ENGINEERING
TOMORROW

Service Manual

K and L Frame
Variable Motors, Cartridge Mount

www.danfoss.com

Revision history

Table of revisions

Date	Changed	Rev
November 2023	Changed document number from 'AX00000042' and '520L0631' to 'AX152886481620'	0504
December 2018	Corrected technical data	0501
July 2017	Updated to Engineering Tomorrow	0402
April 2014	Danfoss layout	DA
July 2013	add anti-cavitation valve	CB
October 2010	new back page	CA
November 2006	Added loop flushing valve	B
July 2004	First edition	A

Contents

Introduction

Overview

This manual includes information for the installation, maintenance, and minor repair of the K and L Frame Cartridge Mount Variable Motors. The manual includes a description of the units and their individual components, troubleshooting information, and minor repair procedures. Performing installation, maintenance, and minor repair of K and L Frame Variable Motors according to the procedures in this manual will not affect your warranty.

Performing minor repairs requires the unit to be removed from the vehicle/machine. Thoroughly clean the unit before beginning maintenance, or repair activities. Since dirt and contamination are the greatest enemies of any type of hydraulic equipment, follow cleanliness requirements strictly. This is especially important when changing the system filter and when removing hoses or plumbing.

A worldwide network of Danfoss Authorized Service Centers (ASCs) is available for major repairs. Major repairs require the removal of the unit's endcap, which voids the warranty unless done by an ASC. Danfoss ASCs are trained by the factory and certified on a regular basis. You can locate your nearest ASC using the distributor locator at www.powersolutions.danfoss.com.

Safety precautions

Always consider safety precautions before beginning a service procedure. Protect yourself and others from injury. Take the following general precautions whenever servicing a hydraulic system.

Warning

Unintended machine movement

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable / disconnect the mechanism while servicing.

Warning

Flammable cleaning solvents

Some cleaning solvents are flammable. To avoid possible fire, do not use cleaning solvents in an area where a source of ignition may be present.

Warning

Fluid under pressure

Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury and/or infection. This fluid may also be hot enough to cause burns. Use caution when dealing with hydraulic fluid under pressure. Relieve pressure in the system before removing hoses, fittings, gauges, or components. Never use your hand or any other body part to check for leaks in a pressurized line. Seek medical attention immediately if you are cut by hydraulic fluid.

Warning

Personal safety

Protect yourself from injury. Use proper safety equipment, including safety glasses, at all times.

Symbols used in Danfoss literature

WARNING may result in injury

CAUTION may result in damage to product or property

Reusable part

Introduction


Non-reusable part, use a new part


Non-removable item


Option – either part may exist


Superseded – parts are not interchangeable


Measurement required


Flatness specification


Parallelism specification


External hex head


Internal hex head


Torx head

O-ring boss port


Tip, helpful suggestion


Lubricate with hydraulic fluid


Apply grease / petroleum jelly


Apply locking compound


Inspect for wear or damage


Clean area or part


Be careful not to scratch or damage


Note correct orientation


Mark orientation for reinstallation


Torque specification


Press in – press fit


Pull out with tool – press fit


Cover splines with installation sleeve

Introduction

Pressure measurement / gauge location or specification

The symbols above appear in the illustrations and text of this manual. They are intended to communicate helpful information at the point where it is most useful to the reader. In most instances, the appearance of the symbol itself denotes its meaning. The legend above defines each symbol and explains its purpose.

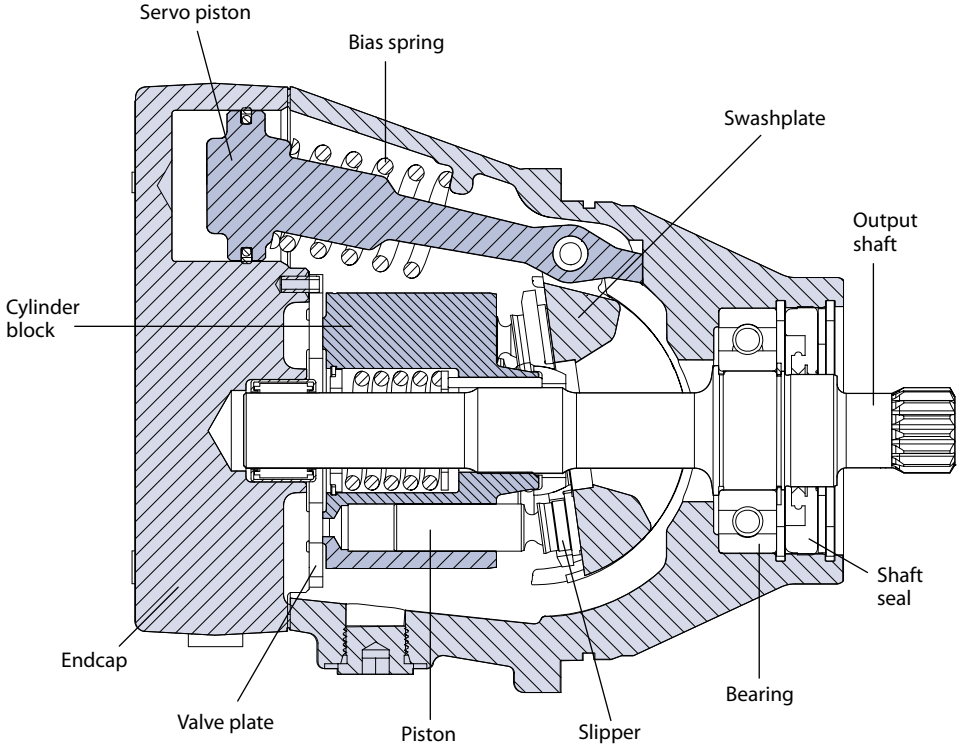
Design

K and L Frame Variable Motors (KC/LC) are low to medium power, two-position axial piston motors incorporating an integral servo piston. They are designed for operation in both open and closed circuit applications. KC/LC motors have a cartridge style mounting configuration. The standard control is a direct acting single line hydraulic control. The integral servo piston controls motor displacement.

The motor is spring biased to maximum displacement and hydraulically shifted to minimum displacement. Minimum and maximum displacement can be set with fixed internal stops. The large diameter servo piston allows smooth acceleration and deceleration with relatively large circuit orificing.

The motor is ideally configured for installations requiring compact packaging and optimized plumbing, such as wheel ends. One face of the motor contains all hydraulic porting.

KC/LC cross section

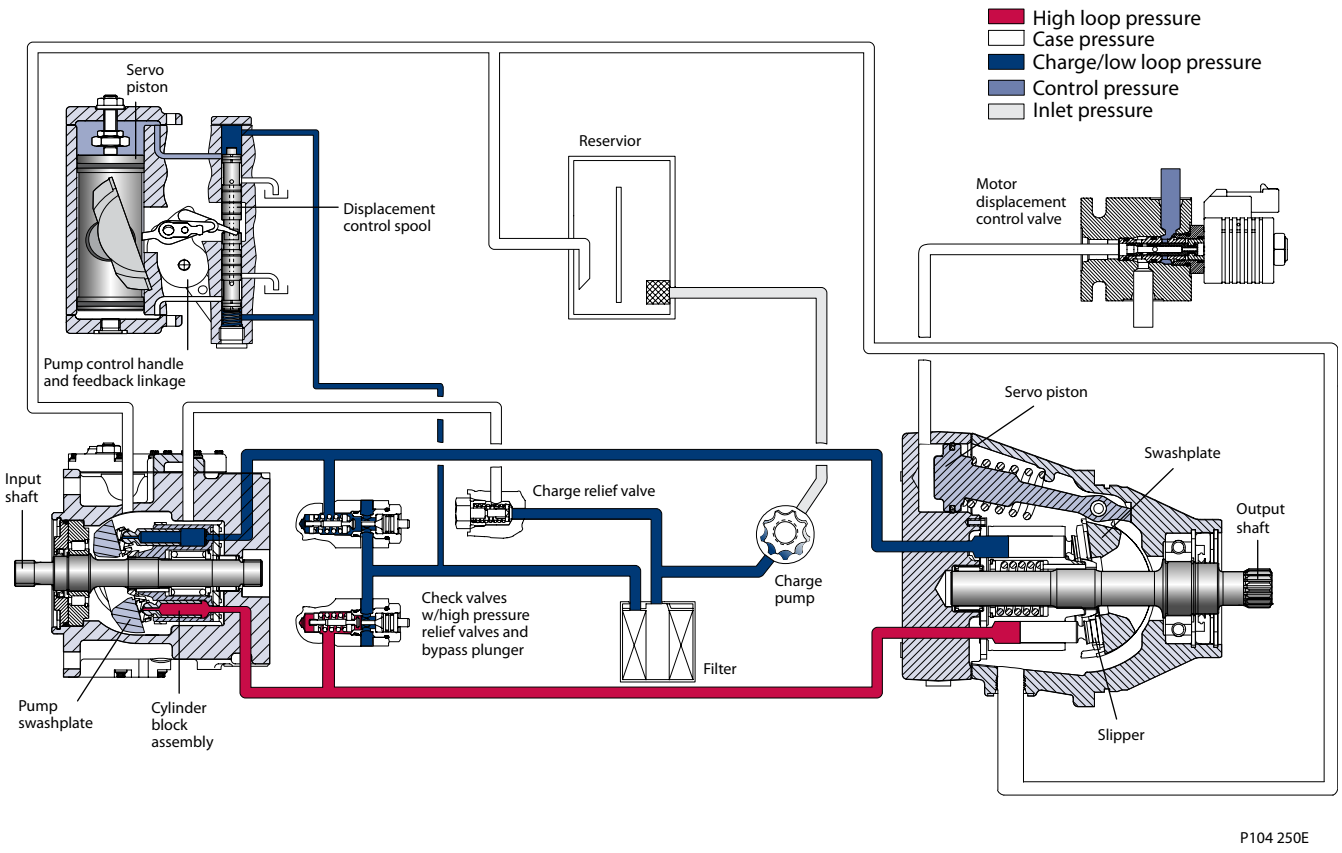


The System circuit

The circuit below shows the KC/LC motor in a simple closed-loop hydrostatic propel application. The motor is driven by a Series 42 medium power axial piston pump with manual displacement control. Control pressure applied through an external control valve shifts the motor to minimum displacement; spring force returns the motor to maximum displacement in the absence of control input.

Introduction

System circuit diagram



Technical specifications

Overview

Specifications and operating parameters for KC/LC motors are given here for reference.

Features and options

Mount	SAE-B (LV/KV)	Cartridge (LC/KC)
Motor type	Inline, axial piston, positive displacement, two-speed variable motors	
Displacement	**L**: 25, 30, or 35 cm^3 [1.50, 1.83, or 2.14 in^3] **K**: 38 or 45 cm^3 [2.32 or 2.75 in^3]	
Rotation	Bidirectional	
Installation position	Discretionary: Housing must always be filled with hydraulic fluid	
Porting	SAE O-ring boss, axial or twin radial	SAE O-ring boss, twin radial
Output shafts	Splined 13 or 15 tooth 16/32 pitch, 0.875 in. straight keyed, and 1:8 taper	Splined 13 or 15 tooth 16/32 pitch
Control options	Single or dual line hydraulic control	Single line hydraulic control
Displacement limiter	Fixed maximum and minimum displacement limiters available	
Speed sensor	Available on L Frame SAE-B motors, in development* on K frame and cartridge motors	
Loop Flushing Valve	Available	

Specifications

Specifications

Parameter	Unit	L25	L30	L35	K38	K45
Displacement (maximum)	cm^3 [in^3]	25 [1.50]	30 [1.83]	35 [2.14]	38 [2.32]	45 [2.75]
Weight (cartridge and SAE-B)	kg [lb]	15.4 [34]				
Mass moment of inertia of rotating components	kg•m^2[slug•ft^2]	0.0017 [0.0012]	0.0016 [0.0012]	0.0015 [0.0011]	0.0023 [0.0017]	0.0023 [0.0017]
Theoretical torque	N•m/bar [lbf•in/1000psi]	0.40 [244]	0.48 [293]	0.56 [347]	0.60 [366]	0.72 [439]

Operating Parameters

Operating parameters

Parameter		Unit	L25	L30	L35	K38	K45
System pressure	maximum working	bar [psi]	400 [5800]	350 [5075]	300 [4350]	350 [5075]	300 [4350]
	maximum		420 [6090]	375 [5440]	325 [4715]	415 [6020]	350 [5075]
Speed limit (at max. disp.)	rated	min^{-1} (rpm)	3400	3500	3600	3600	3500
	maximum		3950	4150	4300	4000	3900
Speed limit (at min. disp., including Zero degrees)	rated		4400	4450	4500	4650	4500
	maximum		5000	5150	5300	5200	5050
Case pressure	maximum working	bar [psi]	2 [29]				
	maximum		6 [87]				

Fluid specifications

Ratings and data are based on operation with premium petroleum-based hydraulic fluids containing oxidation, rust, and foam inhibitors.

Technical specifications

Parameter		Unit	Minimum	Continuous	Maximum
Viscosity		mm^2/sec (cSt) [SUS]	7 [47]	12-60 [70-278]	1600 [7500]
Temperature		°C [°F]	-40 [-40]	82 [180]	104 [220]
Cleanliness			ISO 4406 Class 18/13 or better		
Filtration efficiency	suction filtration		$\beta_{35-44}=75$ ($\beta_{10}\geq 1.5$)		
	charge filtration		$\beta_{15-20}=75$ ($\beta_{10}\geq 10$)		

Features

Output shafts

KC/LC motors may have a 13 or 15 tooth shaft, 16/32 pitch, and ANSI B92.1 1970-Class 5. For dimensions, refer to *L and K Frame Variable Motors Technical Information*, **BC161386484850**.

Controls

KC/LC motors are designed to operate in two positions: maximum and minimum displacement. The motors are spring biased to maximum displacement and hydraulically shifted to minimum displacement. KC/LC motors can operate with a single line control only. Pressure applied at port X1 shifts the motor to minimum displacement. Refer to the table above for control input pressure range.

Control input pressure limits

KC/LC with single line control	14 to 69 bar [200 to 1000 psi]

Control orificing

KC/LC motors can have optional, internal, supply and drain orifices installed to regulate control response times.

KC/LC motors rely on external valving and orificing to regulate shift speeds. You can achieve quick acceleration (shift to min) and slow deceleration (shift to max) simply by installing an orifice in the tank line of the external control valve.

Brake release port

KC/LC motors are equipped with a brake release port to allow access to the brake-release feature of the gear box from the rear of the motor. This consists of a simple passage through the motor housing with a rear-facing 7/16 in. SAE O-ring boss port. Applications using this brake release port require an O-ring to seal the passage against the gear box.

While all motors will have the brake release port, not all gearboxes are compatible with this motor feature. Consult your gearbox manufacturer for suitability and compatibility. If your gearbox is not compatible with this feature, simply leave the port plugged.

Pressure measurements

Required tools

The service procedures described in this manual can be performed using common mechanic's hand tools. Special tools, if required are shown. Calibrate pressure gauges frequently to ensure accuracy. Use snubbers to protect gauges.

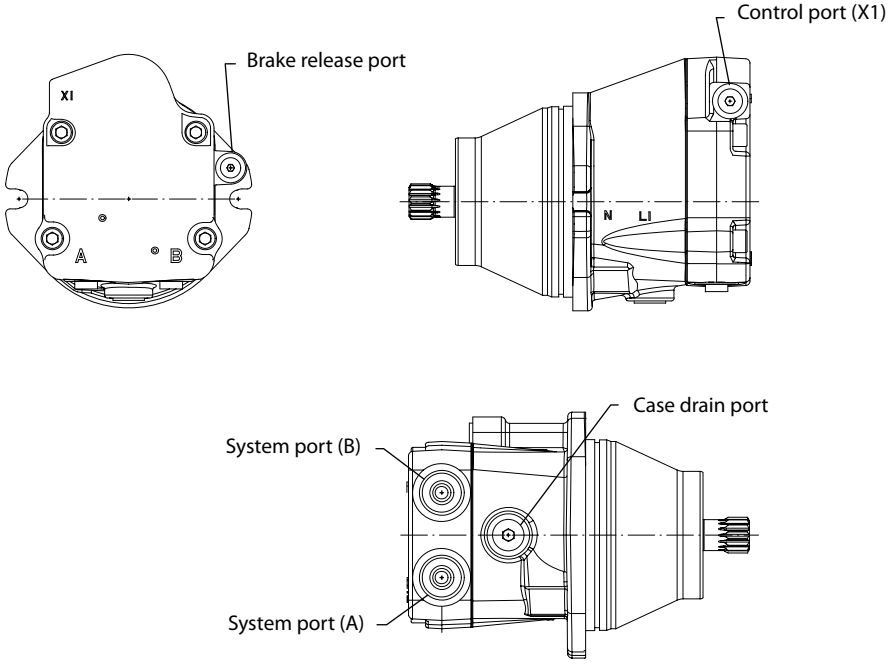
Port locations and gauge installation

For economical reasons, the cartridge motor does not contain any designated gauge installation ports. All pressure measurements can be obtained by installing tee fittings to the connections at the locations listed in the table / drawing below. Recommended gauge sizes are also listed.

Port information

Port identifier	Size	Pressure obtained	Gauge size, bar [psi]
X1	[0.5625]-18 UNF-2B	Control signal	600 [10 000]
Case drain port	[0.750]-16 PER SAE	Case drain	10 [100]
A	[1.0625]-12 PER SAE	System pressure	600 [10 000]
B	[1.0625]-12 PER SAE	System pressure	600 [10 000]
Brake release port	[0.4375]-20 PER SAE	N/A	N/A

Twin radial port locations



P104 249E

Initial start-up procedures

General

Follow this procedure when starting-up a new motor installation or when restarting an installation in which the motor has been removed.

Warning

Unintended vehicle or machine movement hazard

When using the RDM in combination with S45 open circuit pumps with LS or EPC be aware that there will likely be motor movement as long as the engine is turning. Due to the LS-setting of the pump, a standby pressure will remain in the system even if the normally closed control is fully energized. Lowest standby pressures to the motor, 15-18 bar or above, may be enough to turn the RDM and has the potential to cause injury or damage.

Prior to installing the motor, inspect for damage incurred during shipping. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with fluid.

Start-up procedure

1. Fill the reservoir with recommended hydraulic fluid. Always filter fluid through a 10 micron filter when pouring into the reservoir. Never reuse hydraulic fluid.
2. Fill the inlet line leading from the pump to the reservoir. Check the inlet line for properly tightened fittings and be certain it is free of restrictions and air leaks.
3. Fill the pump and motor housing with clean hydraulic fluid. Pour filtered oil directly into the upper most case drain port.
4. To ensure the pump and motor stay filled with oil, install case drain lines into the upper most case drain ports.
5. Install a 0 to 35 bar [0 to 500 psi] gauge in the charge pressure gauge port of the pump to monitor system pressure during start up.

   Follow recommendations in the vehicle / machine operator's manual for prime mover start up procedures.
6. While watching the pressure gauge, jog the prime mover or run at the lowest possible speed until system pressure builds to normal levels (minimum 11 bar [160 psi]). Once system pressure is established, increase to full operating speed. If system pressure is not maintained, shut down the prime mover, determine cause, and take corrective action. Refer to *Troubleshooting* on page 14.
7. Operate the hydraulic system for at least fifteen minutes under light load conditions.
8. Check and adjust pump control settings as necessary after installation.
9. Shut down the prime mover and remove the pressure gauge. Replace plug at the charge pressure gauge port.
10. Check the fluid level in the reservoir; add clean filtered fluid if necessary.

The motor is now ready for operation.

Fluid and filter maintenance

Recommendations

To ensure optimum life of these motors, perform regular maintenance of the fluid and filter. Contaminated fluid is the main cause of unit failure. Take care to maintain fluid cleanliness when servicing.

Check the reservoir daily for proper fluid level, the presence of water, and rancid fluid odor. Fluid contaminated by water may appear cloudy or milky or free water may settle in the bottom of the reservoir. Rancid odor indicates the fluid has been exposed to excessive heat. Change the fluid immediately if these conditions occur. Correct the problem immediately.

Change the fluid and filter per the vehicle / machine manufacturer's recommendations or at these intervals:

Fluid and filter change interval

Reservoir type	Max oil change interval
Sealed	2000 hours
Breather	500 hours

Change the fluid more frequently if it becomes contaminated with foreign matter (dirt, water, grease, etc.) or if the fluid is subjected to temperature levels greater that the recommended maximum.

Dispose of used hydraulic fluid properly. Never reuse hydraulic fluid.

Change filters whenever the fluid is changed or when the filter indicator shows that it is necessary to change the filter. Replace all fluid lost during filter change.

Troubleshooting

Excessive noise and/or vibration

Item	Description	Action
Check oil level in reservoir and oil supply to the motor.	Insufficient hydraulic fluid could lead to cavitation that would cause system noise.	Fill the reservoir to the proper level and ensure that oil supply to the motor is adequate and the lines are unobstructed.
Check for air in the system.	Air trapped within the system lines, or the motor itself, could result in cavitation that would cause system noise.	Ensure that all of the system lines and components are purged of air.
Inspect the output shaft couplings.	A loose or incorrect shaft coupling will produce vibrations that could result in system noise.	Ensure that the correct coupling is used and that it fits properly onto the shaft.
Inspect the output shaft alignment.	Misaligned shafts create excessive frictional vibration that could result in system noise.	Ensure that the shafts are properly aligned.
Hydraulic oil viscosity above limits.	Viscosity above acceptable limits will result in cavitation that would lead to system noise.	Replace hydraulic oil with appropriate fluid for operating conditions. Refer to publication 5200L0463 for information on fluid selection.

System operating hot

Item	Description	Action
Check oil level in reservoir and oil supply to the pump.	Insufficient amount of hydraulic fluid will not meet the cooling demands of the system.	Fill the reservoir to the proper level.
Inspect the heat exchanger, (if so equipped).	If the heat exchanger fails, or becomes obstructed, it may not meet the cooling demands of the system.	Ensure that heat exchanger is receiving adequate air flow and that the heat exchanger is in good operating condition. Repair or replace as necessary.
Check the system relief valves.	If a system relief valve becomes unseated for an extended period of time or fails for any other reason, the system could become overheated.	Repair or replace any malfunctioning relief valves as applicable and verify that the loads on the machine are not excessive.

Motor shifting irregularities

Item	Description	Action
Check the electrical connection and electrical signal to the shifting valve coil.	Electrical signal is needed to energize the valve coil. The energized coil is shifting the motor.	Ensure that the electrical connection between controller valve coil is alright. Check wires and connectors. Check electric signal. Valve coil can be energized with 12V PWM-signal or directly with 12V.
Check valve coil	The energized valve coil is moving the valve spool. That leads to motor shifting.	Measure valve coil resistance. Value needs to be 5,3ohms +-5%. Replace valve if resistance is differing.
Check shifting pressure.	Shifting pressure moves servo piston. Obstruction could result in slow or no shift conditions.	Shifting pressure at full energized valve coil (1500mA) needs to be at 20-32bar [290-464psi] or system input pressure, whichever is lower. Replace shifting valve when measured pressure is differing.

Minor repair

Shaft seal replacement

Remove the shaft seal

1. Remove the snap ring (B002) retaining the shaft seal and support washer.
2. Remove the support washer (M004).
3. Carefully pry out the shaft seal (M003).

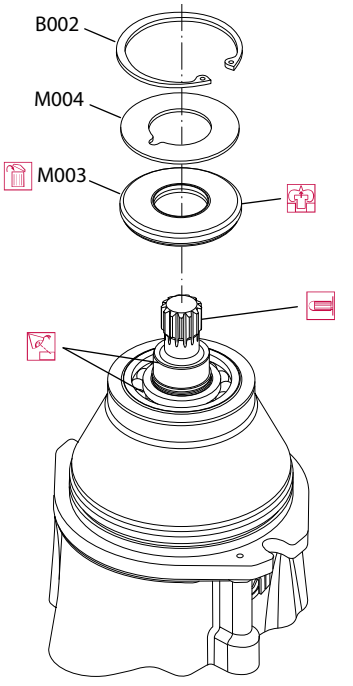
   To avoid damaging the shaft during removal, install a large sheet metal screw into the chuck of a slide hammer. Drive the screw into the seal surface and use the slide hammer to pull the seal.

4. Discard the seal.

Inspect the components

Inspect the new seal, the motor housing seal bore, and the sealing area on the shaft for rust, wear, and contamination. Polish the shaft and clean the housing if necessary.

Replacing the shaft seal



P104 251

Install the new shaft seal

1. Cover the shaft splines with an installation sleeve to protect the shaft seal during installation.
2. Install a new shaft seal (M003) with the cupped side facing the motor. Press seal into housing until it bottoms out. Press evenly to avoid binding and damaging the seal.
3. Install seal support washer (M004).
4. Install snap ring (B002).
5. Remove the installation sleeve.

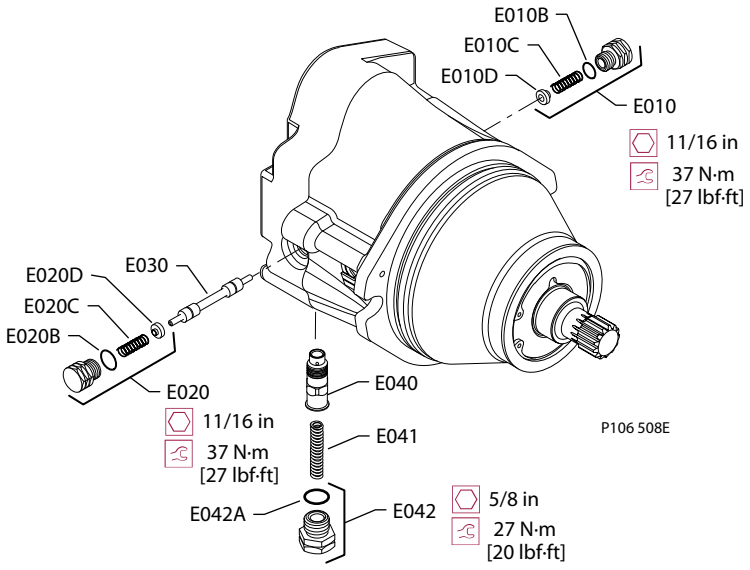
Minor repair

Loop flushing valve

Remove the loop flushing valve

1. Using a 11/16 in internal hex wrench remove plug (E020) and (E010).
2. Using a 1/4 in hex wrench remove plug (E042).
3. Remove O-rings (E020B, E042A, and E010B).
4. Using pliers, remove centering springs (E041, E020C, and E010C).
5. Remove spring retaining washers (E020D and E010D).
6. Remove shift spool (E030). Remove orifice poppet (E040).

Loop flushing valve



Inspect the components

Inspect sealing area for rust, wear, or contamination. Also check springs and poppet for wear.

Install the loop flushing valve

1. Install orifice poppet (E040). Install shift spool (E030).
2. Install spring retaining washers onto springs (E020D and E010D).
3. Carefully install centering springs (E041, E020C, and E010C).
4. Install new O-rings (E010B, E020B, and E042A).
5. Using a 1/4 in hex wrench torque plug (E042) to 27 N•m [20 lbf•ft].
6. Using a 11/16 in internal hex, torque plugs (E010 and E020) to 37 N•m [27 lbf•ft].

Anti-Cavitation Valve

Remove the anti-cavitation valve

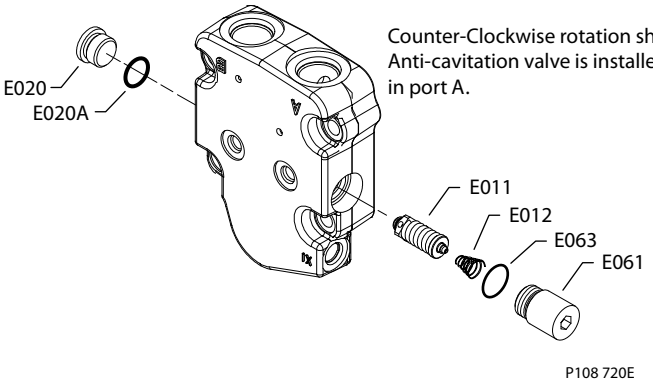
The anti-cavitation valve is installed into the high pressure port. The high pressure port depends on motor rotation. If rotation is counterclockwise, the high pressure port is A. If rotation is clockwise, the high pressure port is B.

1. Using a 5/16 in internal hex wrench remove valve plug (E061). Remove and discard O-ring (E063).
2. Remove spring (E012) and relief valve (E011) from end cap.

Minor repair

3. Using a 5/16 in internal hex wrench remove plug (E020). Remove and discard O-ring (E020A).

Anti-cavitation valve



Inspect the components

Inspect sealing area for rust, wear, or contamination. Check spring and relief valve for wear and damage. Relief valve is non-serviceable, replace as complete unit if damaged.

Install the anti-cavitation valve

1. Lubricate and insert relief valve (E011) and spring (E012) in original location.
2. Lubricate and install new O-ring (E063) on valve plug (E061).
3. If needed lubricate and install new O-ring (E020A) on plug (E020).
4. Using a 5/16 inch internal hex wrench to install valve plug (E061) into port with relief valve (E011). Torque to 80 N•m [59 lbf•ft].
5. If needed using a 5/16 inch internal hex wrench to install plug (E020) into port without relief valve (E011). Torque to 80 N•m [59 lbf•ft].

ENGINEERING
TOMORROW

Products we offer:

- Cartridge valves
- DCV directional control valves
- Electric converters
- Electric machines
- Electric motors
- Gear motors
- Gear pumps
- Hydraulic integrated circuits (HICs)
- Hydrostatic motors
- Hydrostatic pumps
- Orbital motors
- PLUS+1® controllers
- PLUS+1® displays
- PLUS+1® joysticks and pedals
- PLUS+1® operator interfaces
- PLUS+1® sensors
- PLUS+1® software
- PLUS+1® software services, support and training
- Position controls and sensors
- PVG proportional valves
- Steering components and systems
- Telematics

Hydro-Gear
www.hydro-gear.com

Daikin-Sauer-Danfoss
www.daikin-sauer-danfoss.com

Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electric components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market as well as the marine sector. Building on our extensive applications expertise, we work closely with you to ensure exceptional performance for a broad range of applications. We help you and other customers around the world speed up system development, reduce costs and bring vehicles and vessels to market faster.

Danfoss Power Solutions – your strongest partner in mobile hydraulics and mobile electrification.

Go to www.danfoss.com for further product information.

We offer you expert worldwide support for ensuring the best possible solutions for outstanding performance. And with an extensive network of Global Service Partners, we also provide you with comprehensive global service for all of our components.

Local address:

Danfoss
Power Solutions (US) Company
2800 East 13th Street
Ames, IA 50010, USA
Phone: +1 515 239 6000

Danfoss
Power Solutions GmbH & Co. OHG
Krokamp 35
D-24539 Neumünster, Germany
Phone: +49 4321 871 0

Danfoss
Power Solutions ApS
Nordborgvej 81
DK-6430 Nordborg, Denmark
Phone: +45 7488 2222

Danfoss
Power Solutions Trading (Shanghai) Co., Ltd.
Building #22, No. 1000 Jin Hai Rd
Jin Qiao, Pudong New District
Shanghai, China 201206
Phone: +86 21 2080 6201