. 2-speed C200 motor.

Attention:

Always use C2 port to connect the drain line of a multi-speed C200 motor. C1 can only be used for flush oil or to install an accumulator into the motor.

Attention:

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

- Hydraulic system supply must adjust to the rapid change of flowrate.
- 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, C200 series*).

Note:

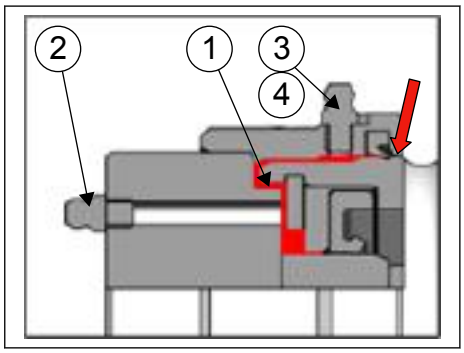
Depressurize the 2-speed spool pilot Y to case drain line to prevent unwanted spool movement.

3.9 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 (2 or 3): position may vary depending on motor model (2 or 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)

3.10 Brakes

There is a variety of brakes available for Black Bruin motors. Brakes, like motors, are designed in compact, powerful packages and tailored to meet the customer specific requirements in various applications.

3.10.1 Static wet multi-disc brake for C2x1, C2x3 and C2x5 series motors

The spring applied, pressure-to-release, wet multi-disc brake is a parking brake, but it can be used dynamically as an emergency brake.

For the minimum brake release pressure, refer to *3.3 Technical data, C200 series*. The brake operating pressure in C200 (low pressure brake) can not be higher than 30 bar. Depending on the Black Bruin frame size, the brake may have internal leakage (max. 0.6 l/min with oil viscosity of 35 cSt), which has to be considered in the brake circuit design. In C200 motors the brake can be manually released for emergency towing.

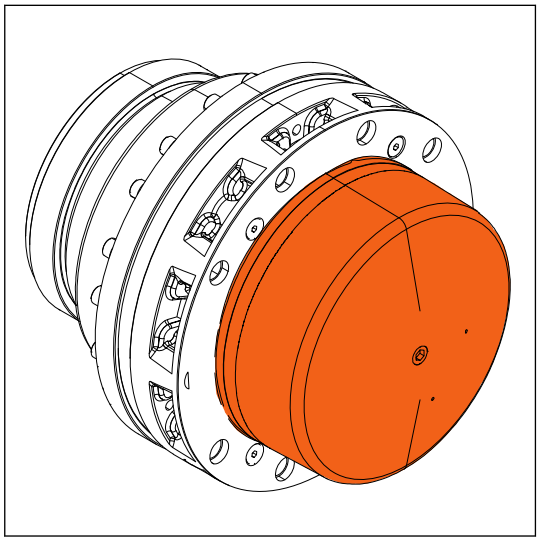


Figure 23. Static wet multi-disc brake

MANUAL BRAKE RELEASING

Ensure that the following things are in order before manually releasing the parking brake:

- Use a long bolt (grade 12.9) with a nut and a thick washer to release the parking brake.
- Ensure that the washer is larger than the brake cover hole diameter so that the cover won't damage.
- Add the nut and washer thickness to the depth to get the correct minimum length for the bolt. See Table 1 below.

Attention:

Using a bolt that is too short without a nut will damage the brake piston and may cause a dangerous situation.

The parking brake is released as follows:

1. Remove the taper plug from the brake cover using an allen wrench.
2. Place the washer against the brake cover. Insert the bolt with the nut into the hole of the brake cover.
3. Turn the bolt to the bottom of the threaded hole in the brake piston by hand. Make sure you turn the bolt all the way in. Also turn the nut against the washer by hand.
4. Holding the bolt stationary, tighten the nut about one full turn. Now the brake piston and the cup springs are pulled/drawn towards the brake cover in order to release the brake.

Note:

The tightening of the nut requires a lot of force which depends on the brake size and the friction of the parts. Excessive tightening may cause the brake piston to crack. Stop tightening when you feel the the cup springs stiffen.

Table 4: Needed tools for brake releasing

Motor frame size	C211	C221/C223	C231/C233	C251/C255/ C265
Brake cover hole Ø (mm)	16	16	20	20
Releasing bolt size (mm)	M12	M12	M16	M16
Releasing bolt thread min. (mm)	50	50	50	60

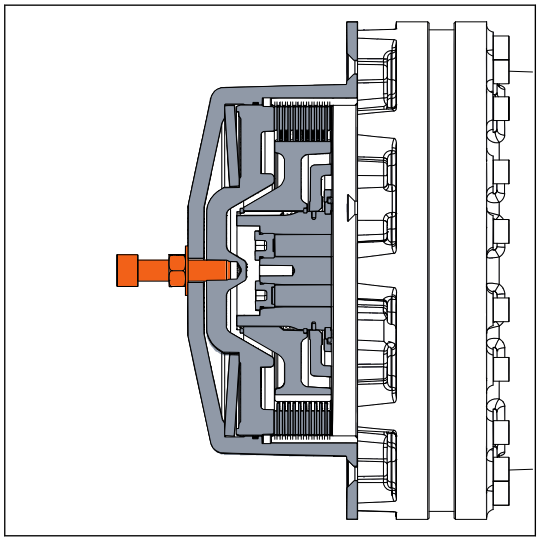


Figure 24. Mechanical brake release

3.10.2 Dynamic wet multi-disc brake for C2x2 and C2x3 series motors

The dynamic multi-disc brake is a pressure applied, spring release service brake. It is the ultimate brake for the most demanding conditions. The dynamic brake has cooling through flushing for dynamic use. It also has a well-sealed structure that isolates the brake from the environment and the motor from the brake.

The C2x3 motor has both a dynamic wet multi-disc brake and a static wet multi-disc low pressure brake.

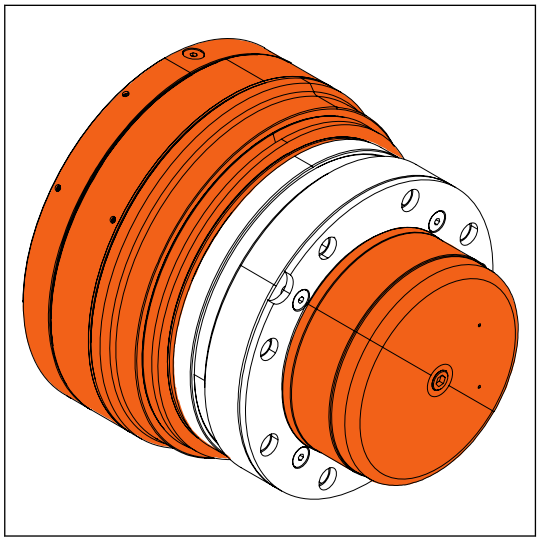


Figure 25. C2x3 motor's double brake

3.11 Speed sensor

It is possible to use the speed sensor with all C200 series motors, excluding the C2x2 and C2x3 series motors. Technical data of the speed sensor can be found below.

Table 5: Speed sensor pulse rate in C200 series motors.

PULSE RATE	C21x	C22x	C23x	C25x	C26x
Pulses per revolution	106	127	135	92	140

The 10-30V DC/200 mA speed sensor is an NPN-type sensor and includes a 2-meter cable. If a longer cable is used, a smaller resistor may also be needed.

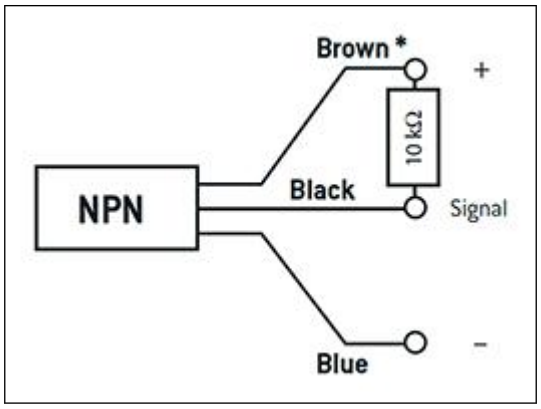


Figure 26. Coupling of the speed sensor.

For detailed sensor installation instructions, see the installation manual for the speed sensor.

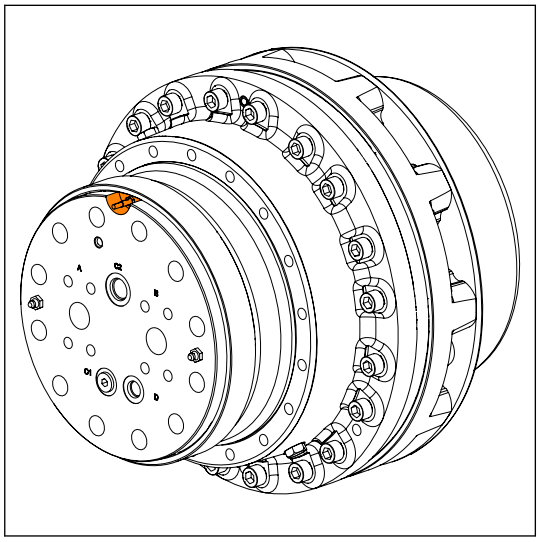


Figure 27. Speed sensor's location on the motor.

The speed sensor's location is on the motor's shaft interface. There must be space in the counter face for the sensor. The detailed dimensions of the sensor can be found on the motor's data sheet.

3.12 Accessories

3.12.1 Disc brake

It is possible to use disc brakes in C200 series motors, excluding the C2x2 and C2x3 series motors.

There are two disc brake series available as an accessory for the C200 series motor models.

The brake caliper is also available separately for all C200 series motor models.

Disc brake series

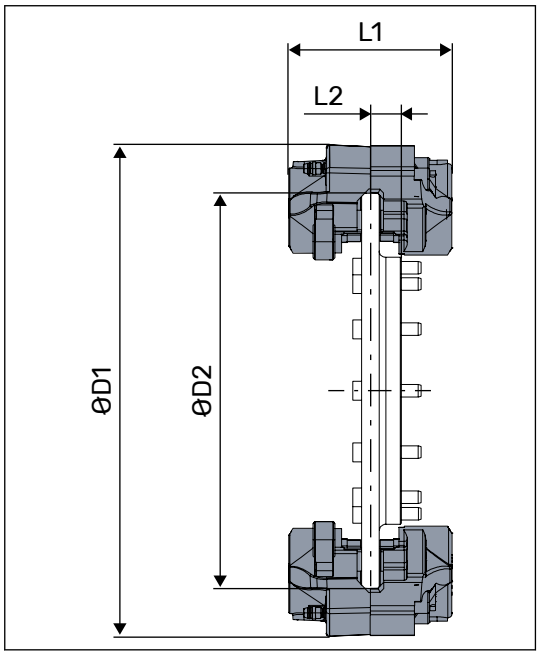


Figure 28. Main dimensions of the disc brake series.

MOTOR		**C26x**	**C25x/C26x**
Item number		**K070500000**	**K020500000**
Brake			
L1	[mm]	148	148
L2	[mm]	24	40
D1	[mm]	545	545
D2	[mm]	468	468
Max. braking pressure [bar]		150	150
Fluid type		Mineral oil	Mineral oil
Caliper position		at 3 and 9	at 3 and 9
Braking torque with 2 calipers [Nm] [1)]		12200	12200

[1)] The braking torque is for information only. Braking performance should be ensured by testing and/or certification.

Brake caliper

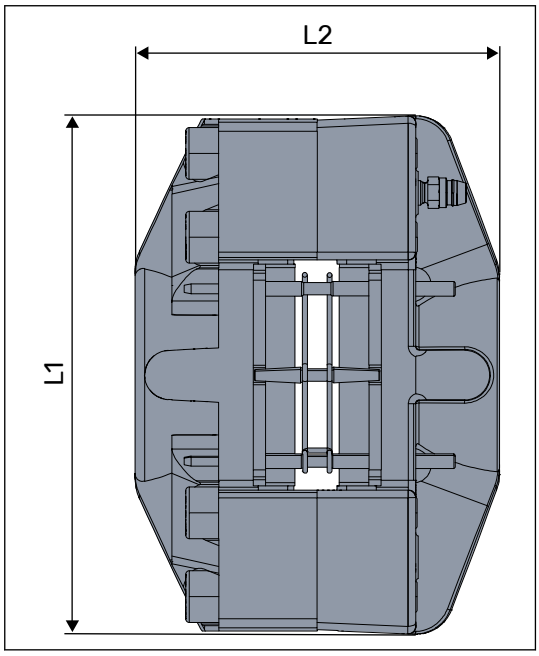


Figure 29. Main dimensions of the brake caliper.

MOTOR		**C200 series**
Item number		**1480500000**
Brake caliper		
L1	[mm]	214
L2	[mm]	148
Max. braking pressure [bar]		150
Fluid type		Mineral oil
Caliper position		at 3 and/or 9
Braking torque with one caliper [Nm]		3800 - 7600

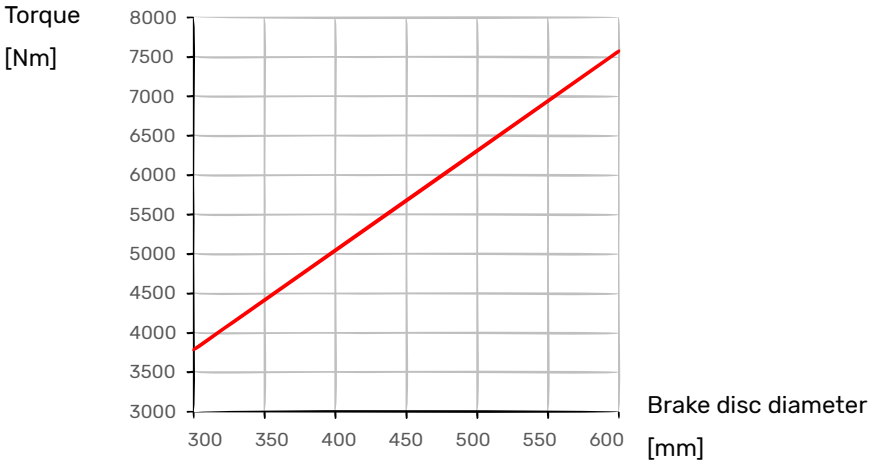


Figure 30. Disc brake torque.

4 System Design

4.1 Motor hydraulic circuit

4.1.1 Simple connection

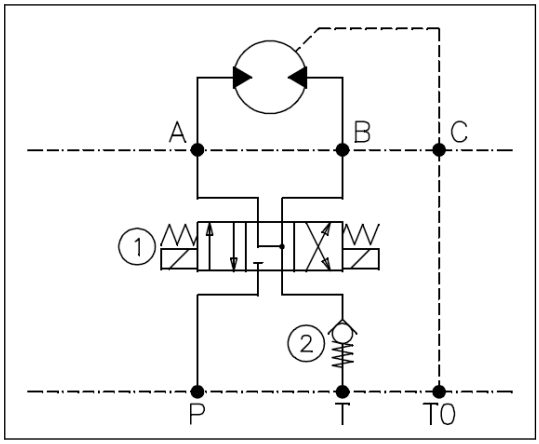


Figure 31. A simple motor hydraulic circuit in an open loop hydraulic system.

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 Motors in parallel or series circuit

The traction of a vehicle may be increased by connecting multiple motors in parallel or in series.

A single powered wheel may transmit only a certain amount of power to traction. By dividing the power to multiple wheels, the vehicle gets more traction. This is advantageous especially in slippery operating conditions.

PARALLEL CIRCUIT

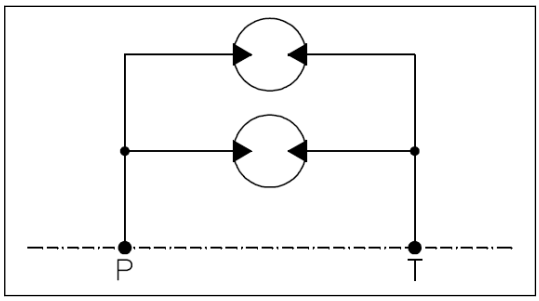


Figure 32. Two motors in parallel circuit.

Two motors in parallel circuit generate double torque and run half slower than one motor with the same flow rate and pressure.

Note:

The flow distribution of the motors must be ensured, if the operating conditions are very slippery or if some of the powered wheels carry much smaller load. The system prefers to rotate only the motor, which has the least resistance.

The flow distribution may be done by sizing the working lines to a certain flow rate or by throttling them slightly.

Ordinary flow divider valve can not be used in most cases, because its resistance of flow increases too much as the speed of the vehicle increases.

The flow distribution is usually required only when starting to move the vehicle. A reliable solution is a flow divider valve, which can be bypassed or switched on when necessary.

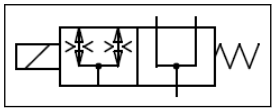


Figure 33. A pilot controlled flow divider valve.

SERIES CIRCUIT

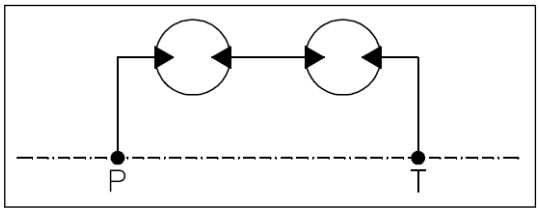


Figure 34. Two motors in series circuit.

Two motors in series circuit generate same torque and rotate as fast as one motor with the same flow rate and pressure.

Attention:

The minimum pressure and a sufficient feed flow must be ensured for all motors.

The use of series circuit is challenging and therefore is not recommended.

4.1.3 Counter pressure operation

Counter pressure operation is needed mainly in series connection (see *4.1.2 Motors in parallel or series circuit*). 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.

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, because high back pressure stresses the motor more than usual operation.

4.1.4 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.

4.1.5 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 *3.6.2 Mechanical freewheeling*).

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 External freewheeling valve

The external freewheeling valve is used for disengaging the motor during motion (see *3.6.2 Mechanical freewheeling*).

The freewheeling valve should be normally open, so that the motor will disengage when the control system is off.

When the motor is disengaged the case drain port (C) should be connected as directly as possible to the working line ports A and B.

There are multiple possibilities for the external freewheeling valve. Some examples of these possibilities are described in this chapter.

MECHANICAL FREEWHEELING, CHECK VALVE

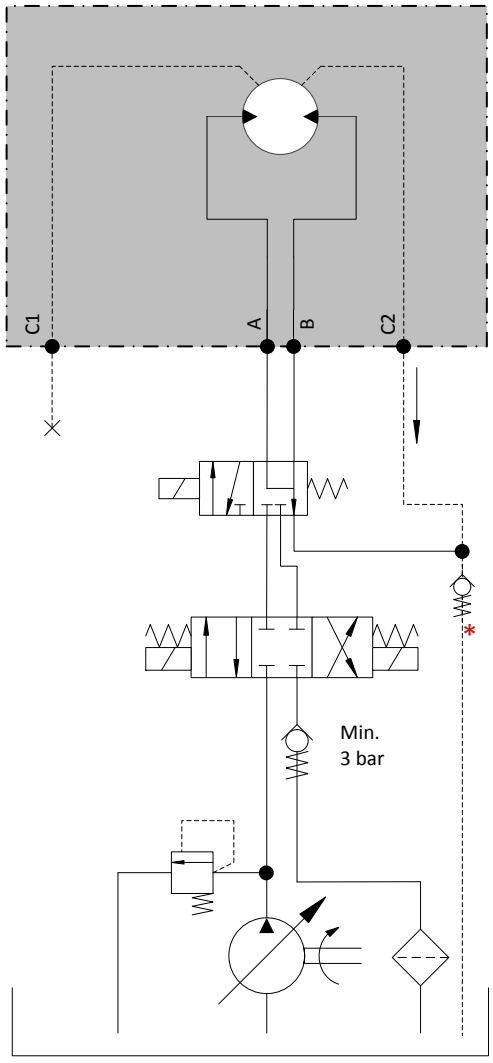


Figure 35. Motor with mechanical free-wheeling, external freewheeling valve and check valve.

MECHANICAL FREEWHEELING, 2/2 VALVE

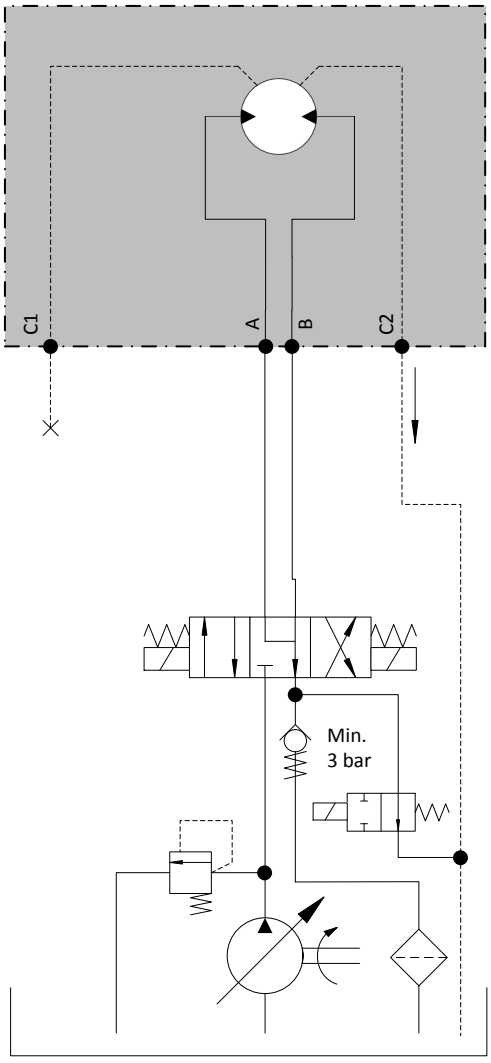


Figure 36. Motor with mechanical free-wheeling and a 2/2-valve to depressurize work lines to case drain (open loop).

MECHANICAL FREEWHEELING, CLOSED LOOP	HYDROSTATIC FREEWHEELING, OPEN LOOP

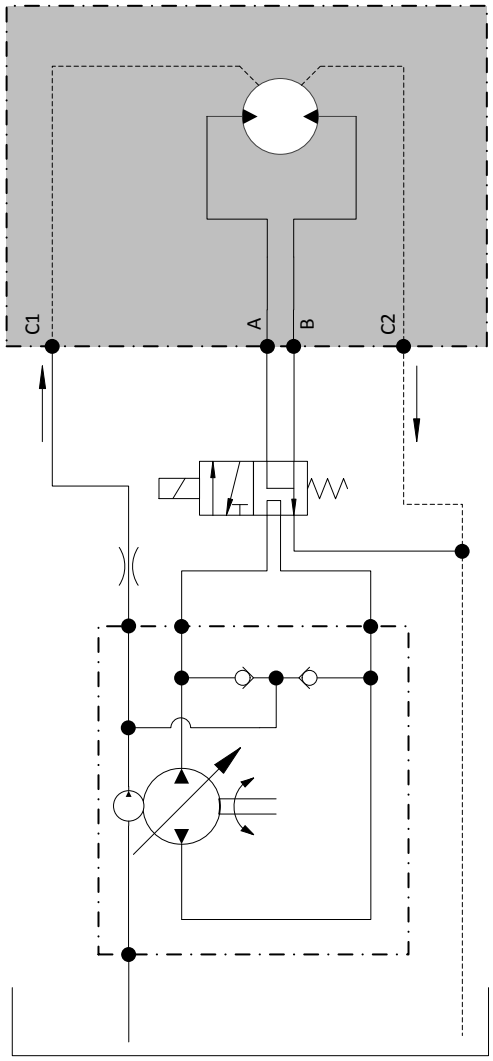
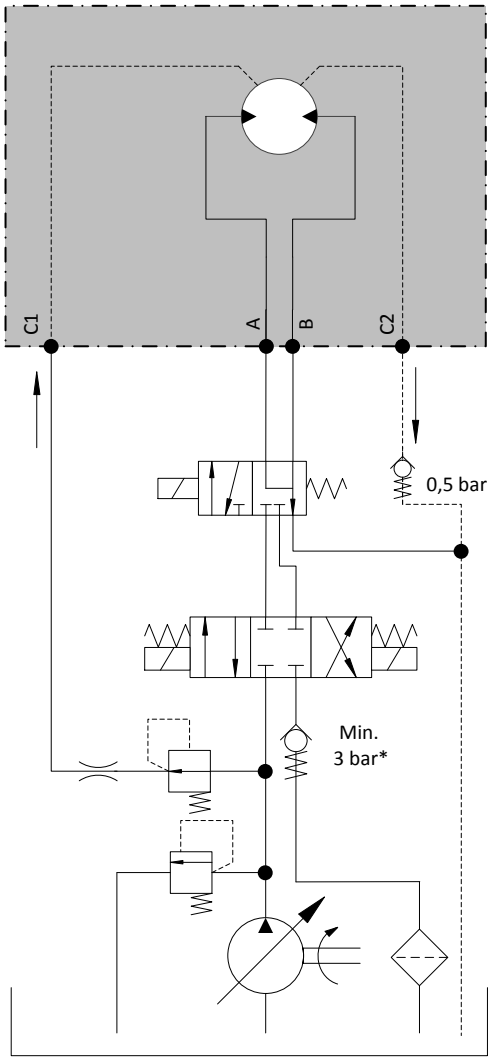

	

Figure 37. Motor with mechanical free-wheeling and external freewheeling valve (closed loop).	Figure 38. Motor with hydrostatic free-wheeling and external freewheeling valve (open loop).

HYDROSTATIC FREEWHEELING, CLOSED LOOP

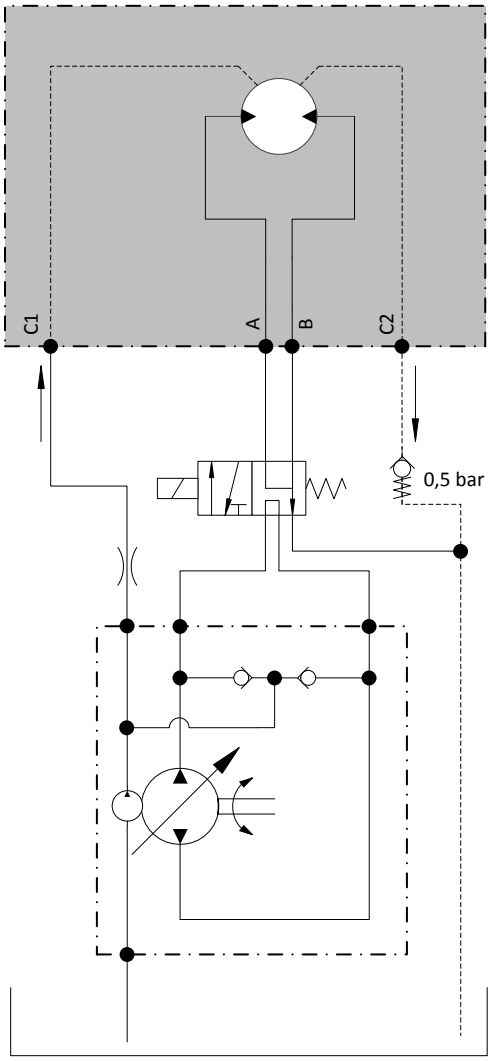


Figure 39. Motor with hydrostatic freewheeling and external freewheeling valve (closed loop).

HYDROSTATIC FREEWHEELING FOR 2-SPEED C200

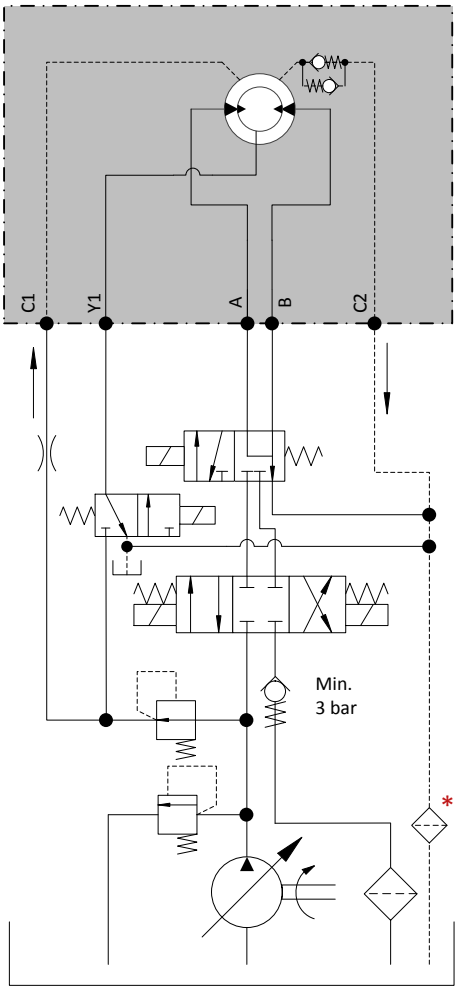


Figure 40. 2-speed C200 motor with hydrostatic freewheeling and external freewheeling valve in open loop system. Maximum case drain pressure 2 bar.

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.

Make sure that the motor case is always full of oil.

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.

If motor is placed above the reservoir, add check valve with 1 bar (15 psi) pressure to case drain line to ensure case oil fill. Maximum continuous case pressure 2 bar.

4.4.2 Pilot pressure

C200 2-speed motors
C2XX - BBBB - **2N00** / D
C2XX - BBBB - **2N10** / D
C2XX - BBBB - **2N01** / D
C2XX - BBBB - **2N11** / D

The pilot pressure is used to engage the options of the multi-speed motors.

The recommended pilot pressure is 15 to 30 bar and the maximum allowed pilot pressure is 350 bar.

For C200 4-speed motors, the pilot pressure is equal to the motor's working pressure.

Attention:

Over 30 bar pilot pressure causes case pressure peaks. This effect should be minimized with an orifice in the pilot line. Recommended orifice size is 1 mm.

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, C200 series*):

- 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).

MAXIMUM PRESSURE

Unless governed by the power limit, oil temperature or oil viscosity, the maximum pressure is the maximum continuous work pressure.

Motor life depends on average speed and pressure. The higher the pressure, the shorter the expected life. For Lh10 calculations, please consult the manufacturer.

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 minimum pressure guarantees continuous contact between cam rollers and cam ring.

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

- 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.

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.

Note:

Minimum work line pressure values are given at zero case pressure. To calculate system specific minimum pressure, add case pressure to the minimum pressure value from the chart.

The required minimum pressure depends on the rotational speed and case pressure. Recommended values for the minimum pressure at zero case pressure are on the following figures:

C200 series motors

WORKING LINE PRESSURE

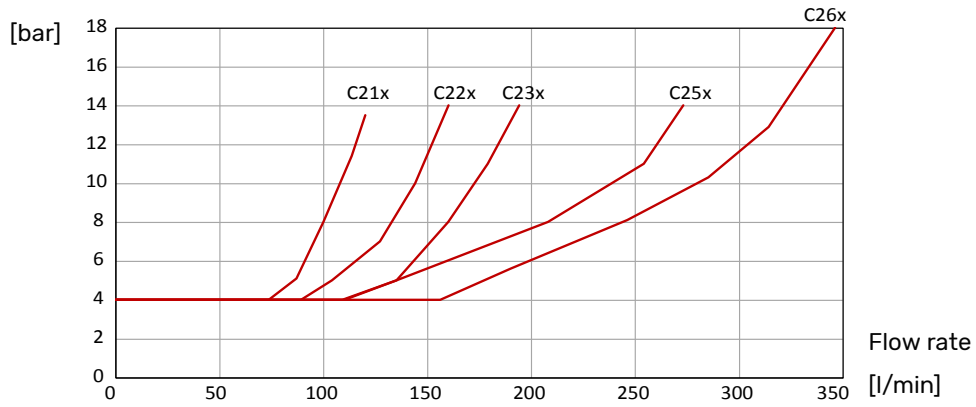


Figure 41. The minimum pressure at full displacement (fluid viscosity 35 cSt).

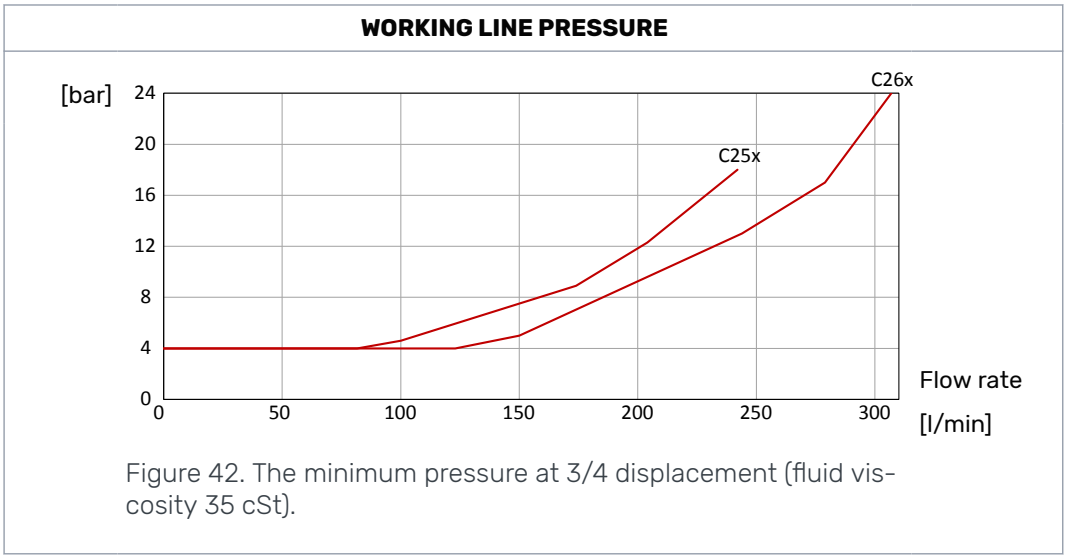


Figure 42. The minimum pressure at 3/4 displacement (fluid viscosity 35 cSt).

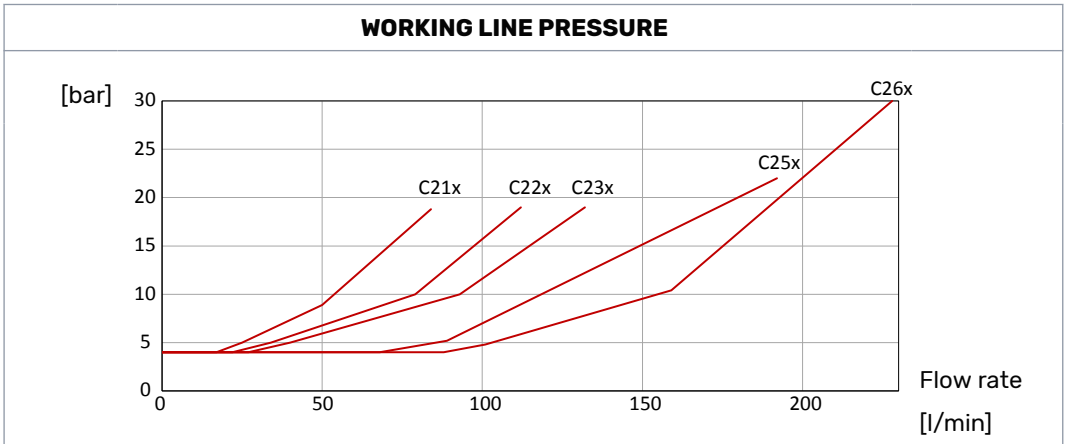


Figure 43. The minimum pressure at half displacement (fluid viscosity 35 cSt).

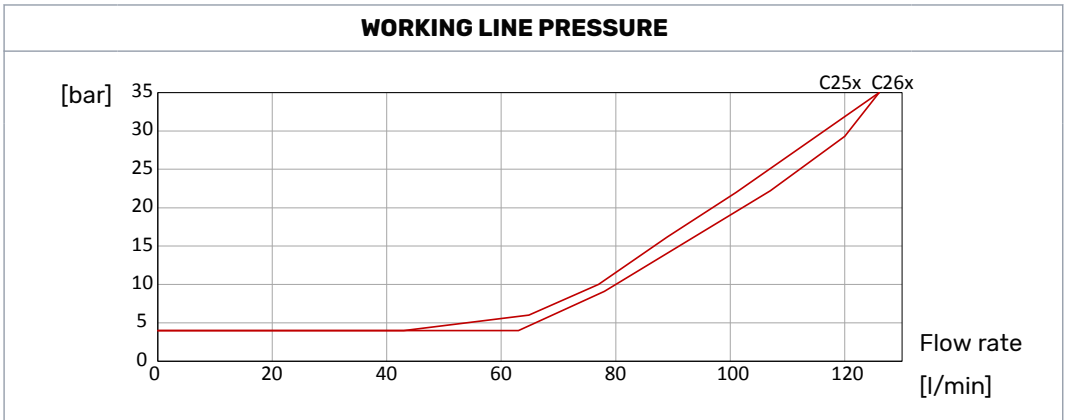


Figure 44. The minimum pressure at 1/4 displacement (fluid viscosity 35 cSt).

5 Motor Sizing

5.1 Load carrying capacity

5.1.1 Wheel offset

The load carrying capacity of the motor is defined by the offset value (a) of the wheel rim and the application specific safety factor.

The offset value is the distance from the wheel center line (CL) to the motor shaft interface. The load charts of the motors are given as a function of offset value. The given load curves refer to the average wheel load on a single motor.

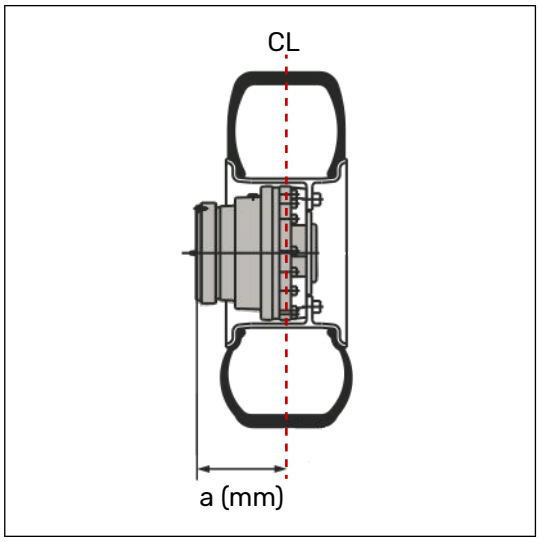


Figure 45. Measurement of the wheel offset (a).

Attention:

The motor load carrying capacity is applicable when the C2 port is orientated to the load direction (excluding the 4-speed motors).

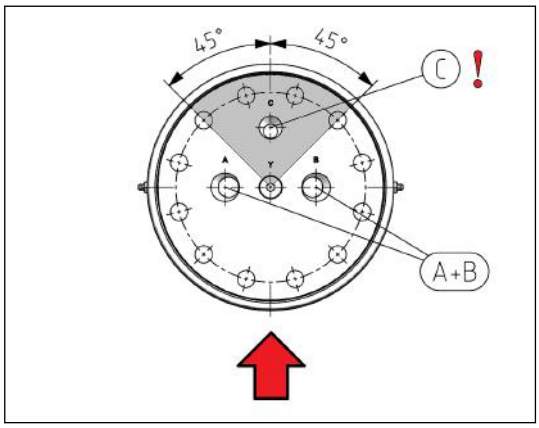
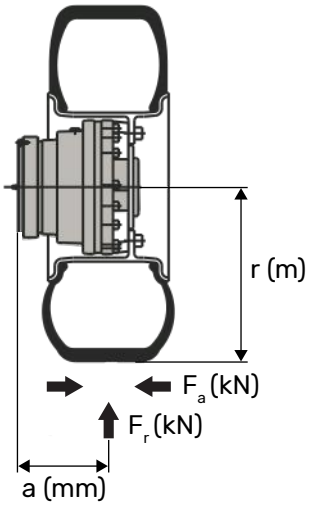


Figure 46. Motor orientation to the load direction.

5.1.2 Allowed wheel load

The allowed wheel load is based on the fatigue strength of the shaft (curved part) and the load carrying capacity of the screw joints (flat part). The maximum allowed wheel load depends on the load point. With applications combining high radial and axial loads, please consult the motor manufacturer or its representative to determine maximum permissible loading.



C200 series motors:

C21x:	$F_{max} \geq \alpha \times F_r + 6{,}25 \times r \times F_a$
C22x:	$F_{max} \geq \alpha \times F_r + 5{,}62 \times r \times F_a$
C23x:	$F_{max} \geq \alpha \times F_r + 5{,}41 \times r \times F_a$
C25x:	$F_{max} \geq \alpha \times F_r + 4{,}45 \times r \times F_a$
C26x:	$F_{max} \geq \alpha \times F_r + 4{,}0 \times r \times F_a$

Dynamic factor (α):

- constant loading at low speed, $\alpha = 1$
- variable loading, $\alpha = 1 - 1{,}5$
- shock loads or high speed (for > 70 km/h or 45 mph), $\alpha = 1{,}4 - 2$

C200 series motors

MOTOR LOAD CURVE: C21x, C22x AND C23x

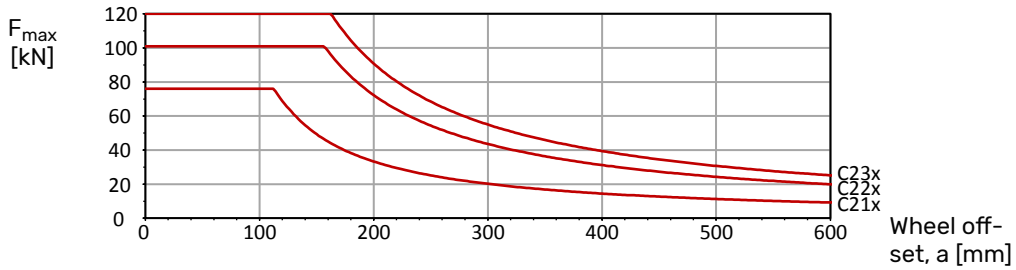


Figure 47. Motor load carrying capacity Fmax.

MOTOR LOAD CURVE: C25x AND C26x

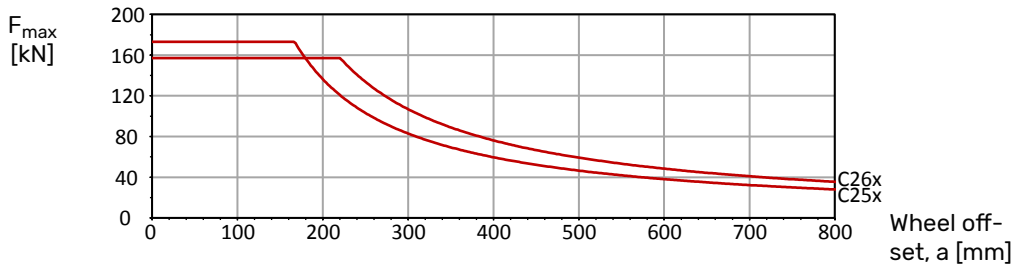


Figure 48. Motor load carrying capacity Fmax.

5.1.3 Service life

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

The service life may be estimated with the following equation:

$$L_{10h} = \frac{166\,667}{RPM} \cdot \left(\frac{F_{10m}}{F_r}\right)^{\frac{10}{3}}$$

L_{10h} = nominal service life [h]
RPM = rotating speed [rpm]
F_r = average wheel load [kN]
F_{10m} = bearing load carrying capacity [kN]

C200 series motors

BEARINGS LOAD CURVE: C21x, C22x AND C23x

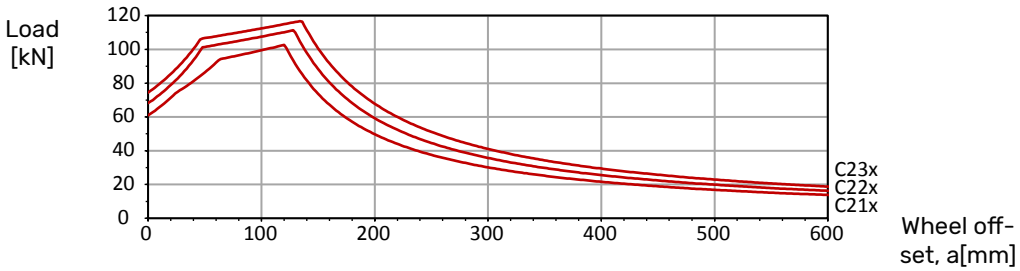


Figure 49. Bearing load carrying capacity F10m.

BEARINGS LOAD CURVE: C25x AND C26x

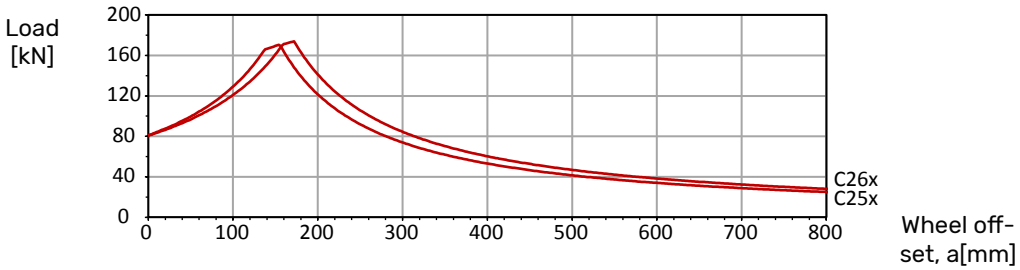


Figure 50. Bearing load carrying capacity F10m.

5.1.4 Axial load capacity

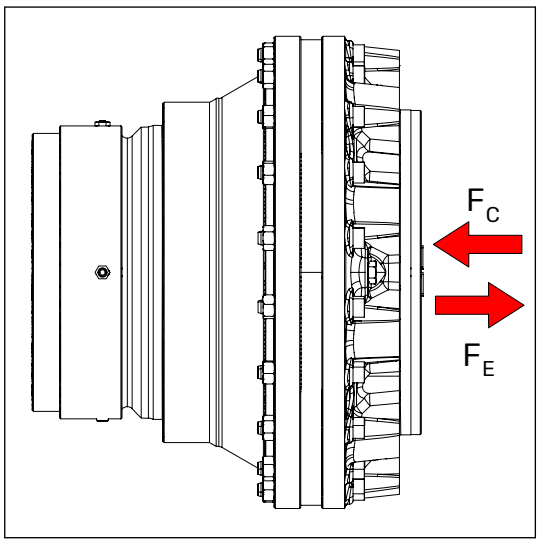


Figure 51. Axial load capacity of the motor.

MAX. AXIAL LOAD	C21x	C22x	C23x	C25x/C26x
Compression (F_C)	32 kN	42 kN	50 kN	72 kN
Expansion (F_E)	22 kN	27 kN	35 kN	61 kN

5.2 Performance

5.2.1 Rotating speed and flow rate

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

ROTATING SPEED

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

or

$$RPM = 2653 \cdot \frac{KMH}{R}$$

or

$$RPM = 9549 \cdot \frac{MPS}{R}$$

RPM = rotating speed [rpm]
KMH = vehicle speed [km/h]
MPS = vehicle speed [m/s]
R = wheel radius [mm]
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 2 rpm may be difficult to achieve.

WORKING SPEED - WHEEL RADIUS

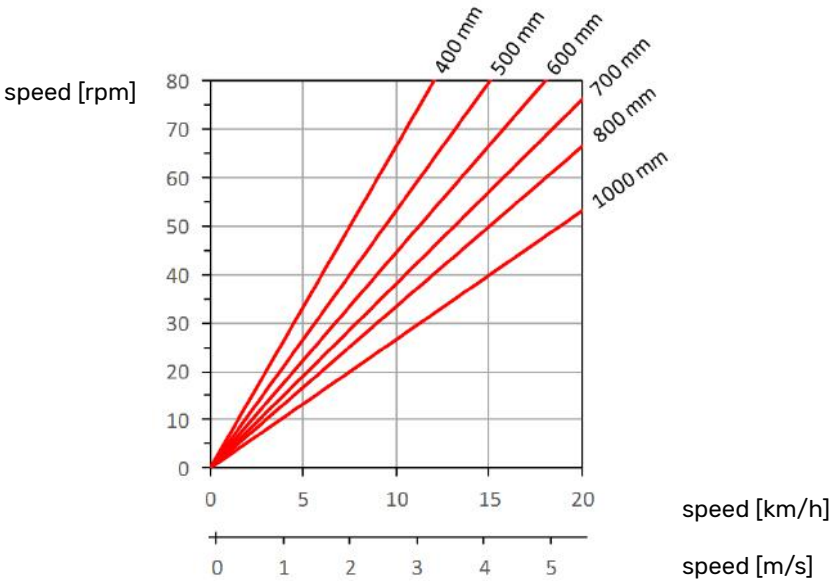


Figure 52. Vehicle speed and motor rotating speed with different wheel radius.

FREEWHEELING SPEED - WHEEL RADIUS

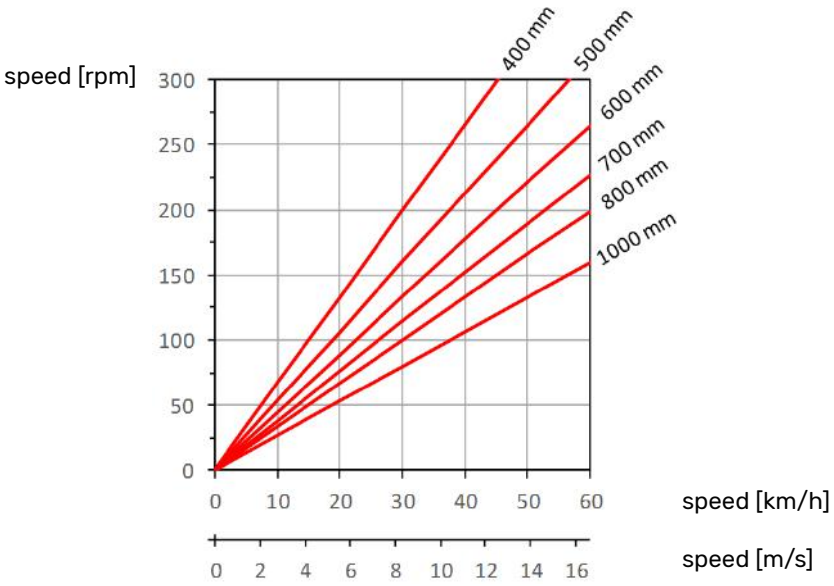


Figure 53. Vehicle freewheeling speed and motor rotating speed with different wheel radius.

5.2.2 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

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

STARTUP TORQUE

$$T_o = 0{,}75 \cdot T_{max}$$

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

5.2.3 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.

5.3 Performance charts

5.3.1 C200 motors performance curves

C21x

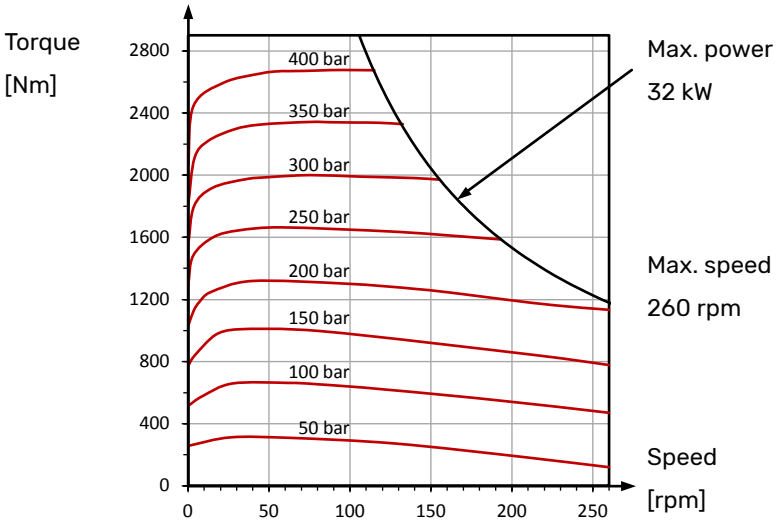


Figure 54. Performance curves C21x, 462ccm (fluid viscosity 35cSt).

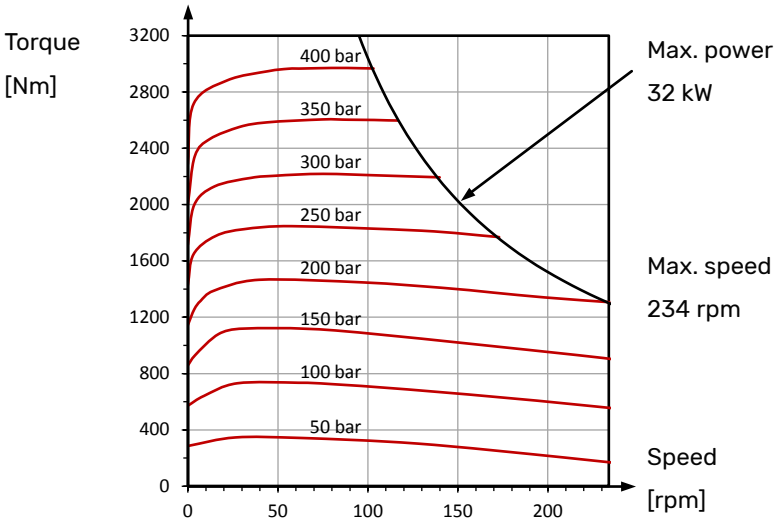


Figure 55. Performance curves C21x, 513ccm (fluid viscosity 35cSt).

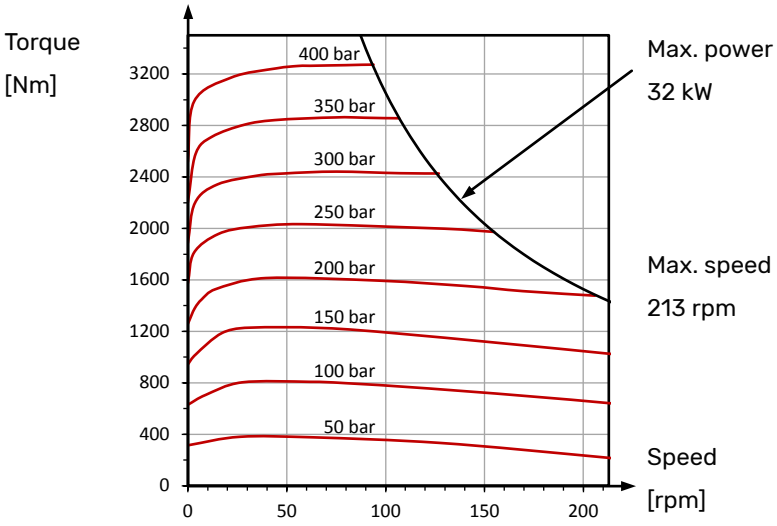


Figure 56. Performance curves C21x, 564ccm (fluid viscosity 35cSt).

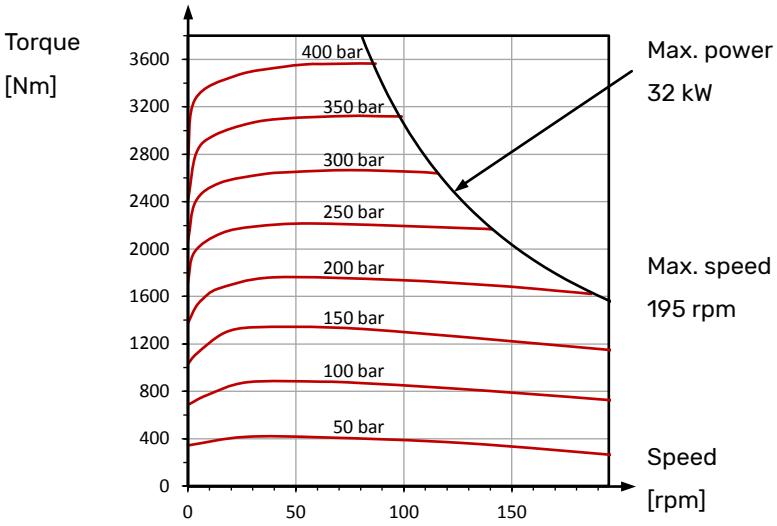


Figure 57. Performance curves C21x, 615ccm (fluid viscosity 35cSt).

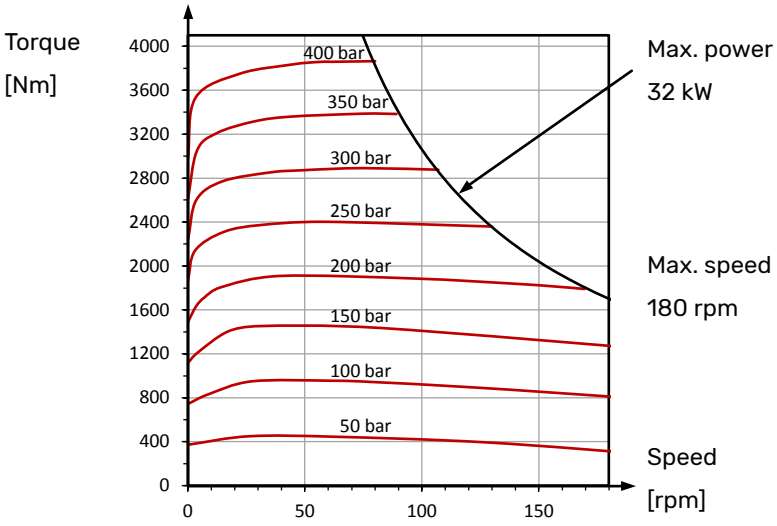


Figure 58. Performance curves C21x, 667ccm (fluid viscosity 35cSt).

C22x

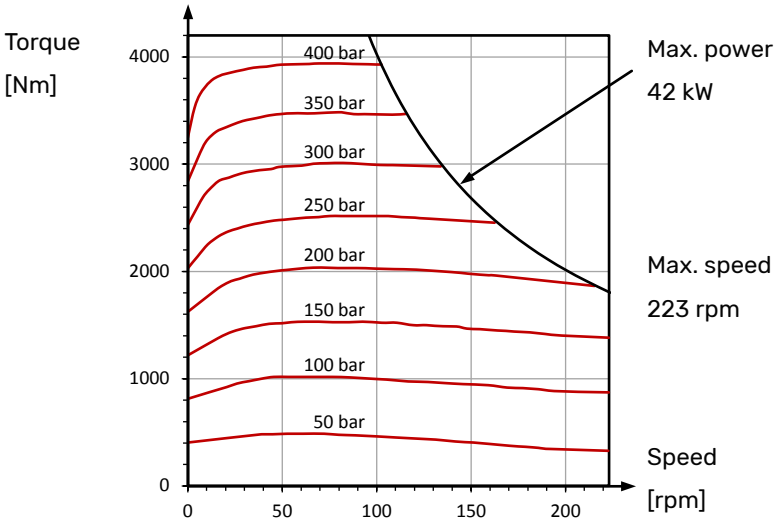


Figure 59. Performance curves C22x, 705ccm (fluid viscosity 35cSt).

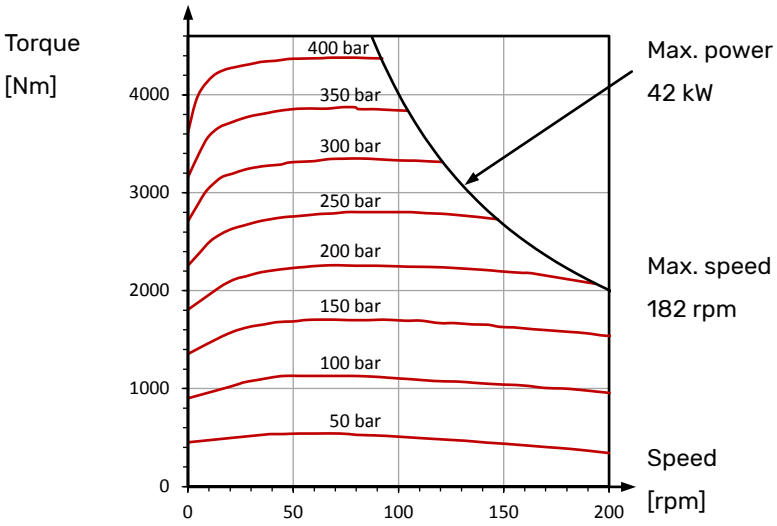


Figure 60. Performance curves C22x, 783ccm (fluid viscosity 35cSt).

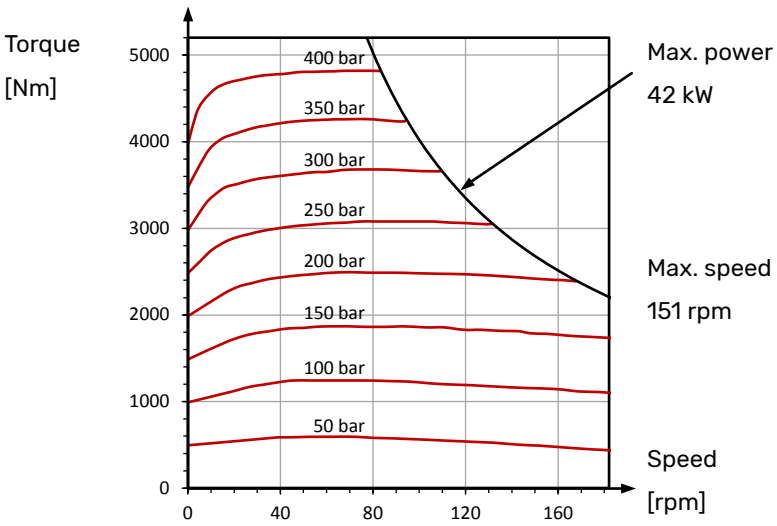


Figure 61. Performance curves C22x, 862ccm (fluid viscosity 35cSt).

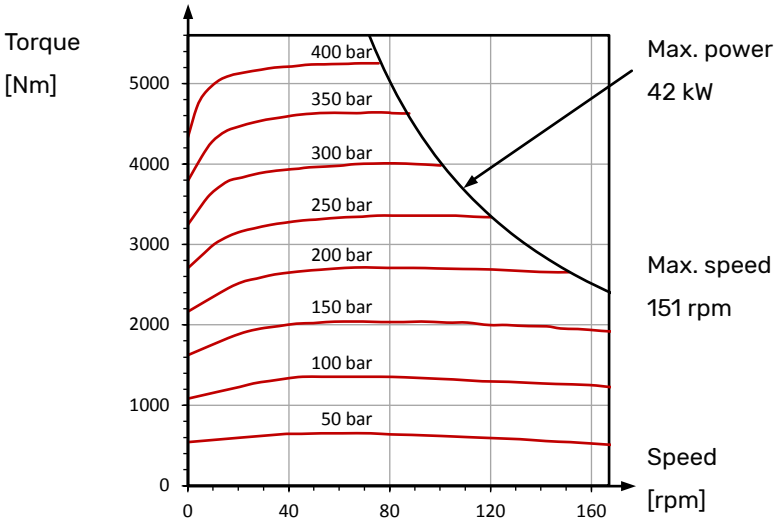


Figure 62. Performance curves C22x, 940ccm (fluid viscosity 35cSt).

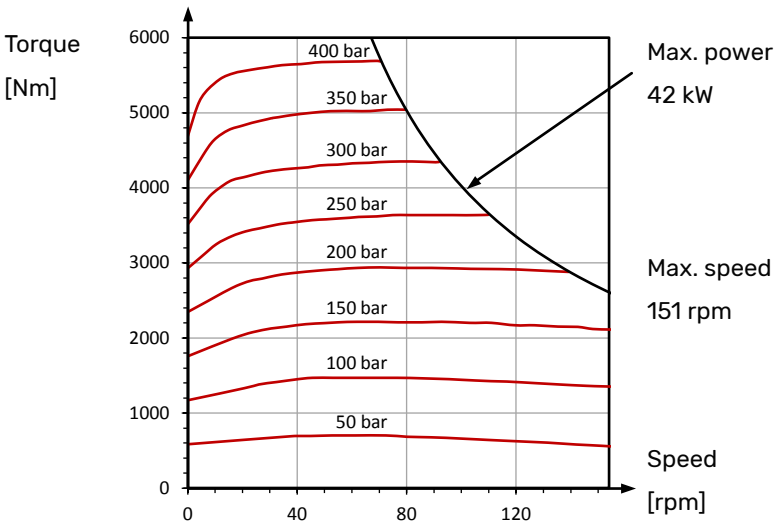


Figure 63. Performance curves C22x, 1018ccm (fluid viscosity 35cSt).

C23x

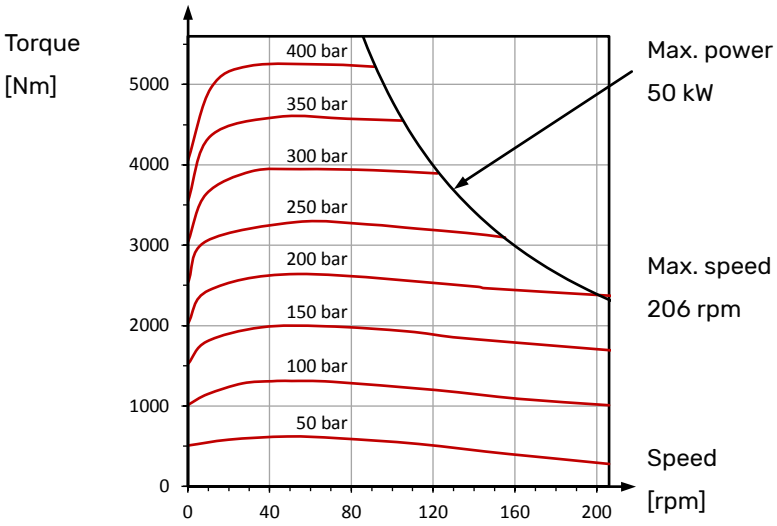


Figure 64. Performance curves C23x, 909ccm (fluid viscosity 35cSt).

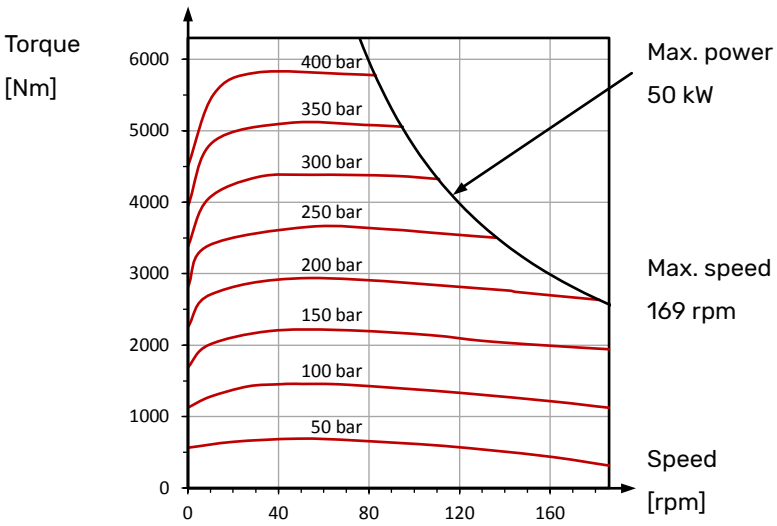


Figure 65. Performance curves C23x, 1010ccm (fluid viscosity 35cSt).

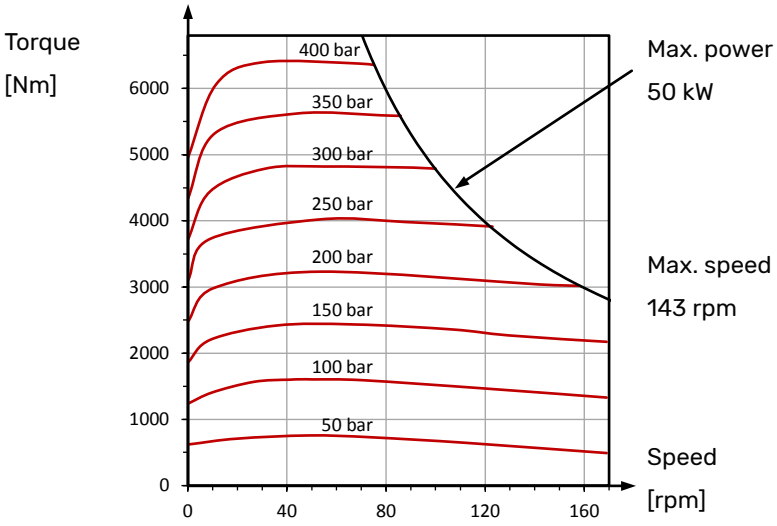


Figure 66. Performance curves C23x, 1111ccm (fluid viscosity 35cSt).

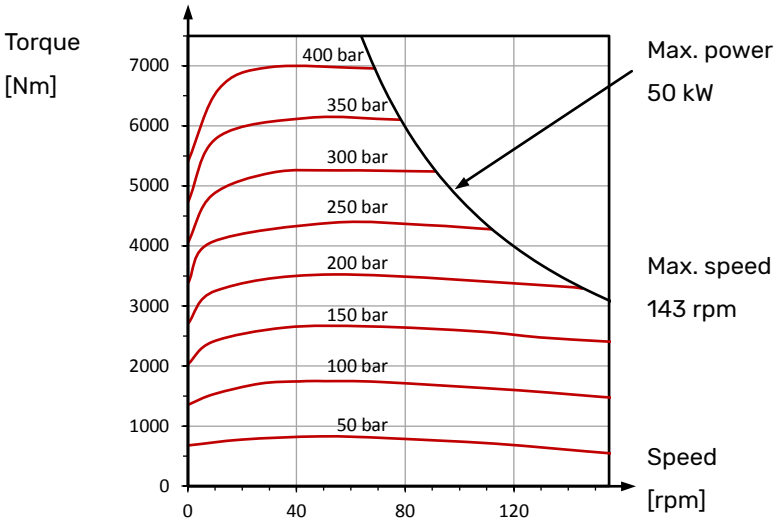


Figure 67. Performance curves C23x, 1212cm (fluid viscosity 35cSt).

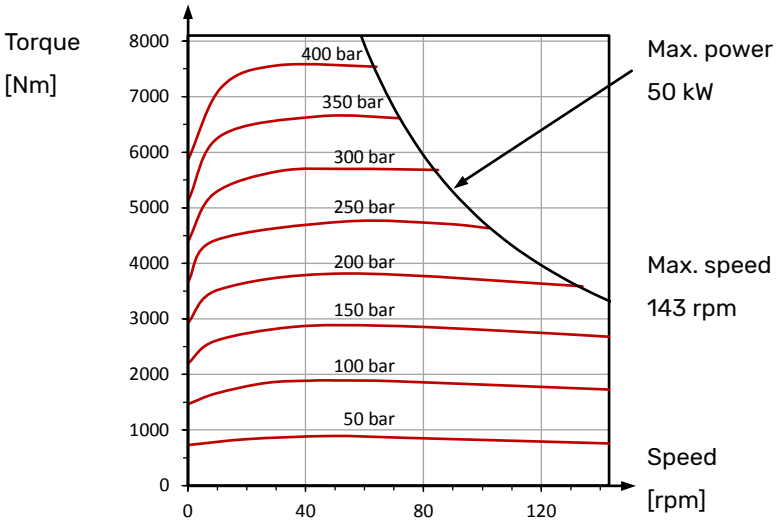


Figure 68. Performance curves C23x, 1313ccm (fluid viscosity 35cSt).

C25x

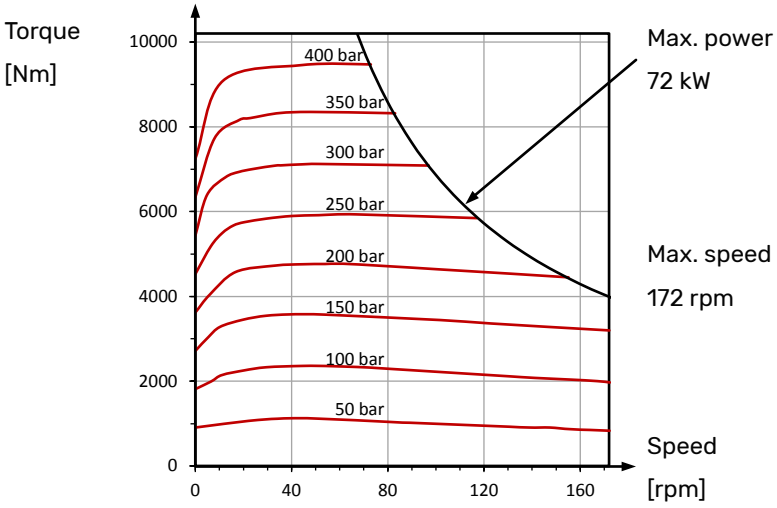


Figure 69. Performance curves C25x, 1572ccm (fluid viscosity 35cSt).

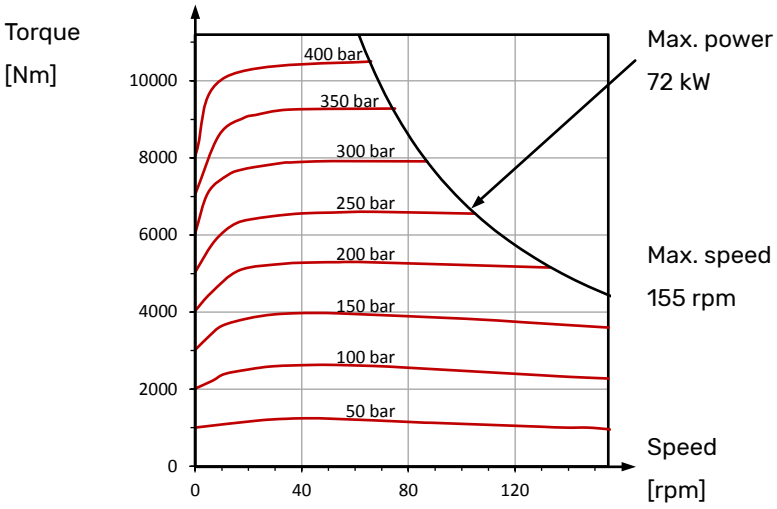


Figure 70. Performance curves C25x, 1747ccm (fluid viscosity 35cSt).

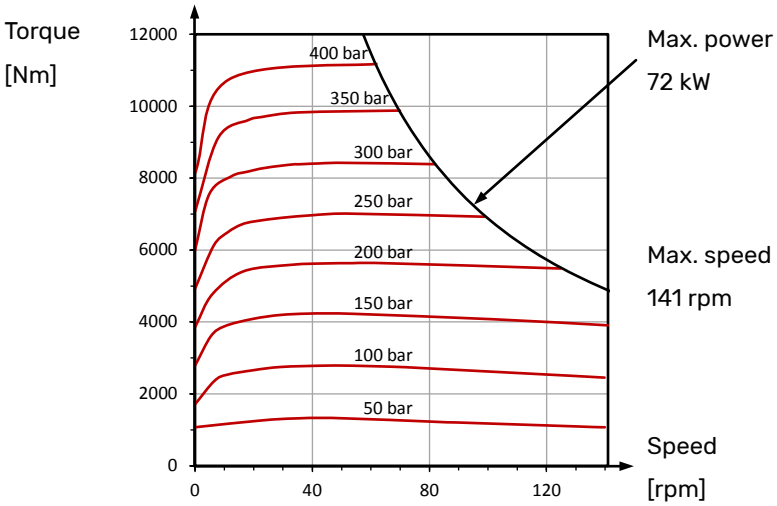


Figure 71. Performance curves C25x, 1922ccm (fluid viscosity 35cSt).

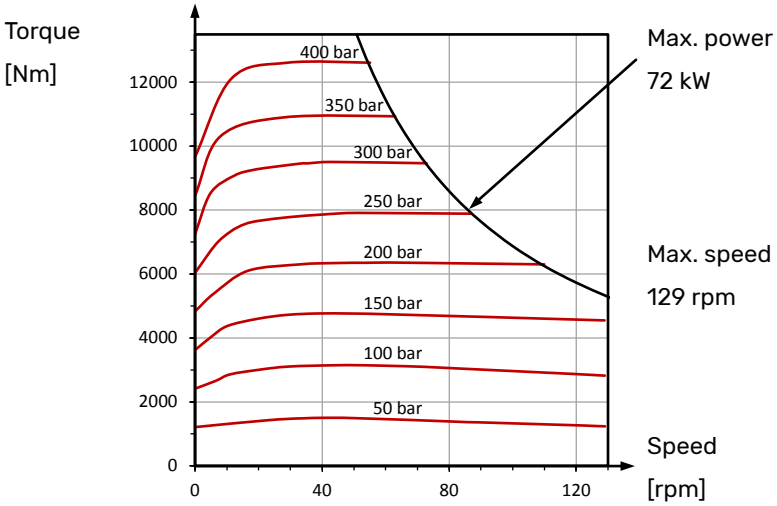


Figure 72. Performance curves C25x, 2096ccm (fluid viscosity 35cSt).

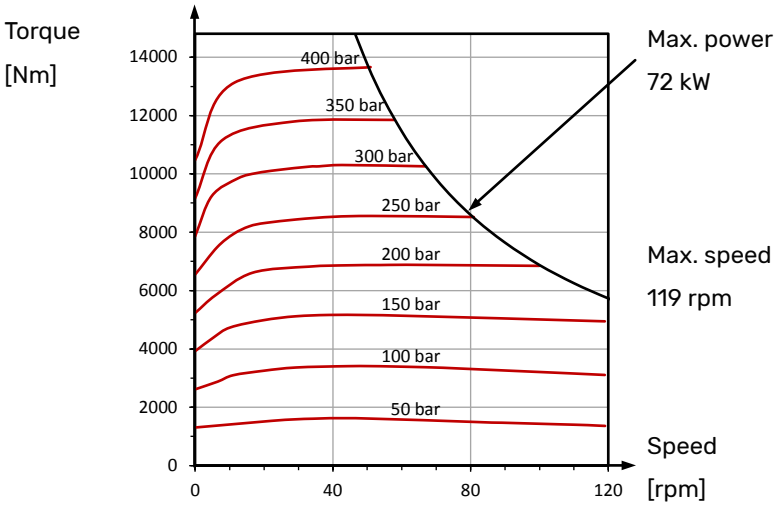


Figure 73. Performance curves C25x, 2271ccm (fluid viscosity 35cSt).

C26x

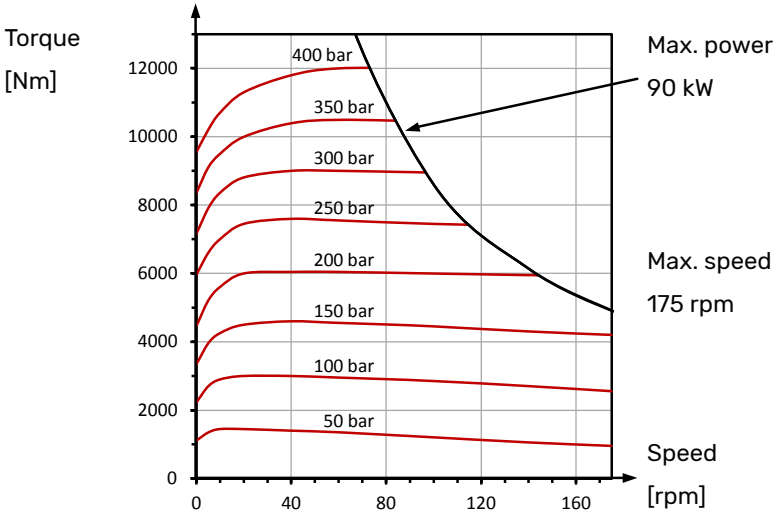


Figure 74. Performance curves C26x, 2000ccm (fluid viscosity 35cSt).

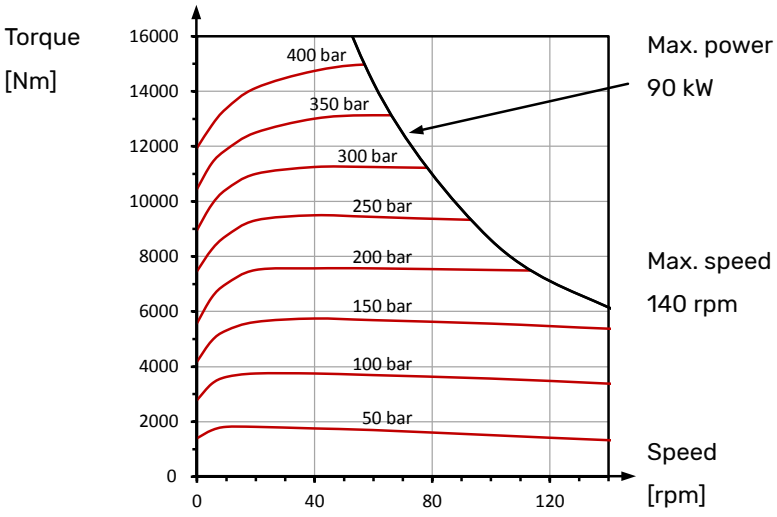


Figure 75. Performance curves C26x, 2500ccm (fluid viscosity 35cSt).

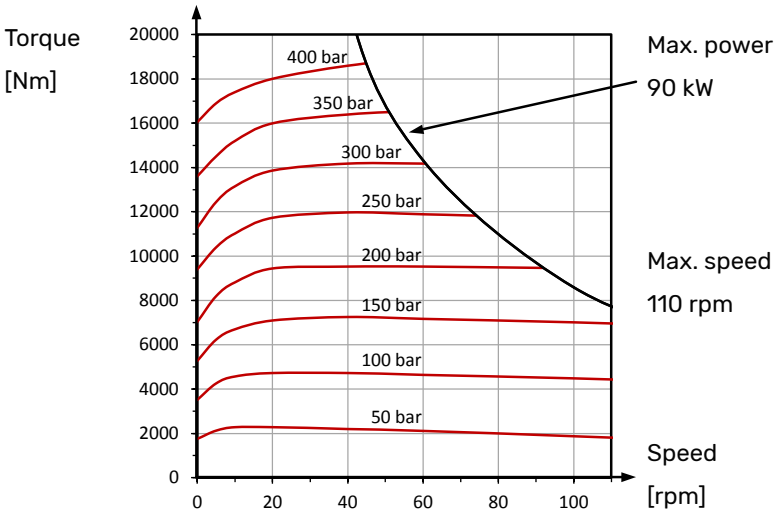


Figure 76. Performance curves C26x, 3150ccm (fluid viscosity 35cSt).

5.3.2 C200 motors case leakage

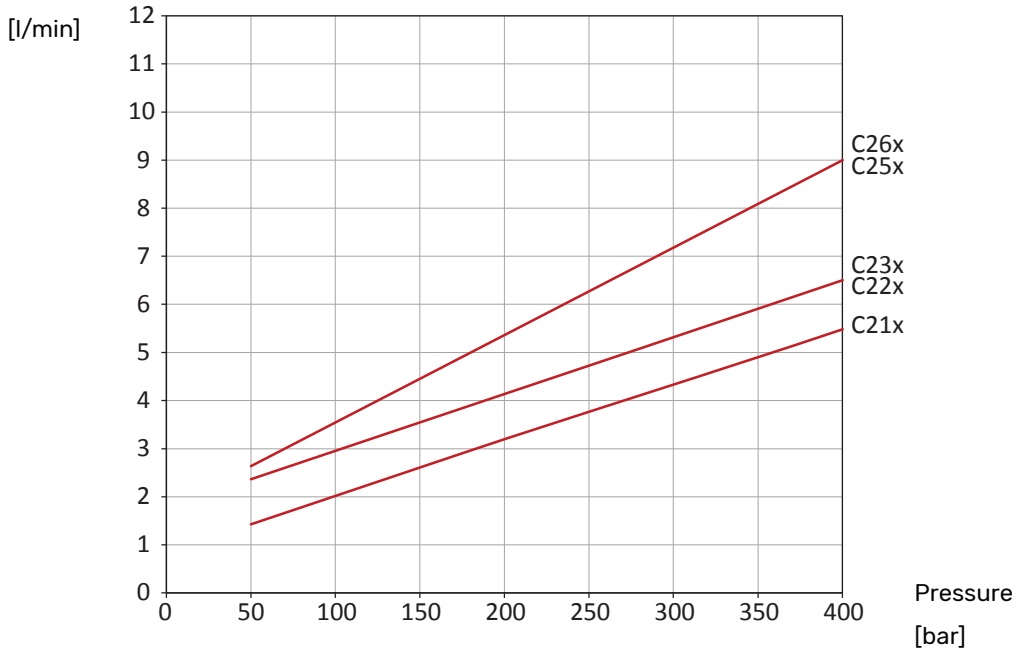


Figure 77. Case leakage curves of C200 series motors (fluid viscosity 35 cSt).

6 Installation Instructions

6.1 Conditions of installation and application

An Application Data Sheet (ADS) is used to select the correct Black Bruin hydraulic motor for each application. A filled and signed ADS is required for each motor model and application to validate the motor manufacturer's warranty. Always advise the motor manufacturer or its representative, when selecting motors for exceptional circumstances, like underwater applications, use with special fluids, etc.

6.2 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.

Attention:

When using stud bolts, do not tighten the bolt. Tightening of the stud bolt is done with the nut.

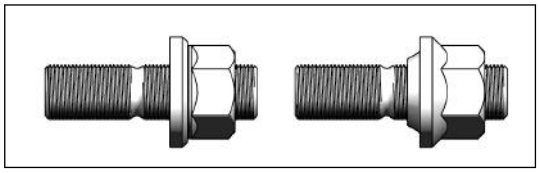


Figure 78. Stud bolt variants.

6.3 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.

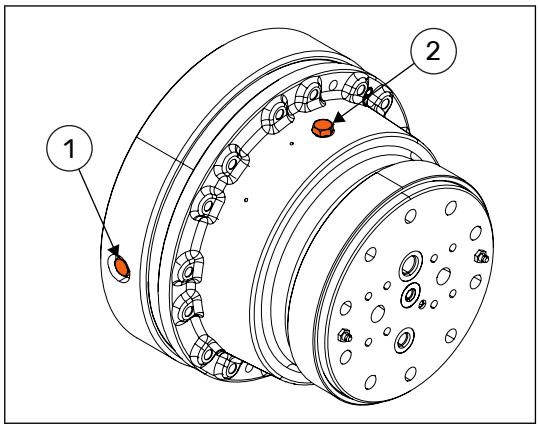
6.4 Hydraulic connections

Warning:

Do not apply the working pressure to the case drain line port (C, C1 or C2). This can break the motor.

Before you make any hydraulic connections to the motor, examine the motor product datasheet for the correct hydraulic connections.

6.5 Air bleeding procedure



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

- Locate the air bleed screws on the hub cover (1) or rear cover (2). Turn the motor to a position in which the bleed screw is at its topmost position.
- Make sure the drain line of the motor is connected.
- Feed hydraulic fluid into the motor with low pressure throughout the procedure (with system charge pressure or flow through the case drain line).
- Unscrew the air bleed screw by half a turn and wait for the air to bleed out.
- Close the screw when only hydraulic fluid is pouring through it.

Note:

If charge pressure is not available (open loop) or return flow through drain line is prevented, fill the case manually by pouring oil in through the bleed screw hole.

6.6 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:

- At the initial startup, start the motor without a load.
- 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. Refer to *7.1 Break-in period*.

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.

Note:

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

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

6.7 Tightening torques

SCREW / HARDNESS	HUB COVER, f10.9 (Nm)	SHAFT FLANGE, f12.9 (Nm)
M12	110	135
M14	180	215
M16	275	330
M18	383	460
M20	540	650
M22	728	874

The tightening torques are valid for standard and fine thread.

Note:

The maximum torque can be limited at lower value by the motor attachment.

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 the first eight hours (8 h) of use.
- Operate the motors at average of 50% of rated speed and pressure.
- Limit the power output by limiting the working pressure, the speed of rotation or both.
- Do not exceed 75% of the maximum pressure for more than two seconds every minute.

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 flange 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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