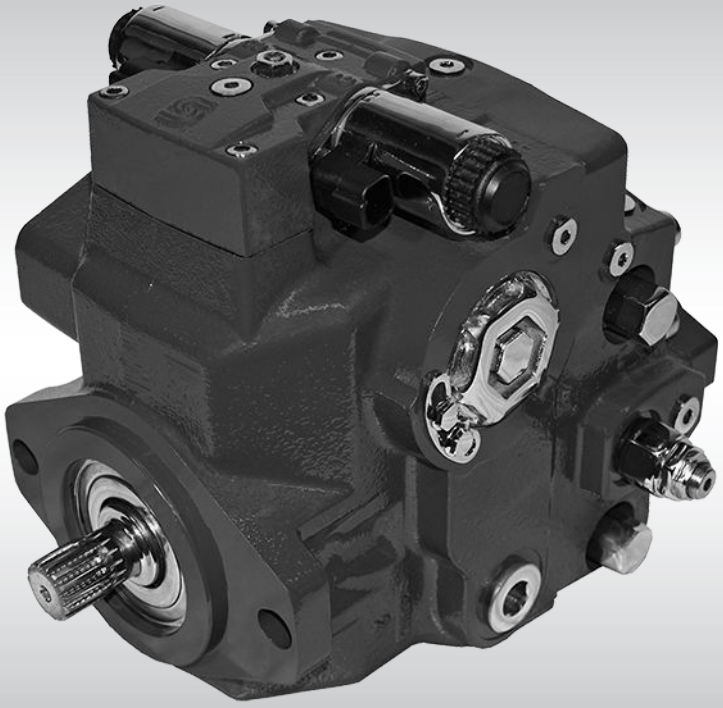
MAKING MODERN LIVING POSSIBLE

Service Manual

H1 - 045/053/060/068

Closed Circuit Axial Piston Pumps



powersolutions.danfoss.com

Revision History

Table of Revisions

Date	Changed	Rev
March 2014	Danfoss layout	CA
March 2013	control topic titles - to be more generic	BD
June 2011	add automotive control protection bracket	BC
March 2011	corrections to specifications and port information	BB
October 2010	added 060-068	BA
August 2010	new last page	AE
March 2010	add automotive control	AD
March 2010	Fix Osaka address	AC
November 2008	changed wrench size and torques for cover bolts	AB
Jun 2007	First edition	AA

Contents

Contents

Introduction

Overview

This manual includes information for the installation, maintenance, and minor repair of H1 pumps. It includes a description of the unit and its individual components, troubleshooting information, and minor repair procedures.

Performing minor repairs may require 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 Global Service Partners is available for major repairs. Danfoss trains and certifies Global Service Partners on a regular basis. You can locate your nearest Global Service Partner using the distributor locator at www.danfoss.com.

Warranty

Performing adjustments and minor repairs according to the procedures in this manual will not affect your warranty. Major repairs requiring the removal of a unit's center section, servo sleeves, or front flange voids the warranty unless a Danfoss Authorized Service Center performs them.

General Instructions

Follow these general procedures when repairing H1 tandem variable displacement closed circuit pumps.

Remove the unit

If necessary, remove the unit from the vehicle/machine. Chock the wheels on the vehicle or lock the mechanism to inhibit movement. Be aware that hydraulic fluid may be under high pressure and/or hot. Inspect the outside of the pump and fittings for damage. Cap hoses after removal to prevent contamination.

Keep it clean

Cleanliness is a primary means of assuring satisfactory pump life on either new or repaired units. Clean the outside of the pump thoroughly before disassembly. Take care to avoid contamination of the system ports. Cleaning parts by using a clean solvent wash and air drying is usually adequate.

As with any precision equipment, you must keep all parts free of foreign material and chemicals. Protect all exposed sealing surfaces and open cavities from damage and foreign material. If left unattended, cover the pump with a protective layer of plastic.

Replace all O-rings and gaskets

We recommend you replace all O-rings and seals removed during service. Lightly lubricate O-rings with clean petroleum jelly prior to assembly.

Secure the unit

If removed from machine, place the unit in a stable position with the shaft pointing downward. It will be necessary to secure the pump while removing and torquing fasteners and components.

Introduction

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.

Unintended machine movement

Warning

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.

Flammable cleaning solvents

Warning

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.

Fluid under pressure

Warning

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.

Personal safety

Warning

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

Non-reusable part, use a new part

Option – either part may exist

Measurement required

External hex head

Internal hex head

Lubricate with hydraulic fluid

Inspect for wear or damage

Introduction

Note correct orientation

Torque specification

Cover splines with installation sleeve

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

The **H1** axial piston variable displacement pumps are of cradle swashplate design and are intended for closed circuit applications.

The flow rate is proportional to the pump input speed and displacement.

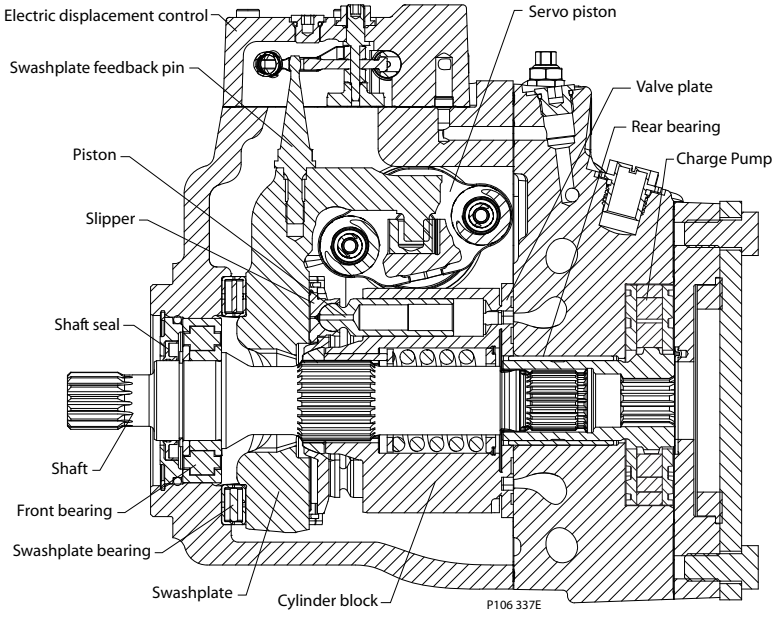
The latter is infinitely adjustable between zero and maximum displacement.

Flow direction is reversed by tilting the swashplate to the opposite side of the neutral (zero displacement) position.

The H1 family of closed circuit variable displacement axial piston pumps is designed for use with all existing Danfoss hydraulic motors for the control and transfer of hydraulic power. H1 pumps are compact and high power density where all units utilize an integral electro-hydraulic servo piston assembly that controls the rate (speed) and direction of the hydraulic flow. H1 pumps are specifically compatible with the Danfoss family of PLUS+1™ microcontrollers for easy Plug-and-Perform™ installation.

H1 pumps can be used together in combination with other Danfoss pumps and motors in the overall hydraulic system. Danfoss hydrostatic products are designed with many different displacement, pressure and load-life capabilities. Go to the Danfoss website or applicable product catalog to choose the components that are right for your complete closed circuit hydraulic system.

Cross section view



Introduction

The System Circuit

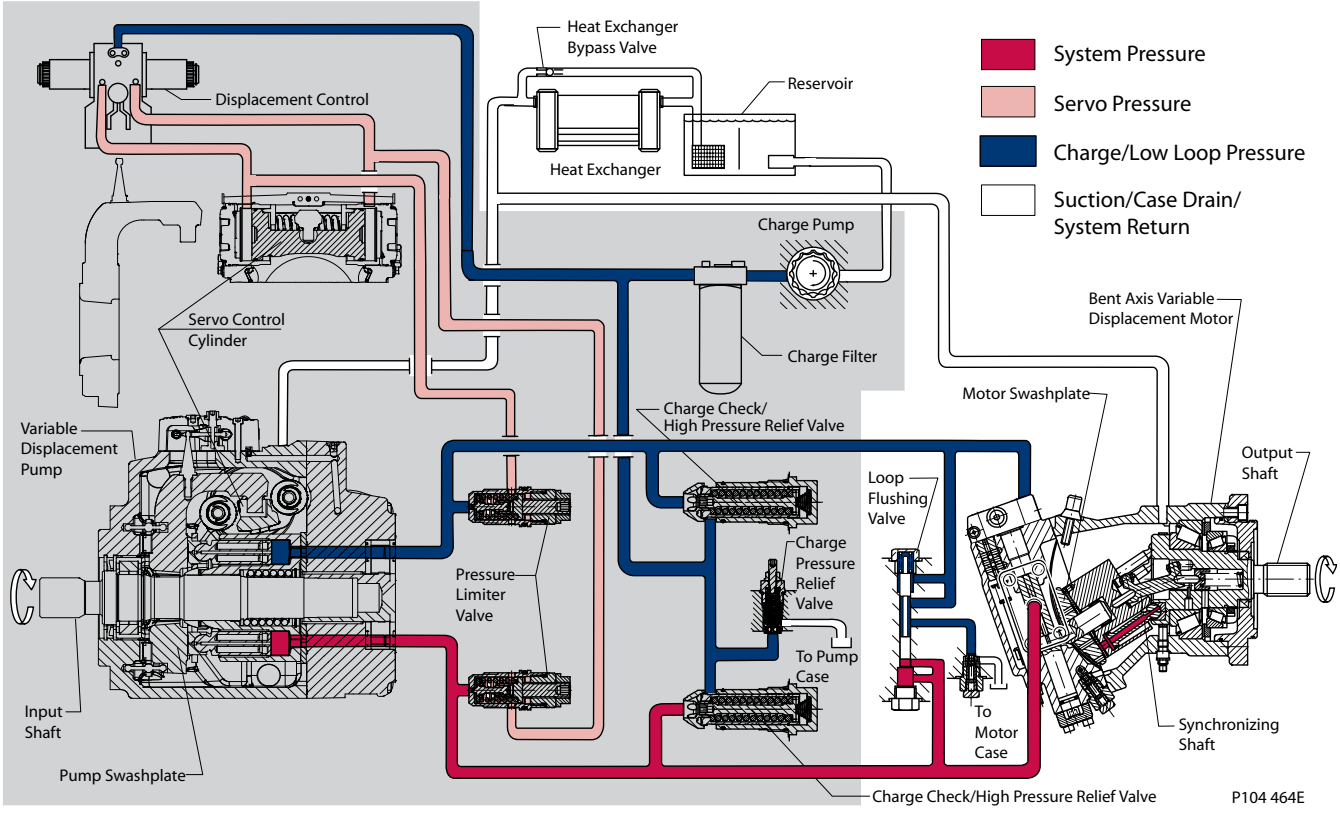
The basic closed circuit

Hydraulic lines connect the main ports of the pump to the main ports of the motor. Fluid flows in either direction from the pump to the motor and back. Either of the hydraulic lines can be under high pressure. In pumping mode the position of the pump swashplate determines which line is high pressure as well as the direction of fluid flow.

Case drain and heat exchanger

The pump and motor require case drain lines to remove hot fluid from the system. The pump and motor drain from the topmost port to ensure the cases remain full of fluid. The motor case drain can connect to the lower drain port on the pump housing or it can tee into the case drain line upstream of the heat exchanger. A heat exchanger with bypass valve cools the case drain fluid before it returns to the reservoir.

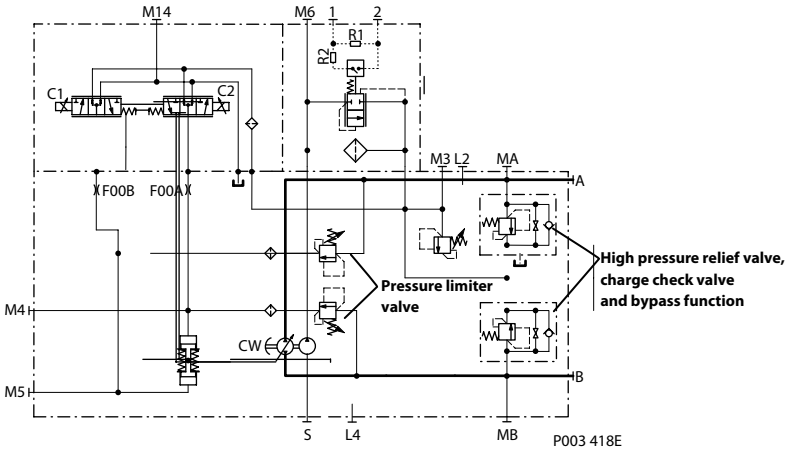
System circuit diagram



Introduction

The System Schematic

System schematic



Above schematic shows the function of an H1 45/53/60/68 axial piston variable displacement pump with electric displacement control (EDC).

Operation

Pressure Limiter Valves

Pressure limiter valves provide system pressure protection by compensating the pump swashplate position when the set pressure of the valve is reached. A pressure limiter is a non-dissipative (non heat generating) pressure regulating system.

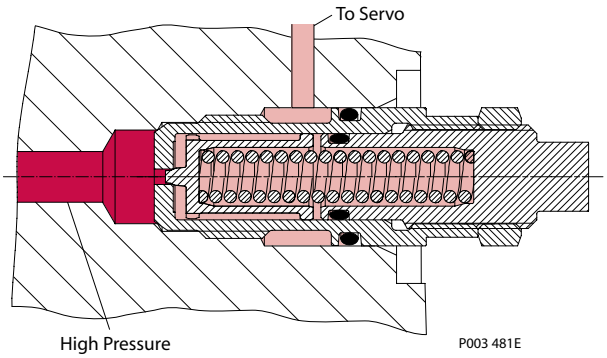
Each side of the transmission loop has a dedicated pressure limiter valve that is set independently. Each system port may have a different pressure limiter setting.

The pressure limiter setting is the maximum differential pressure between the high and low loops. When the pressure limiter setting is reached, the valve ports oil to the low-pressure side of the servo piston. The change in pressure across the servo rapidly reduces pump displacement. Fluid flow from the valve continues until the resulting drop in pump displacement causes system pressure to fall below the pressure limiter setting.

An active pressure limiter destrokes the pump to near neutral when the load is in a stalled condition. The pump swashplate moves in either direction necessary to regulate the system pressure, including increasing stroke when overrunning or over-center.

The pressure limiter is optional on H1 pumps.

Pressure limiter valve



High Pressure Relief Valve (HPRV) and Charge Check

All H1 pumps have a combination high pressure relief and charge check valve. The high-pressure relief function is a dissipative (heat generating) pressure control valve for the purpose of limiting excessive system pressures. The charge check function replenishes the low-pressure side of the working loop with charge oil. Each side of the transmission loop has a dedicated non-adjustable, factory-set HPRV valve. When system pressure exceeds the factory setting, oil is passed from the high pressure system loop into the charge gallery, and into the low pressure system loop via the charge check.

The pump may have different pressure settings at each system port. When an HPRV valve is used in conjunction with a pressure limiter, the HPRV valve is always factory set above the setting of the pressure limiter. The system pressure shown in the order code for pumps with only HPRV is the HPRV setting. The system pressure shown in the order code for pumps with pressure limiter and HPRV, is the pressure limiter setting.

HPRVs are set at low flow condition. Any application or operating condition which leads to elevated HPRV flow will cause a pressure rise with flow above the valve setting.

Pressures marked on HPRV valve

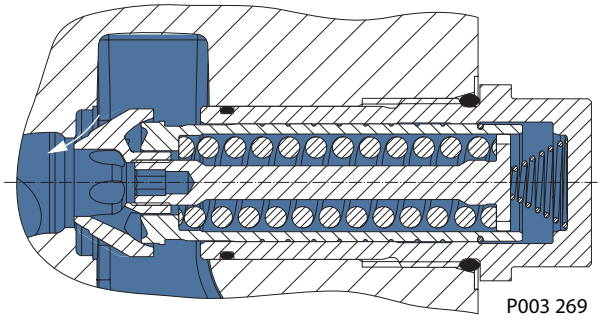
Mark	Pressure bar [psi]
15	150 [2175]
18	180 [2610]
20	200 [2900]
23	230 [3335]

Operation

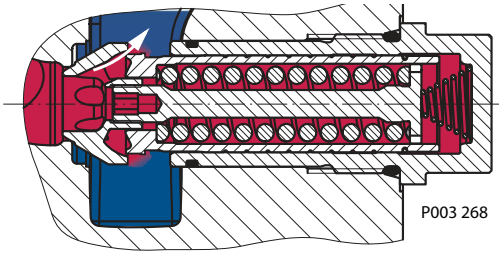
Pressures marked on HPRV valve (continued)

25	250 [3626]
28	280 [4061]
30	300 [4351]
33	330 [4786]
35	350 [5076]
38	380 [5511]
40	400 [5801]
42	420 [6092]

High Pressure Relief and Charge Check Valve with Bypass Valve in charging mode



High Pressure Relief and Charge Check Valve with Bypass Valve in relief mode



Bypass Function

The HPRV valve also provides a loop bypass function when each of the two HPRV hex plugs are mechanically backed out 3 full turns. Engaging the bypass function hydraulically connects both A & B sides of the working loop to the common charge gallery. The bypass function allows you to move a machine or load without rotating the pump shaft or prime mover.

Caution

The HPRV valves are not tow valves. Damage to the pump and motor can occur when operating without charge flow. Limit vehicle/machine movement to no more than 20% of maximum speed and no longer that three minutes. Reseat the HPRV valves after vehicle/machine movement.

Charge Pressure Relief Valve

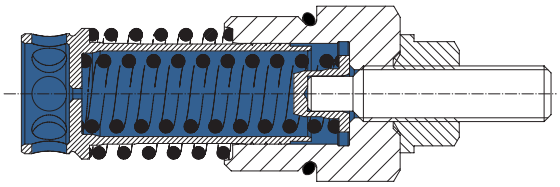
The charge pressure relief valve maintains charge pressure at a designated level above case pressure. The charge pressure relief valve is a direct acting poppet valve that opens and discharges fluid to the pump case when pressure exceeds a designated level. This level is nominally set with the pump running at 1800 min^{-1} (rpm). For external charge flow, the CPRV is set with a flow of 30 l/min [8 US gal/min]. In forward or

Operation

reverse, charge pressure will be slightly lower than in neutral position. The model code of the pump specifies the charge relief setting.

Typically charge pressure increases from 1.2-1.5 bar per 10 l/min [17.4-21.8 psi per 2.64 US gal/min].

Charge pressure relief valve

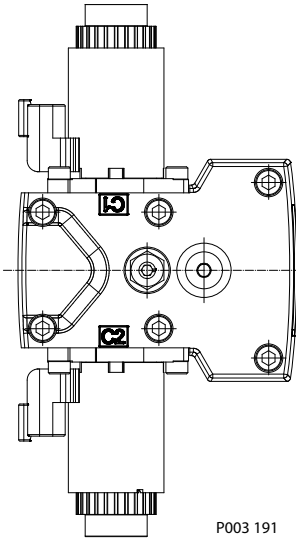


P003 200

Electrical Displacement Control (EDC)

EDC Principle

An EDC is a displacement (flow) control. Pump swashplate position is proportional to the input command and therefore vehicle or load speed (excluding influence of efficiency), is dependent only on the prime mover speed or motor displacement.

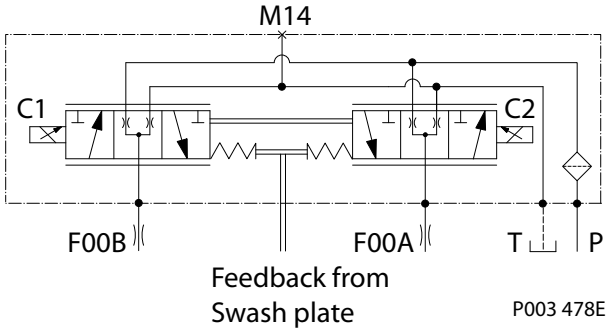


P003 191

The Electrical Displacement Control (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Operation

EDC-Schematic diagram



A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

EDC Operation

H1 EDC's are current driven controls requiring a Pulse Width Modulated (PWM) signal. Pulse width modulation allows more precise control of current to the solenoids. The PWM signal causes the solenoid pin to push against the porting spool, which pressurizes one end of the servo piston, while draining the other. Pressure differential across the servo piston moves the swashplate.

A swashplate feedback link, opposing control links, and a linear spring provide swashplate position force feedback to the solenoid. The control system reaches equilibrium when the position of the swashplate spring feedback force exactly balances the input command solenoid force from the operator. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the effect of the control neutral deadband, we recommend the transmission controller or operator input device incorporate a jump up current to offset a portion of the neutral deadband.

The neutral position of the control spool does provide a positive preload pressure to each end of the servo piston assembly.

When the control input signal is either lost or removed, or if there is a loss of charge pressure, the spring-loaded servo piston will automatically return the pump to the neutral position.

Manual OverRide (MOR)

All controls are available with a Manual Over Ride (MOR) either standard or as an option for temporary actuation of the control to aid in diagnostics.

Forward-Neutral-Reverse (FNR) and Non Feedback Proportional Electric (NFPE) controls are always supplied with MOR functionality.

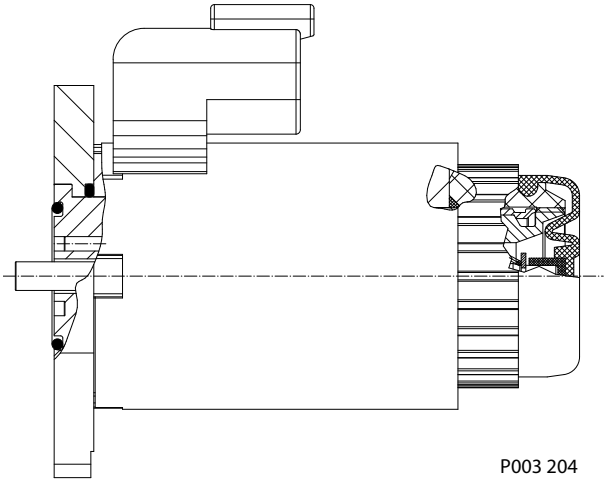
Unintended MOR operation will cause the pump to go into stroke. The vehicle or device must always be in a safe condition (i.e. vehicle lifted off the ground) when using the MOR function. The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

Warning

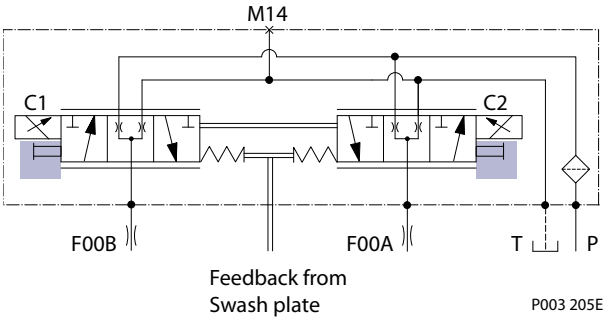
An o-ring seal is used to seal the MOR plunger where initial actuation of the function will require a force of 45 N to engage the plunger. Additional actuations typically require less force to engage the MOR plunger. Proportional control of the pump using the MOR should not be expected.

Operation

Refer to the control flow table in the size specific technical information for the relationship of solenoid to direction of flow.



MOR-Schematic diagram (EDC shown)



Operating Parameters

Overview

This section defines input speed and pressure operating parameters and limitations for H1 pumps. For actual parameters, refer to the technical specifications for each displacement.

Input Speed

Minimum speed is the lowest input speed recommended during engine idle condition. Operating below minimum speed limits the pump's ability to maintain adequate flow for lubrication and power transmission.

Rated speed is the highest input speed recommended at full power condition. Operating at or below this speed should yield satisfactory product life.

Maximum speed is the highest operating speed permitted. Exceeding maximum speed reduces product life and can cause loss of hydrostatic power and braking capacity. Never exceed the maximum speed limit under any operating conditions.

Operating conditions between Rated speed and Maximum speed should be restricted to less than full power and to limited periods of time. For most drive systems, maximum unit speed occurs during downhill braking or negative power conditions.

For more information consult *Pressure and speed limits*, BLN-9884, when determining speed limits for a particular application.

During hydraulic braking and downhill conditions, the prime mover must be capable of providing sufficient braking torque in order to avoid pump over speed. This is especially important to consider for turbocharged and Tier 4 engines.

Warning

Unintended vehicle or machine movement hazard

Exceeding maximum speed may cause a loss of hydrostatic drive line power and braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss. The braking system must also be sufficient to hold the machine in place when full power is applied.

System Pressure

System pressure is the differential pressure between high pressure system ports. It is the dominant operating variable affecting hydraulic unit life. High system pressure, which results from high load, reduces expected life. Hydraulic unit life depends on the speed and normal operating, or weighted average, pressure that can only be determined from a duty cycle analysis.

Application pressure - is the high pressure relief or pressure limiter setting normally defined within the order code of the pump. This is the applied system pressure at which the driveline generates the maximum calculated pull or torque in the application.

Maximum working pressure - is the highest recommended Application pressure. Maximum working pressure is not intended to be a continuous pressure. Propel systems with Application pressures at, or below, this pressure should yield satisfactory unit life given proper component sizing.

Charge Pressure

Minimum charge pressure is the lowest pressure allowed to maintain a safe working condition in the low side of the loop. Minimum control pressure requirements are a function of speed, pressure, and swashplate angle, and may be higher than the minimum charge pressure shown in the Operating parameters tables.

Maximum charge pressure is the highest charge pressure allowed by the charge relief adjustment, and which provides normal component life. Elevated charge pressure can be used as a secondary means to reduce the swashplate response time.

Charge Inlet Pressure

At normal operating temperature charge inlet pressure must not fall below **rated charge inlet pressure (vacuum)**.

Operating Parameters

Minimum charge inlet pressure is only allowed at cold start conditions. In some applications it is recommended to warm up the fluid (e.g. in the tank) before starting the engine and then run the engine at limited speed.

Maximum charge pump inlet pressure may be applied continuously.

Case Pressure

Under normal operating conditions, the **rated case pressure** must not be exceeded. During cold start case pressure must be kept below maximum intermittent case pressure. Size drain plumbing accordingly.

Auxiliary Pad Mounted Pumps. The auxiliary pad cavity of H1 pumps configured without integral charge pumps is referenced to case pressure. Units with integral charge pumps have auxiliary mounting pad cavities referenced to charge inlet (vacuum).

Caution

Possible component damage or leakage.

Operation with case pressure in excess of stated limits may damage seals, gaskets, and/or housings, causing external leakage. Performance may also be affected since charge and system pressure are additive to case pressure.

Temperature and Viscosity

Temperature

The high temperature limits apply at the hottest point in the transmission, which is normally the motor case drain. The system should generally be run at or below the quoted **rated temperature**.

The **maximum intermittent temperature** is based on material properties and should never be exceeded.

Cold oil will generally not affect the durability of the transmission components, but it may affect the ability of oil to flow and transmit power; therefore temperatures should remain 16 °C [30 °F] above the pour point of the hydraulic fluid.

The **minimum temperature** relates to the physical properties of component materials.

Size heat exchangers to keep the fluid within these limits. Danfoss recommends testing to verify that these temperature limits are not exceeded.

Viscosity

For maximum efficiency and bearing life, ensure the fluid viscosity remains in the **recommended range**.

The **minimum viscosity** should be encountered only during brief occasions of maximum ambient temperature and severe duty cycle operation.

The **maximum viscosity** should be encountered only at cold start.

Specifications

Technical Specifications

Design specifications

Design	Axial piston pump of cradle swashplate design with variable displacement
Direction of rotation	Clockwise, counterclockwise
Pipe connections	Main pressure ports: ISO split flange boss
	Remaining ports: SAE straight thread O-ring boss
Recommended installation position	Pump installation position is discretionary, however the recommended control position is on the top or at the side, with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control. Vertical input shaft installation is acceptable. If input shaft is at the top 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.
Auxiliary cavity pressure	Will be inlet pressure with internal charge pump. For reference see operating parameter on next page. Will be case pressure with external charge supply. Please verify mating pump shaft seal capability.
	T000 126E

Technical specifications

Feature	Unit	Frame size			
		045	053	060	068
Displacement	cm^3 [in^3]	45 [2.75]	53.8 [3.28]	60.4 [3.69]	68.0 [4.15]
Flow at rated (continuous) speed	l/min [US gal/min]	153 [40]	183 [48]	210 [55.5]	238 [62.8]
Torque at maximum displacement (theoretical)	N•m/bar [lbf•in/1000psi]	0.72 [437.7]	0.86 [522.03]	0.69 [590]	1.08 [610]
Mass moment of inertia of rotating components	$kg•m^2$ [$slug•ft^2$]	0.00465 [0.00343]	0.00458 [0.00338]	0.00709 [0.00523]	0.00707 [0.00522]
Weight (weight) dry (without aux. mounting flange and filter	kg [lb]	41.0 [90.0]		50 [110]	
Oil volume	liter [US gal]	1.3 [0.34]		2.1 [055]	

Mounting flange	ISO 3019-1 flange 101-2 (SAE B) Special bolt diameter. See *installation drawings*	ISO 3019-1 flange 127-4 (SAE C)
Input shaft outer diameter, splines and tapered shafts	ISO 3019-1, outer diameter 22 mm -4 (SAE B, 13 teeth) ISO 3019-1, outer dia. 25 mm -4 (SAE B-B, 15 teeth) ISO 3019-1, outer diameter 32 mm -4 (SAE B, 14 teeth) Conical keyed shaft end similar to ISO 3019-1 code 25-3 taper 1:8	ISO 3019-1, outer diameter 32 mm -4 (SAE C, 14 teeth) ISO 3019-1, outer diameter 35 mm -4 (SAE C, 21 teeth)
Auxiliary mounting flange with metric fasteners, shaft outer diameter and splines	ISO 3019-1, flange 82-2, outer dia. 16 mm -4 (SAE A, 9 teeth) ISO 3019-1, flange 82-2, outer dia. 19 mm -4 (SAE A, 11 teeth) ISO 3019-1, flange 101-2, outer dia. 22 mm -4 (SAE B, 13 teeth) ISO 3019-1, flange 101-2, outer dia. 25 mm -4 (SAE B-B, 15 teeth)	ISO 3019-1, flange 82-2, outer dia. 16 mm -4 (SAE A, 9 teeth) ISO 3019-1, flange 82-2, outer dia. 19 mm -4 (SAE A, 11 teeth) ISO 3019-1, flange 101-2, outer dia. 22 mm -4 (SAE B, 13 teeth) ISO 3019-1, flange 101-2, outer dia. 25 mm -4 (SAE B-B, 15 teeth) ISO 3019-1, flange 127-2, outer dia. 32 mm -4 (SAE C, 14 teeth)
Suction port	ISO 11926-1 – 1 5/16 -12 (SAE O-ring boss)	

Specifications

Main port configuration	Ø19.0 - 450 bar split flange boss per ISO 6162, M10x1.5 ISO 11926-1 – 1 5/16 -12 (SAE O-ring boss)	Ø25.4 - 450 bar split flange boss per ISO 6162, M12x1.75
Case drain ports L1, L2, L4	ISO 11926-1 – 1 1/16 -12 (SAE O-ring boss)	
Other ports	SAE O-ring boss. *See installation drawings in Tech Manual*	
Customer interface threads	Metric fasteners	

Operating parameters

Feature		Unit		045	053	060	068
Input speed	Minimum for internal charge supply	min-1 (rpm)		500		500	
	Minimum for external charge supply			500		500	
	Minimum for full performance			1175	1250	1200	
	Rated			3400		3500	
	Maximum			3500		4000	
System pressure	Maximum working pressure	bar	[psi]	400 [5800]	350 [5075]	420 [6090]	380 [5510]
	Maximum pressure			450 [6525]	400 [5800]	450 [6525]	400 [5800]
	Maximum low loop			45 [650]		45 [650]	
	Minimum low loop pressure			10 [150]		10 [145]	
Charge pressure	Minimum	bar	[psi]	16 [232]		14.5 [210]	
	Maximum			35 [508]		34 [493]	
Control pressure	Minimum (at corner power for EDC and FNR)	bar	[psi]	21.5 [312]		18.5 [270]	
	Minimum (at corner power for NFPE, AC, FDC)			24 [348]		23.5 [340]	
	Maximum			40 [580]		40 [580]	
Charge pump inlet pressure	Rated	bar (absolute)	[inches Hg vacuum]	0.7 [9]		0.7 [9]	
	Minimum (cold start)			0.2 [24]		0.2 [24]	
	Maximum	bar	[psi]	4.0 [58]		4.0 [58]	
Case pressure	Rated	bar	[psi]	3.0 [44]		3.0 [44]	
	Maximum			5.0 [73]		5.0 [73]	
Lip seal external pressure	Maximum	bar	[psi]	0.4 [5.8]		0.4 [5.8]	

Fluid specifications

Feature		Unit			
Viscosity	Intermittent 1)	mm2/s	[SUS]	5	[42]
	Minimum			7	[49]
	Recommended range			12-80	[66-370]
	Maximum			1600	[7500]
Temperature	Minimum (cold start) 3)	°C	[°F]	-40	[-40]

Specifications

Fluid specifications (continued)

range 2)	Recommended range			60-85	[140-185]
	Rated			104	[220]
	Maximum intermittent 1)			115	[240]
Filtration (recommended minimum)	Cleanliness per ISO 4406			22/18/13	
	Efficiency (charge pressure filtration)	β-ratio		$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)	
	Efficiency (suction and return line filtration)			$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)	
	Recommended inlet screen mesh size	µm		100 – 125	
1) Intermittent = Short term t < 1min per incident and not exceeding 2 % of duty cycle based load-life 2) At the hottest point, normally case drain port 3) Cold start = Short term t < 3min, p ≤ 50 bar [725 psi], n ≤ 1000 min^{-1}(rpm)					T000 129E

Fluid and Filter Maintenance

Filtration System

To prevent premature wear, ensure only clean fluid enters the hydrostatic transmission circuit. A filter capable of controlling the fluid cleanliness to ISO 4406 class 22/18/13 (SAE J1165) or better, under normal operating conditions, is recommended.

These cleanliness levels can not be applied for hydraulic fluid residing in the component housing/case or any other cavity after transport.

The filter may be located on the pump (integral) or in another location (remote). The integral filter has a filter bypass sensor to signal the machine operator when the filter requires changing. Filtration strategies include suction or pressure filtration. The selection of a filter depends on a number of factors including the contaminant ingression rate, the generation of contaminants in the system, the required fluid cleanliness, and the desired maintenance interval. Filters are selected to meet the above requirements using rating parameters of efficiency and capacity.

Filter efficiency can be measured with a Beta ratio[1] (β_X). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a β-ratio within the range of $\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$) or better has been found to be satisfactory. For some open circuit systems, and closed circuits with cylinders being supplied from the same reservoir, a considerably higher filter efficiency is recommended. This also applies to systems with gears or clutches using a common reservoir. For these systems, a charge pressure or return filtration system with a filter β-ratio in the range of $\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$) or better is typically required.

Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. Please see *Design Guidelines for Hydraulic Fluid Cleanliness Technical Information*, **520L0467** for more information.

Cleanliness level and β_x-ratio			
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β-ratio	$\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$)
	Efficiency (suction and return line filtration)		$\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$)
	Recommended inlet screen mesh size	µm	100 – 125
			T000 158E

[1] Filter β_x-ratio is a measure of filter efficiency defined by ISO 4572. It is defined as the ratio of the number of particles greater than a given diameter ("x" in microns) upstream of the filter to the number of these particles downstream of the filter.

Pressure Measurements

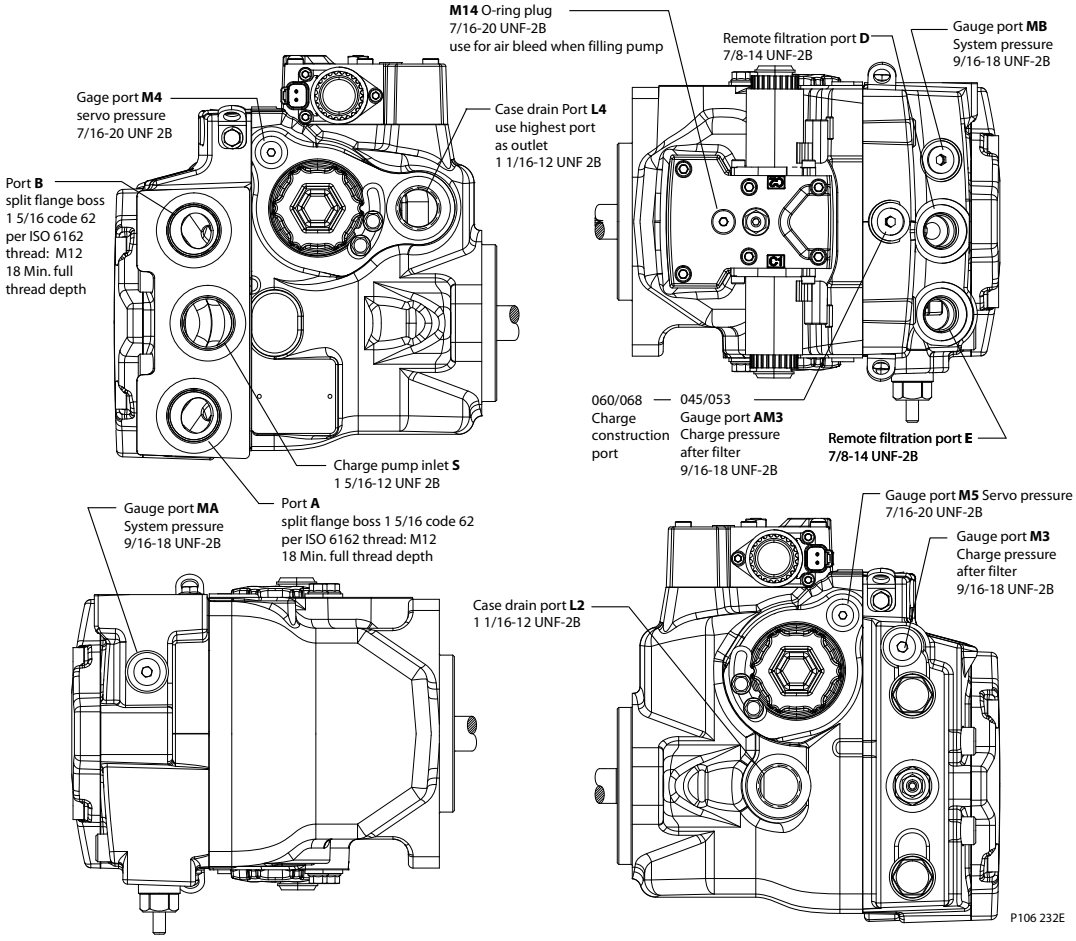
Port Locations and Gauge Installation

The following table and drawing show the port locations and gauge sizes needed. When testing system pressures, calibrate pressure gauges frequently to ensure accuracy. Use snubbers to protect gauges.

Port information

Port identifier	Port size	Wrench size	Pressure obtained	Gauge size, bar [psi]
L2, L4	1 1/16-12 UNF 2B	9/16 internal hex	Case drain	10 bar [100 psi]
MA, MB,	9/16-18 UNF	1/4 internal hex	System pressure	600 bar [10,000 psi]
M3	9/16-18 UNF 2B	1/4 internal hex	Charge pressure	50 bar [1000 psi]
AM3 (045/053) Alternate	9/16-18 UNF 2B	1/4 internal hex	Charge pressure	50 bar [1000 psi]
M4, M5	7/16-20 UNF 2B	3/16 internal hex	Servo pressure	50 bar [1000 psi]
M14	7/16-20 UNF 2B	3/16 internal hex	Servo pressure	50 bar [1000 psi]

Port locations



Initial Startup Procedure

General

Follow this procedure when starting-up a new pump installation or when restarting an installation in which the pump has been removed and re-installed on a machine. Ensure pump has been thoroughly tested on a test stand before installing on a machine.

Warning

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.

Prior to installing the pump, inspect for damage that may have occurred during shipping.

Start-up Procedure

1. Ensure that the machine hydraulic oil and system components (reservoir, hoses, valves, fittings, and heat exchanger) are clean and free of any foreign material.
2. Install new system filter element(s) if necessary. Check that inlet line fittings are properly tightened and there are no air leaks.
3. Install the pump. Install a 50 bar [1000 psi] gauge in the charge pressure gauge port M3.
4. Fill the housing by adding filtered oil in the upper case drain port. If the control is installed on top, open the construction plug in the top of the control to assist in air bleed.
5. Fill the reservoir with hydraulic fluid of the recommended type and viscosity. Use a 10-micron filler filter. Fill inlet line from reservoir to pump. Ensure construction plug in control is closed after filling.
6. Disconnect the pump from all control input signals.
7. Close construction plug removed in step 4.

   Caution

   After start-up the fluid level in the reservoir may drop due to system components filling. Damage to hydraulic components may occur if the fluid supply runs out. Ensure reservoir remains full of fluid during start-up.

   Air entrapment in oil under high pressure may damage hydraulic components. Check carefully for inlet line leaks.

   Do not run at maximum pressure until system is free of air and fluid has been thoroughly filtered.
8. Use a common method to disable the engine to prevent it from starting. Crank the starter for several seconds. Do not to exceed the engine manufacturer's recommendation. Wait 30 seconds and then crank the engine a second time as stated above. This operation helps remove air from the system lines. Refill the reservoir to recommended full oil level.
9. When the gauge begins to register charge pressure, enable and start engine. Let the engine run for a minimum of 30 seconds at low idle to allow the air to work itself out of the system. Check for leaks at all line connections and listen for cavitation. Check for proper fluid level in reservoir.
10. When adequate charge pressure is established (as shown in model code), increase engine speed to normal operating rpm to further purge residual air from the system.
11. Shut off engine. Connect pump control signal. Start engine, checking to be certain pump remains in neutral. Run engine at normal operating speed and carefully check for forward and reverse control operation.
12. Continue to cycle between forward and reverse for at least five minutes to bleed all air and flush system contaminants out of loop.

    Normal charge pressure fluctuation may occur during forward and reverse operation.
13. Check that the reservoir is full. Remove charge pressure gauge. The pump is now ready for operation.

Troubleshooting

Overview

This section provides general steps to follow if you observe undesirable system conditions. Follow the steps listed until you solve the problem. Some of the items are system specific. We reference the section in this manual of more information is available. Always observe the safety precautions listed in the Introduction section and precautions related to your specific equipment.

Safety Precautions

Caution

High inlet vacuum causes cavitation which can damage internal pump components.

Warning

Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury and/or infection. Relieve pressure in the system before removing hoses, fittings, gauges, or components. Seek immediate medical attention if you are cut or burned by hydraulic fluid.

Warning

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.

Caution

Contamination can damage internal components and void the manufacturer's warranty. Take precautions to ensure system cleanliness when removing and reinstalling system components and lines.

Warning

Hydraulic fluid contains hazardous material. Avoid contact with hydraulic fluid. Always dispose of used hydraulic fluid according to state, and federal environmental regulations.

Electrical Troubleshooting

Item	Description	Action
Control operates pump in one direction only.	Control coil failure	Measure resistance at coil pins. Resistance should be 14.20 Ω (24V) or 3.66 Ω (12V) at 20°C [70°F]. Replace coil.
No pump function	No power to controller	Restore power to controller.
Erratic pump function	Electrical connection to pump is bad.	Disconnect connection, check wires, reconnect wires.
Filter bypass indicator switch	Filter switch may be bad.	Check/replace filter switch. Add gauge to filter bypass port to verify proper fluid flow and verify switch operation by measuring resistance. open resistance=>510 Ω, closed resistance<=122 Ω

If available, use a manual override to check proper pump operation and verify electrical problem.

System Operating Hot

Item	Description	Action
Oil level in reservoir.	Insufficient hydraulic fluid does not meet cooling demands of system.	Fill reservoir to proper level.
Heat exchanger.	Heat exchanger is not sufficiently cooling the system.	Check air flow and input air temperature for heat exchanger. Clean, repair or replace heat exchanger.
Charge pressure.	Low charge pressure overworks system.	Measure charge pressure. Inspect and adjust or replace charge relief valve. Inspect charge pump. Repair or replace charge pump.

Troubleshooting

Item	Description	Action
Charge pump inlet vacuum.	High inlet vacuum overworks system. A dirty filter increases the inlet vacuum. Inadequate line size will restrict flow.	Check charge inlet vacuum. If high, inspect inlet filter and replace as necessary. Check for adequate line size, length or other restrictions
System relief pressure settings	If the system relief valves are worn, contaminated, or valve settings are too low, the relief valves get overworked.	Verify settings of pressure limiters and high pressure relief valves and adjust or replace as necessary.
System pressure.	Frequent or long term operation over system relief setting creates heat in system.	Measure system pressure. If pressure is too high, reduce loads.

Transmission Operates Normally in One Direction Only

Item	Description	Action
Open bypass valves.	Open bypass causes one or both directions to be inoperative.	Close/repair bypass function.
Input to pump control.	Input to control module is operating improperly.	Check control input and repair or replace as necessary.
Control orifices	Control orifice(s) are blocked.	Clean control orifices.
Control screens	Control screen(s) are blocked.	Clean or replace control screens.
Pressure limiters	Malfunctioning pressure limiter can affect one direction while the other functions normally.	Exchange pressure limiters. If the problem changes direction, replace the valve that does not operate correctly. Remember to return the PLs to their original position afterward. Settings may be different for forward/reverse.
High pressure relief valves (HPRV)	Malfunctioning HPRV can affect one direction while the other functions normally.	Exchange HPRVs. If the problem changes direction, replace the valve that does not operate correctly. Remember to return HPRVs to their original position afterward. Settings may be different for forward/reverse.
Servo pressure	Servo pressure low or decaying.	Check for torn/missing servo seals. Replace and retest. Refer to **520L0957** H1 45/53/06/68 Repair instructions for seal locations. Only a Danfoss Global Service Partner may remove the servo piston without voiding the warranty.

System Does Not Operate in Either Direction

Item	Description	Action
Oil level in reservoir	Insufficient hydraulic fluid to supply system loop.	Fill reservoir to proper level.
Pump control orifices	Control orifices are blocked.	Clean control orifices.
Pump control screens	Control screens are blocked.	Clean control screens. Refer to **520L0957** H1 45/53/60/68 Repair instructions for screen locations. If pump is being repaired for warranty evaluation, repair must be done by a Danfoss Global Service Partner.
Open bypass valve	If bypass valves are open, the system loop becomes depressurized.	Close bypass valves. Replace high pressure relief valve if defective.
Charge pressure with pump in neutral	Low charge pressure insufficient to recharge system loop	Measure charge pressure with the pump in neutral. If pressure is low, go to next step.
Pump charge relief valve	A pump charge relief valve that is leaky, or contaminated, or set too low depressurizes the system.	Adjust or replace pump charge relief valve as necessary.
Charge pressure with pump in stroke	Low charge pressure, resulting from elevated loop leakage, is insufficient control pressure to hold pump in stroke.	Isolate pump from motor. With pump in partial stroke and engaged for only a few seconds, check pump charge pressure. Low charge pressure indicates a malfunctioning pump. Good charge pressure indicates a malfunctioning motor or other system component. Check motor charge relief operation (if present).

Troubleshooting

Item	Description	Action
Charge pump inlet filter	A clogged filter under supplies system loop.	Inspect filter and replace if necessary.
Charge pump	A malfunctioning charge pump provides insufficient charge flow.	Repair or replace the charge pump.
System pressure	Low system pressure does not provide enough power to move load.	Measure system pressure. Continue to next step.
System relief valves	Defective high pressure relief or pressure limiter valves cause slow system pressure.	Repair or replace high pressure relief or pressure limiter valves.
Input to control	Input is operating improperly.	Repair/replace control.

System Noise or Vibration

Item	Description	Action
Reservoir oil level	Low oil level leads to cavitation.	Fill reservoir.
Aeration of the oil/pump inlet vacuum	Air in system decreases efficiency of units and controls. Air in system is indicated by excessive noise in pump, foaming in oil, and hot oil.	Find location where air is entering into the system and repair. Check that inlet line is not restricted and is proper size.
Cold oil	If oil is cold, it may be too viscous for proper function and pump cavitates	Allow the oil to warm up to its normal operating temperature with engine at idle speed.
Pump inlet vacuum	High inlet vacuum causes noise/cavitation.	Check that inlet line is not restricted and is proper size. Check filter and bypass switch.
Shaft couplings	A loose shaft coupling causes excessive noise.	Replace loose shaft coupling.
Shaft alignment	Misaligned pump and prime mover shafts create noise.	Align shafts.
Charge/system relief valves	Unusual noise may indicate sticking valves. Possible contamination.	Clean/replace valves and test pump.

Neutral Difficult or Impossible to Find

Item	Description	Action
Input to pump control	Input to control module is operating improperly.	Disconnect input and check to see if pump comes back to neutral. If Yes, input fault, replace/repair external controller. If No, go to next step.
Pump control neutral	Neutral set improperly.	Shunt servo gauge ports M4 and M5 together with external hose and see if pump comes back to neutral. If Yes: control neutral improperly set (see page 35). If no: balance swashplate (see *Mechanical neutral adjustment*). If you still cannot set neutral, replace control.

Sluggish System Response

Item	Description	Action
Oil level in reservoir	Low oil level causes sluggish response.	Fill reservoir.
High pressure relief valves/ pressure limiter settings	Incorrect pressure settings affects system reaction time.	Adjust or replace high pressure relief valves.
Low prime mover speed	Low engine speed reduces system performance	Adjust engine speed.
Charge pressure	Incorrect pressure affects system performance	Measure and adjust charge pressure relief or replace charge pump.
Air in system	Air in system produces sluggish system response	Fill tank to proper level. Cycle system slowly for several minutes to remove air from system.

Troubleshooting

Item	Description	Action
Contaminated control orifices	Control orifices are plugged.	Clean control orifices.
Contaminated control screens	Control screens are plugged.	Clean or replace control screens.
Pump inlet vacuum	Inlet vacuum is too high resulting in reduced system pressure.	Measure charge inlet vacuum. Inspect line for proper sizing. Replace filter. Confirm proper bypass operation.

Adjustments

Pump Adjustment

This section offers instruction on inspection and adjustment of pump components. Read through the entire topic before beginning a service activity. Refer to *Pressure measurements* for location of gauge ports and suggested gauge size.

Standard Procedures

Caution

Contamination can damage internal components and void your warranty. Take precautions to ensure system cleanliness when removing and reinstalling system lines

1. With the prime mover off, thoroughly clean the outside of the pump.
2. If removing the pump, tag each hydraulic line. When you disconnect hydraulic lines, cap them and plug each open port to prevent contamination.
3. Ensure the surrounding area is clean and free of contaminants like dirt and grime.
4. Inspect the system for contamination.
5. Check the hydraulic fluid for signs of contamination: oil discoloration, foam in the oil, sludge, or metal particles.
6. If there are signs of contamination in the hydraulic fluid, replace all filters and drain the hydraulic system. Flush the lines and refill the reservoir with the correct filtered hydraulic fluid.
7. Before re-installing the pump, test for leaks.

Charge Pressure Relief Valve Adjustment

This procedure explains how to check and adjust the charge pressure relief valve.

1. Install a 50 bar [1000 psi] pressure gauge in charge pressure gauge port M3. Install a 10 bar [100 psi] gauge at case pressure port L2, or L4. Operate the system with the pump in neutral (zero displacement) when measuring charge pressure.
2. The table shows the acceptable pump charge pressure range for some nominal charge relief valve settings (refer to model code located on serial number plate). These pressures assume 1800 min-1 (rpm) pump speed and a reservoir temperature of 50°C [120°F], and are referenced to case pressure.

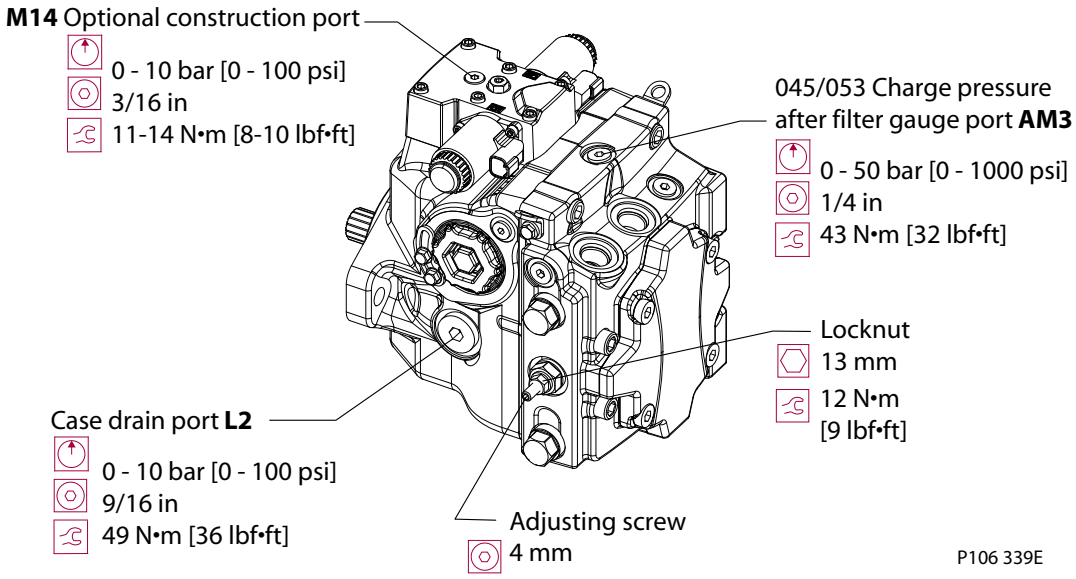
   Ensure charge pressure is properly set before checking pressure limiter.

   Other charge pressure relief valves are available. See page 49 for torques and wrench sizes on other charge pressure relief valves.

   Listed pressures assume a pump speed of 1800 min-1 (rpm) and charge flow of 26.5 l/min [7 US gal/min]. At higher pump speeds or higher charge flows the charge pressure will rise over the rated setting.

Adjustments

Charge pressure adjustment



3. Rotate the adjusting screw clockwise to increase the setting; counter clockwise to decrease it. Subtract the case pressure reading to compute the actual charge pressure.

Charge pressure ranges

Model code	Actual charge pressure*
20	20 bar [290 psi] ± 1.5 bar [21.8 psi]
24	24 bar [348 psi] ± 1.5 bar [21.8 psi]
26	26 bar [377 psi] ± 1.5 bar [21.8 psi]
30	30 bar [435 psi] ± 1.5 bar [21.8 psi]

* This is the actual charge pressure port gauge reading minus the case pressure port gauge reading. Factory set at 1800 min-1 (rpm) with a reservoir temperature of 50° C [120° F].

Pressure change per turn is dependant on charge flow entering pump.

4. While holding the adjusting screw, torque locknut to 17 N•m [13 lbf•ft].
5. When you achieve the desired charge pressure setting, remove the gauges and plug the ports.

Pressure Limiter Adjustment

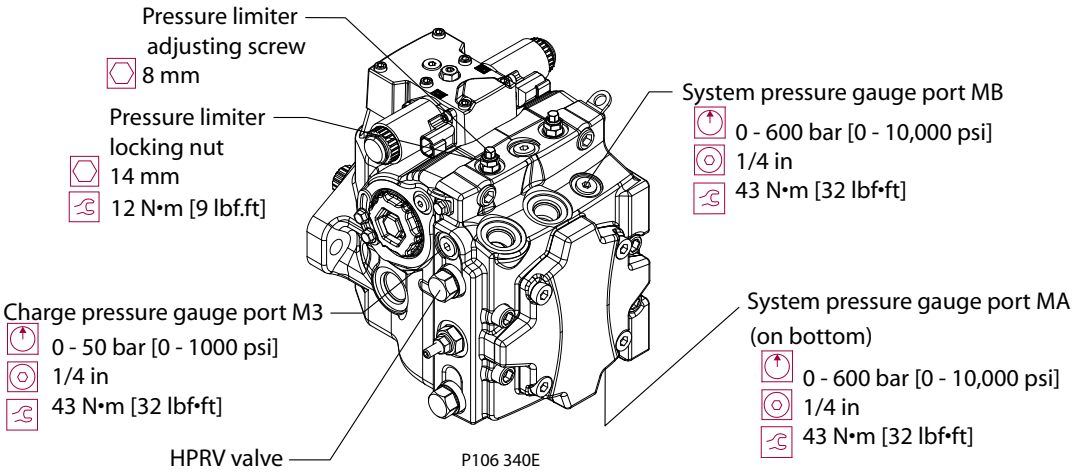
Lock motor output shaft to adjust the pressure limiter setting. Lock the vehicle's brakes or rigidly fix the work function so it cannot rotate.

1. Install 600 bar [10,000 psi] pressure gauges in the high pressure gauge ports (MA and MB). Install a 50 bar [1000 psi] pressure gauge in the charge pressure gauge port (M3).

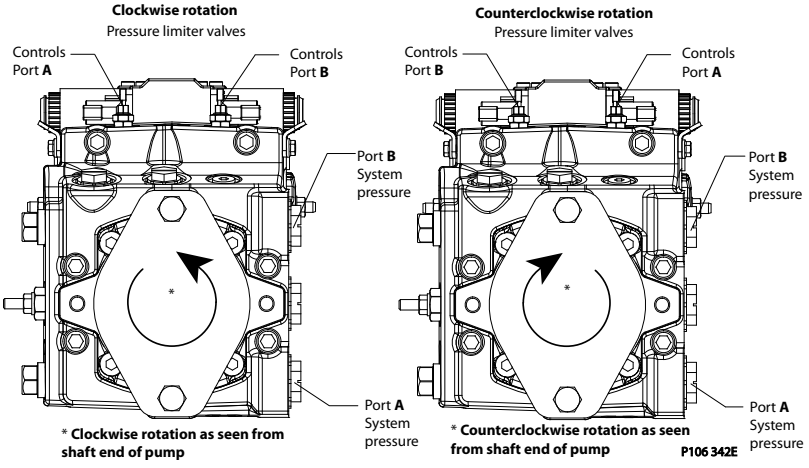
Ensure charge pressure is properly set before checking pressure limiter.

Adjustments

Pressure limiter adjustment



Pressure limiter valve adjustment



If you change pressure limiter settings, you must also change the HPRV valve to maintain proper PL function. Refer to table on next page for corresponding settings.

Endcaps are different for clockwise and counter clockwise rotation.

2. Start the prime mover and operate at normal speed.
3. Use a 17mm wrench to loosen the locking nut (L024).
4. Activate the control input until pressure in the high side of the system loop stops rising. This pressure is the PL setting.
5. Return the pump to neutral and adjust the PL setting using an internal hex wrench. Wrench size is in the diagram on the previous page. Turn the adjusting screw clockwise to increase the PL setting, counter clockwise to decrease it. The adjustment is very sensitive. Change per turn is approximately 150 bar [2176 psi].

Change per turn is 150 bar/rev [2176 psi/rev].

The model code on the serial plate gives the factory setting of the PL (Pressure Limiter). The PL setting is referenced to charge pressure. Subtract charge pressure from system pressure gauge readings to compute the effective PL setting.

Adjustments

6. Repeat steps four and five until you reach the desired PL setting. After adjustment, torque the locknut (L024) to 12 N•m [9 lbf•ft]. Do not over torque.
7. Shut down the prime mover. Remove gauges and replace plugs.

Pressure limiter settings

Pressure limiter setting	HPRV setting
150	200
180	230
200	250
230	280
250	300
280	330
300	350
330	380
350	400
380	420

Pressure limiter setting	HPRV setting
400	450
410	
420	
430	480
440	
450	
460	510
470	
480	

Engaging the Bypass Function

Use this procedure to bypass the pump to allow moving the vehicle/machine short distances when you cannot start the prime mover.

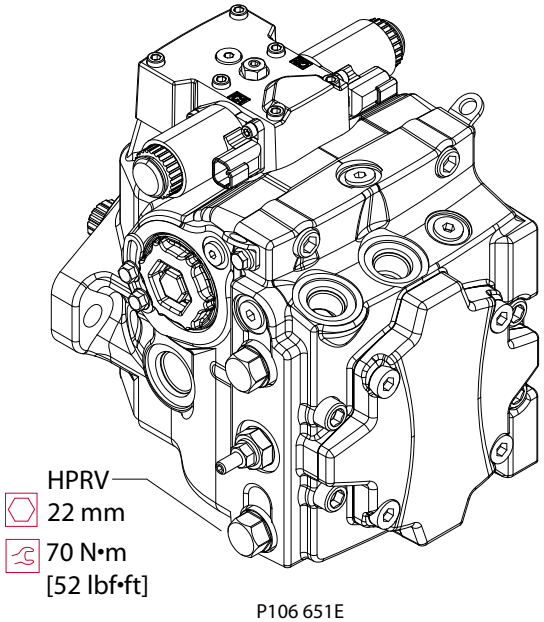
Caution

It is possible to damage the drive motor(s) by operating in bypass mode without charge pressure. Move the vehicle/machine at a speed not more than 20% of maximum for a duration not exceeding 3 minutes.

1. To open the HPRVs (L150), rotate three revolutions counter clockwise using a 22mm hex wrench. Do not rotate more than 3 revolutions, leakage will result.
2. To close the HPRVs, rotate them clockwise until seated. Torque to 70 N•m [52 lbf•lb].
3. If machine is towable with HPRVs opened three turns and if wheels are locked (not towable) with HPRV valves closed, bypass function is working correctly.

Adjustments

Engaging the bypass function



P106 651E

Displacement Limiter Adjustment

If your pump has displacement limiters, you will find them on either servo cover. You can limit forward and reverse displacement independently.

Displacement limiters are not pre-set by the factory. We install them as far as possible without contacting the servo piston. Limiting displacement requires clockwise adjustment of the limiting screw.

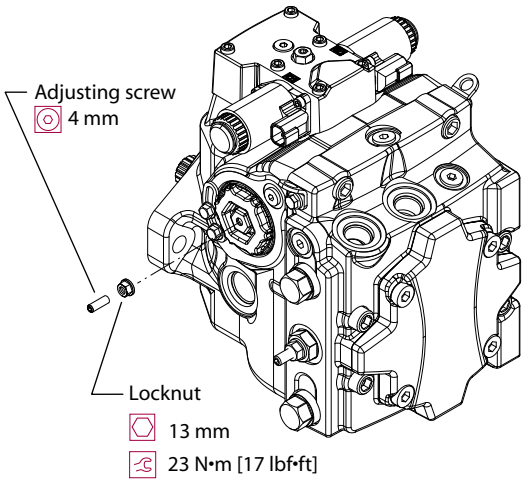
Caution

Before adjusting the displacement limiter, mark the position of the servo cylinder. Be sure the servo cylinder does not turn when setting the displacement limiter locknut.

1. Loosen the lockingnut.
2. Rotate the adjusting screw to achieve the desired maximum displacement. Set the adjusting screw against the servo piston by feel before counting turns. Refer to the table below for change per turn. Clockwise rotation decreases displacement, counter clockwise rotation increases it. Adjustment is possible from zero to maximum.
3. After establishing the desired maximum displacement setting, hold the adjusting screw while torquing the locknut to the value in the table below.
4. Test operation of the vehicle/machine to verify proper maximum speed of vehicle/work function.

Adjustments

Displacement limiter adjustment



Displacement limiter adjustment data

Displacement	Locknut wrench size and torque	Adjusting screw size	Approximate displacement change per revolution of adjusting screw
45	13 mm 23 N•m [17 lbf•ft]	4 mm internal hex	5.1 cm^3 [0.31 in^3]
53	13 mm 23 N•m [17 lbf•ft]	4 mm internal hex	6.0 cm^3 [0.37 in^3]
60	13 mm 23 N•m [17 lbf•ft]	4 mm internal hex	6.8 cm^3 [0.41 in^3]
68	13 mm 23 N•m [17 lbf•ft]	4 mm internal hex	7.7 cm^3 [0.47 in^3]

Control Neutral Adjustment

All functions of the Electric Displacement Control (EDC) are preset at the factory. Adjust the pump to neutral with the pump running on a test stand or on the vehicle/machine with the prime mover operating. If adjustment fails to give satisfactory results, you may need to replace the control or coils. See *Minor repair* for details.

Warning

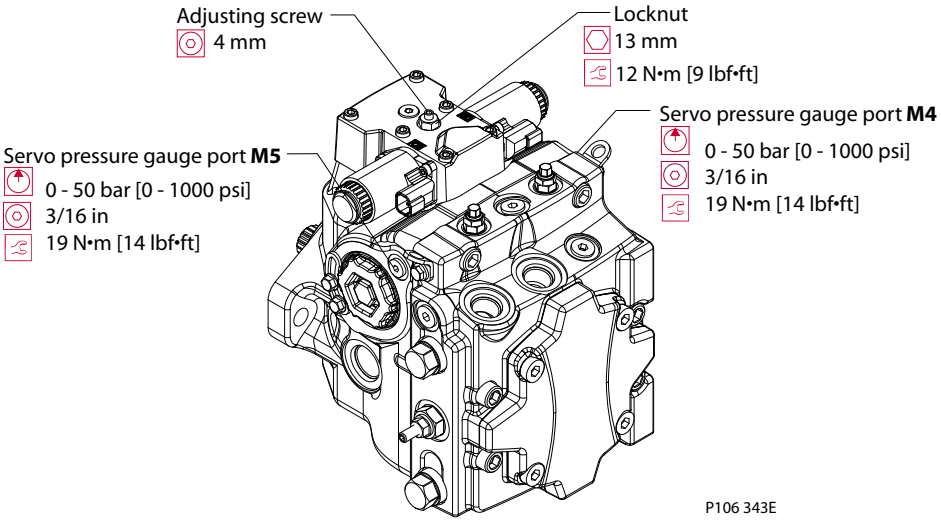
Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable/disconnect the mechanism while servicing.

1. Install a 50 bar [1000 psi] gauge in each of the two servo gauge ports (M4 and M5). Disconnect the external control input (electrical connections) from the control. Start the prime mover and operate at normal speed.
2. Use a 4mm internal hex wrench to hold the neutral adjusting screw (D015) stationary while loosening the locknut (D060) with a 13mm wrench.
3. Observe pressure gauges. If necessary, turn adjusting screw (D015) to reduce any pressure differential.

   Adjustment of the EDC is very sensitive. Be sure to hold the hex wrench steady while loosening the locknut. Total adjustment is less than 120 degrees.

Adjustments

Control adjustment



4. Rotate the neutral adjusting screw (D015) clockwise until the pressure increases on the gauge. Note the angular position of the wrench. Then rotate the neutral adjusting screw counter clockwise until the pressure increases by an equal amount on the other gauge. Again note the angular position of the wrench.

Neutral adjustment (EDC) (bottom view)

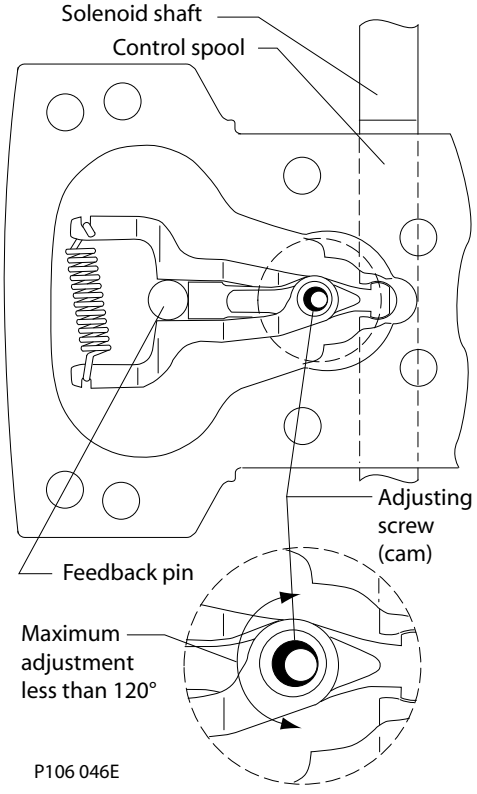


Illustration shows how cam on adjusting pin rotates to adjust for neutral position after pump is re-installed.

Adjustments

5. Rotate the neutral adjusting screw clockwise half the distance between the wrench positions noted above. The gauges should read the same pressure, indicating that the control is in its neutral position.
6. Hold the neutral adjusting screw stationary and tighten the lock nut (D060). Torque to 10 N•m [7 lbf•ft]. Do not over torque the nut.
7. When the neutral position is set, stop the prime mover, remove the gauges, and install the gauge port plugs. Reconnect the external control input.

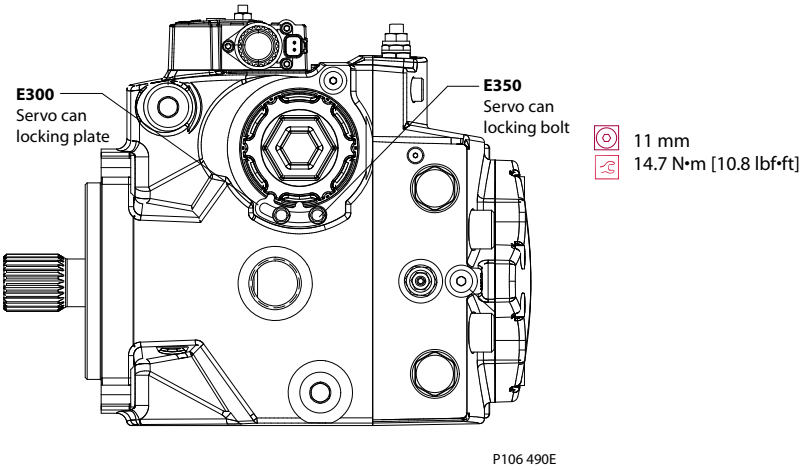
A small pressure differential of 1.5 bar [22 psi] or less is acceptable. Zero differential is usually not possible.

Mechanical Neutral Adjustment

Servo adjustment

1. Run prime mover at 1800 min^{-1}(rpm).
2. If using a PWM signal, ensure the signal is off. Check the servo pressure gauges. Ensure the differential between M4 and M5 is less than 1.5 bar [22 psi].
3. Using a 3/4 in hex deep socket, unthread both servo cylinders 2-3 turns. This step ensures the servo cylinders have no contact with the servo piston.
4. Stroke the pump by turning the control eccentric screw (or supplying current to solenoid C1) until the servo pressure at port M4 is 1 to 2 bar [14– 29 psi] greater than at port M5 and the system pressure gauges indicate displacement. Pressure should be greater at port MA for clockwise rotation, or MB for counter clockwise rotation. This also indicates the servo piston is in contact with the servo cylinder on side M5.
5. Slowly thread the servo cylinder on the M5 side in until the system pressure differential starts to decrease. Maintain servo pressure differential between 1-2 bar [14-29 psi] during this step. Continue turning the servo cylinder in until the system pressure differential (between ports MA/MB) is less than 1.5 bar [22 psi]. This procedure sets the servo and swashplate to mechanical neutral on the M5 side.
6. To complete setting neutral, repeat steps 1-5 but stroke the pump in the opposite direction by turning the eccentric screw in the opposite direction, or by supplying current to solenoid C2. Reverse gauge locations (M4 for M5, MB for MA) from those stated above since the pump is now stroking the other direction.
7. Remove all gauges and replace gauge port plugs.

Servo adjustment



P106 490E

Adjustments

Verify neutral setting

1. If using a PWM signal to set mechanical neutral, check that servo pressure differential is less than 5 bar [22 psi]. Refer to TS-392 or *Control neutral adjustment*.
2. To verify mechanical neutral, provide current to solenoid C1, or turn neutral adjust excenter screw, until the servo pressure differential is 3 bar [43 psi]. The system pressure differential must be below 1.5 bar [22 psi]. Repeat test on solenoid C2 side.
3. The current required to set the servo pressure differential to 3 bar [43 psi] should be the same for each solenoid. Refer to TS-392.
4. If using neutral adjust excenter screw to set mechanical neutral, reset control neutral (see *page 35*).

Servo Adjustment Side M4

1. Run prime mover at 1800 rpm.
2. If using a PWM signal to set mechanical neutral, start with the electronic control testing tool off (no current to either solenoid). Check to be sure the servo pressure differential is less than 1.5 bar [22 psi]. Reference Danfoss testing specifications TS-392 or control neutral adjustment page 35.
3. Turn neutral adjust excenter screw (or supply current to solenoid C2) until the servo pressure at port M5 is 1 - 2 bar [14– 29 psi] greater than at port M4.
4. The system pressure differential must be greater than zero and the pressure at port A (B for clockwise rotation) must be greater than the pressure at port B (A for clockwise rotation). This step ensures the servo is in contact with the servo cylinder on side M4.
5. Slowly turn in the servo cylinder on the M4 side until the system pressure differential starts to decrease. The servo pressure differential must be maintained between 1-2 bar [14-29 psi] during this step. Continue turning in the servo cylinder until the system pressure differential is less than 1.5 bar [22 psi]. This procedure sets the servo and swashplate to mechanical neutral.

Minor Repair

Standard Procedures, Removing the Pump

Before working on the pump, thoroughly clean the outside. If the pump has an auxiliary pump attached, remove both pumps as a single unit. Tag and cap all hydraulic lines as they are disconnected, and plug all open ports to ensure that dirt and contamination do not get into the system.

Caution

Contamination can damage internal components and void the manufacturer's warranty. Take precautions to ensure system cleanliness when removing and installing system lines.

1. With the prime mover off, thoroughly clean all dirt and grime from the outside of the pump.
2. Tag, disconnect, and cap each hydraulic line connected to the pump. As hydraulic lines are disconnected, plug each open port, to ensure that dirt and contamination do not get into the pump.
3. Remove the pump and its auxiliary pump (if applicable) as a single unit.

   Be careful, do not damage solenoids and electrical connections when using straps or chains to support the pump.
4. Ensure the work surface and surrounding area are clean and free of contaminants such as dirt and grime.
5. Inspect the system for contamination.
6. Look at the hydraulic fluid for signs of system contamination, oil discoloration, foam in the oil, sludge, or metal particles.
7. Before replacing the pump, replace all filters and drain the hydraulic system. Flush the system lines and fill the reservoir with the correct, filtered hydraulic fluid.
8. Fill the pump with clean, filtered hydraulic fluid.
9. Attach the pump to the prime mover. Torque mounting screws according to the manufacturers recommendation.
10. Replace all hydraulic lines. Ensure the charge inlet line is filled with fluid.

Control Module

Refer to exploded diagram, next page.

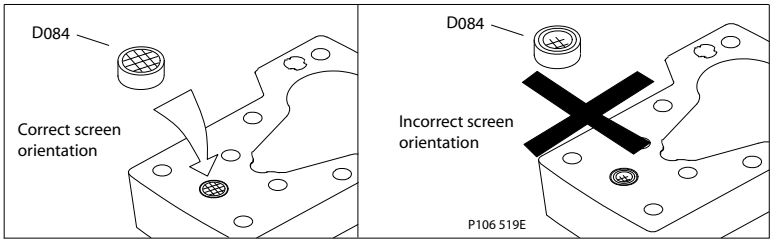
1. Using a 5 mm internal hex wrench, remove the six cap screws (D250).
2. Remove the control module and gasket (D150). Discard the gasket.
3. If necessary, remove orifices (F100) using a 3 mm internal hex wrench. Tag and number them for reinstallation.
4. Inspect the machined surfaces on the control and top of the pump. If you find any nicks or scratches, replace the component.
5. Ensure you install dowel pins (D300) in housing before installing control.

   Install a new gasket (D150).
6. If you removed screen (D084), install a new one. Install with the mesh facing outward (see drawing).

   Remove plug on top of control to ensure the swashplate feedback pin is properly positioned in the center of the control module when installing control.

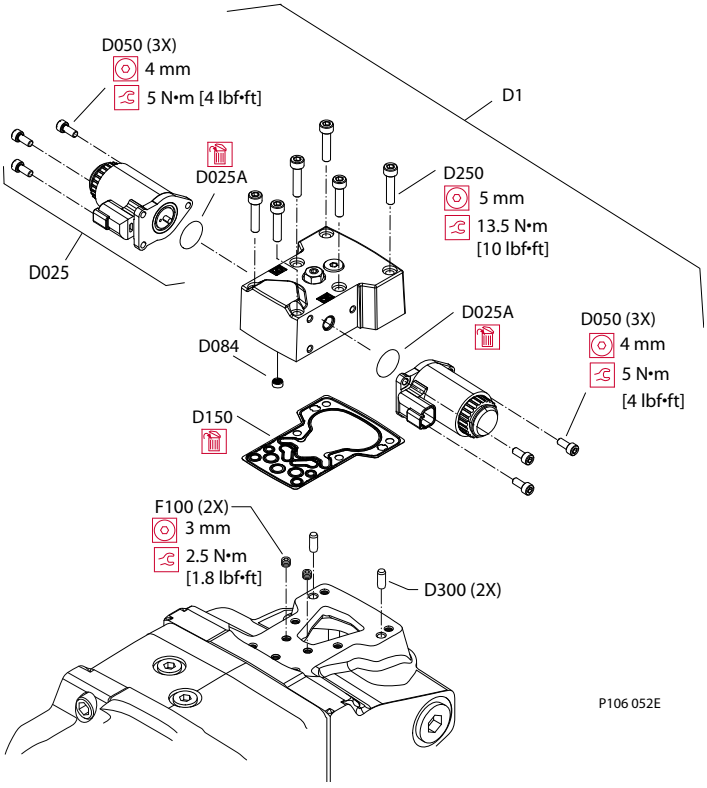
Minor Repair

Proper screen orientation



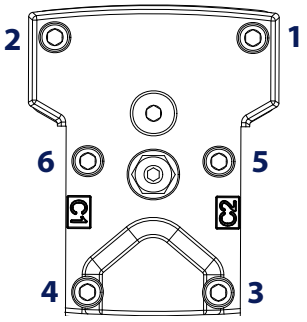
7. If previously removed, install orifices (F100) using a 3 mm internal hex wrench. Torque to 2.5 N•m [1.8 lbf•ft].
8. Install the control module and six cap screws (D250).
9. Using a 5 mm internal hex wrench, torque the cap screws (D250) to 13.5 N•m [10 lbf•ft].

Control module removal/installation



Minor Repair

Torque sequence



Control Solenoids

1. Disconnect electrical connection and remove the three cap screws (D050) using a 4 mm internal hex wrench.
2. Remove the solenoid (D025) and O-ring (D025A). Discard the O-ring.
3. If necessary, remove the coil using a 12 point 26 mm socket.
4. Inspect the machined surface on the control. If you find any nicks or scratches, replace the component.
5. Lubricate new O-ring (D025A) using petroleum jelly and install.
6. Install solenoid with three cap screws (D050) using a 4 mm internal hex wrench. Torque screws to 5 N•m [4 lbf•ft].
7. Install coil using a 12 point 26 mm socket. Torque coil nut to 5 N•m [3.7 lbf•ft].
8. Reconnect electrical connections and test the pump for proper operation.

For repair part information, see Danfoss publication *H1 Parts Manual* for your model.

Automotive Control

Removal

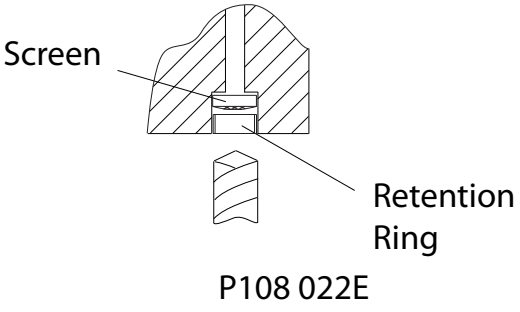
1. Drain pump completely before removing control. Disconnect and remove wiring (D640).
2. Fabricate a special tool to remove two plastic plugs (D610). See drawing below for tool dimensions. Push down on plug and turn 45 degrees counterclockwise. Discard plugs.

   Wax seals will be destroyed when the plugs are removed. Do not damage the housing in the plug sealing area.
3. Use a 5 mm internal hex to remove two screws (D674). Remove shield (D672).
4. Use a 5 mm internal hex to remove six screws (D250). Remove control from pump.
5. Remove and discard gasket (D150).

   Alignment pins are pressed into control. Do not remove them.
6. If necessary, use a 3 mm internal hex to remove orifices (F00A, F00B) from housing. Tag each orifice for reinstallation. Each orifice may be a different size.

Minor Repair

Drill Out Retention Ring

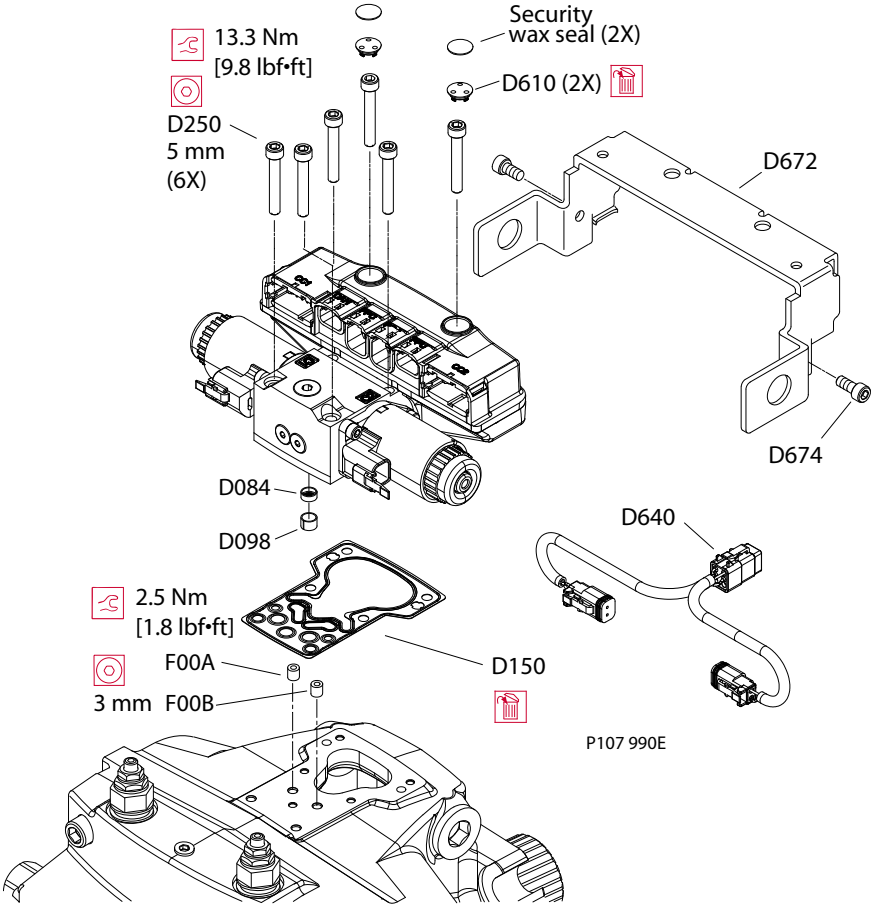


7. If it is necessary to remove the screens, drill out screen retention ring (D098) and remove and discard screen (D084). Note screen orientation for reassembly.

Warning

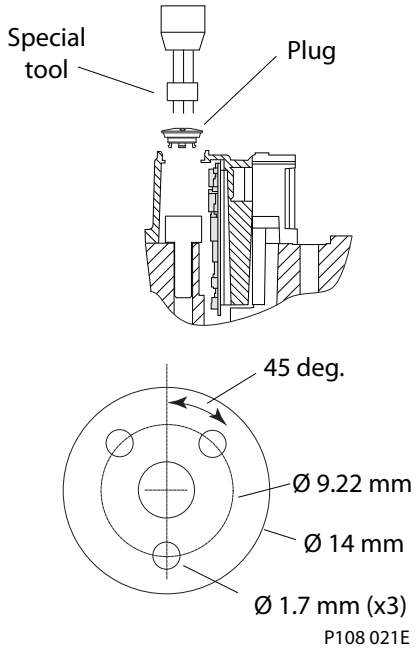
Do not allow metal fragments to fall into control housing. This may cause erratic pump operation.

Remove Control



Minor Repair

Special Tool



Inspection

Inspect machined surfaces on control and pump housing. Inspect plastic PC board housing and its sealing areas. If any damage is found, replace damaged components.

Controls are available as a complete unit. Do not disassemble the control.

Assembly

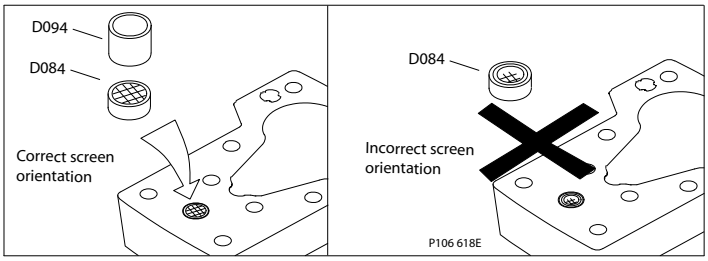
1. If previously removed, install new screen (D084) in original orientation. Press in new retention ring (D098).

   Be sure screen will not move axially in bore after retention ring is installed.

   Warning

   Failure to install screen will result in erratic pump operation.

   Proper Screen Orientation



2. If previously removed, use a 3 mm internal hex to install orifices (F00A, F00B) in original orientation. Torque to 2.5 N•m [1.8 lbf•ft][.
3. Install new gasket (D150) to bottom of control.

Minor Repair

4. Install control on pump. Use a 5 mm internal hex to install six screws (D250). Torque to 13.3 N•m [9.8 lbf•ft]. Follow torque sequence shown on page 43.

   Do not damage the plastic housing in the plug sealing area when installing the screws.

   If pump has been rebuilt or a new control is being installed, control software must be recalibrated. Refer to *H1-Automotive Control User Manual* **70012797** for recalibration instructions.

5. Connect wiring (D640).
6. Use the special tool to install new plastic plugs with O-rings (D610). Press plugs in and turn 45 degrees clockwise.

   If control will continue to be under warranty, install new sealing wax of a different color (original wax is blue). Pumps without sealing wax installed will not be warrantied.

7. Install protection bracket (D672). Install screws (D674). Torque to 5 N•m [3.7 lbf•ft].

Shaft Seal, Roller Bearing and Shaft Replacement

The shaft assembly is serviceable without disassembling the pump. Orient the pump on the work surface so the shaft is pointing to the side.

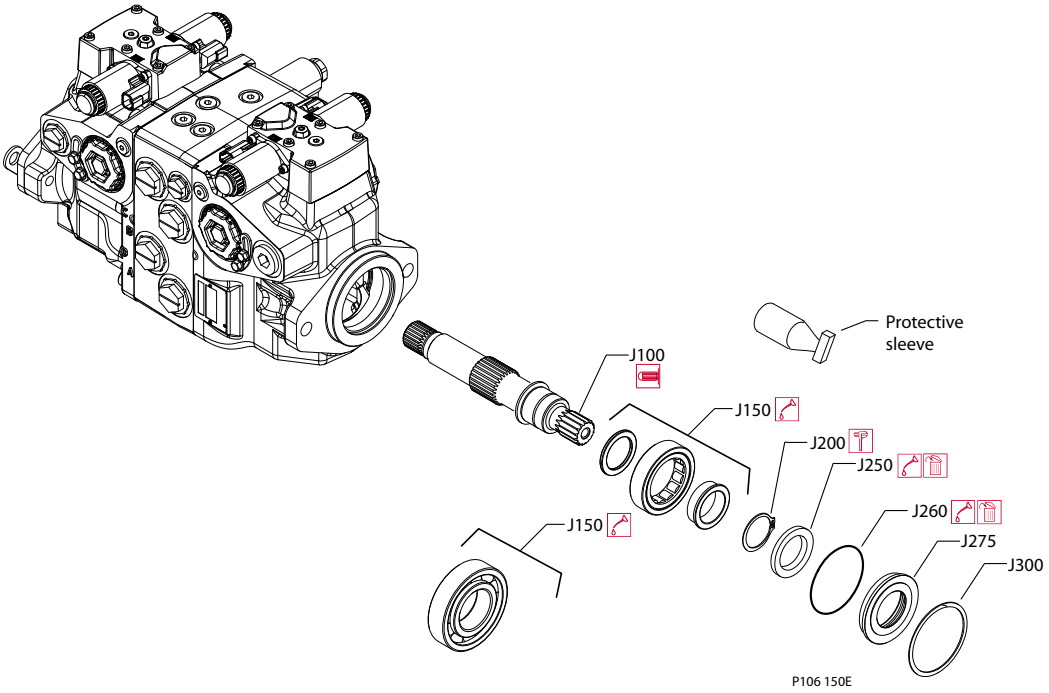
1. Unwind the spiral ring (J300) from the housing to release the shaft/seal/bearing subassembly.
2. Pry on the lip of the seal carrier (J275) to dislodge it from the pump. Remove the seal carrier. Remove and discard O-ring (J260). Press the seal (J250) out of the carrier and discard.
3. Pull the shaft (J100) with bearing (J150) out of the pump. If necessary, tap lightly on the shaft to dislodge it from the cylinder block.

   Caution

   Do not damage the housing bore, shaft or bearing when removing the shaft and shaft seal.

4. Remove the retaining ring (J200) using retaining ring pliers. Press the bearing off the shaft.

   Shaft assembly

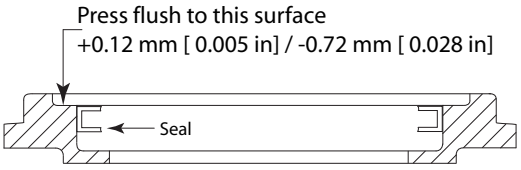


5. Inspect the shaft journals for wear, scratching, and pits. Check the splines for fretting; replace if damaged. Rotate the bearing, if it does not rotate smoothly, replace it.

Minor Repair

6. Press the bearing (J150) onto the shaft (J100) and replace the retaining ring (J200). Ensure the retaining ring diameter is less than 38.84 mm [1.53 in] when installed on the shaft.
7. Install the shaft/bearing assembly into the pump.
8. Lubricate and install a new O-ring (J260) onto seal carrier (J275). Press a new seal (J250) into the seal carrier. Press the seal until it is flush within +0.12mm [0.005 in] or -0.72 mm [0.0028 in] of the inside lip of the carrier: *see illustration.*

Positioning seal in seal carrier



P106 498E

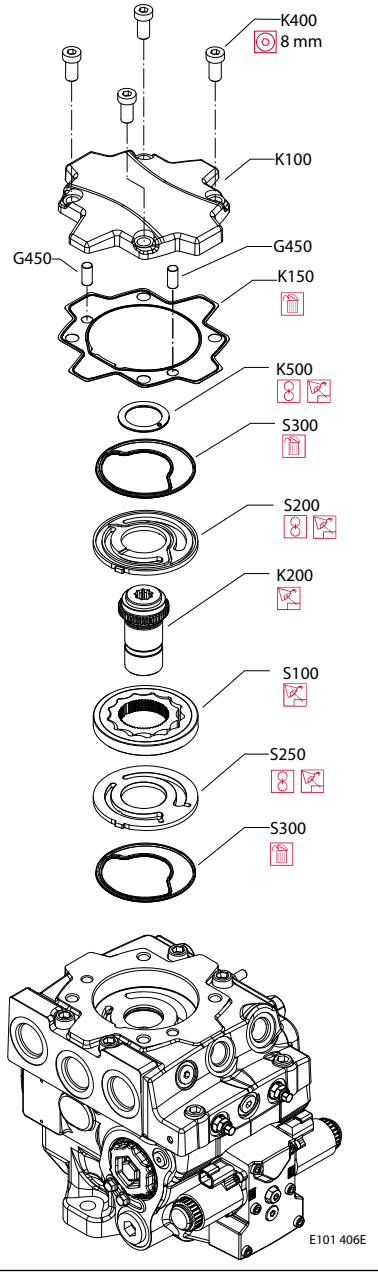
9. Cover the shaft with a protective sleeve while installing the seal carrier. Hand press the seal carrier into the housing. Ensure the seal carrier clears the spiral ring groove in the housing. Remove the protective sleeve.
10. Wind the spiral ring into the housing. Ensure the inside diameter of the spiral ring is greater than 68 mm [2.677 in] after installation.

Charge Pump

If the pump has an auxiliary pump attached, remove the auxiliary pump and connecting shaft before removing the auxiliary pad.

Minor Repair

Charge pump removal/installation



Ensure proper torque on aux pad screws (K400) If necessary, replace screws.

1. Position pump so end cover or auxiliary pad is on top.
2. If necessary, remove auxiliary pump (not shown), or shipping cover (K300) and pad seal (K250) as shown on following page.
3. Remove end cover/auxiliary pad screws (K400) using a 8 mm internal hex wrench.

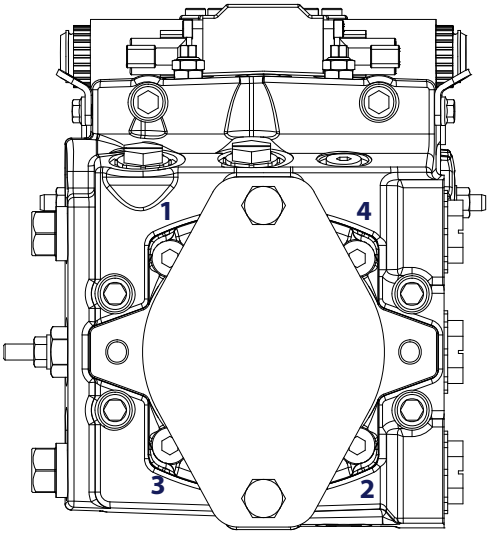
   Alignment pins (G450) are in end cover. They may dislodge during disassembly.
4. Remove and discard gasket (K150).
5. Remove thrust washer (K500). Note thrust washer orientation.

Minor Repair

6. Use a small hook to remove pressure balance plate (S200) and seal (S300). Note plate orientation. Discard seal.
7. Remove coupling (K200). Use a small hook if necessary.
8. Remove the charge pump outer ring (S150), and gearset (S100).
9. Remove valve plate (S250) with seal (S300). Discard seal.
10. Inspect the components for wear, scratches or pitting. Carefully inspect the valve and pressure-balance plates. Scratches on these components will cause a loss of charge pressure. If any component shows signs of wear, scratching or pitting, replace it.
11. Install new seals (S300) in the valve (S250) and pressure-balance (S200) plates.
12. Install valve plate (S250) in the same orientation as removed.
13. Lubricate and install charge pump (S100) and outer ring (S150).
14. Install charge pump coupling (K200).
15. Install pressure balance plate (S200) in the same orientation as removed.
16. Install the thrust washer (K500). Coated side goes toward charge pump coupling (K200).
17. Install a new cover gasket. (K150). If removed, install guide pins (K450).
18. Install the auxiliary pad or charge pump cover and cap screws. Using a 8mm internal hex wrench, torque the cap screws (K400) to 92 N•m [68 lbf•ft]. Torque in sequence below.
19. Reinstall auxiliary pump or pad seal (K250) and shipping cover ((K300).

If necessary, you must replace charge pump components (gearset, outer ring, valve and pressure-balance plates) as a kit.

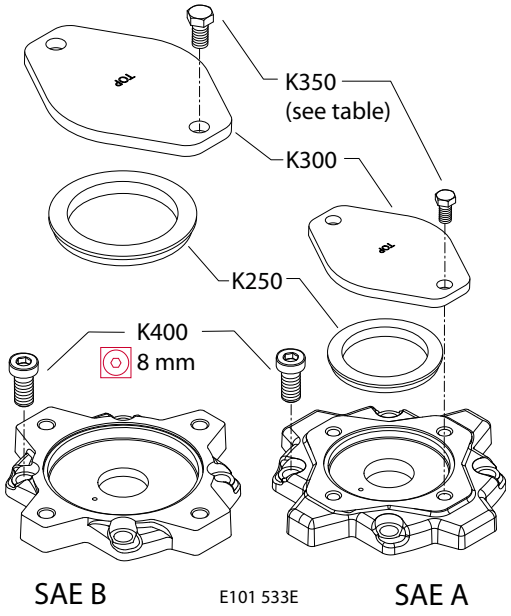
Torque sequence



P106 346E

Minor Repair

Auxilliary pads



Cover Screw K350

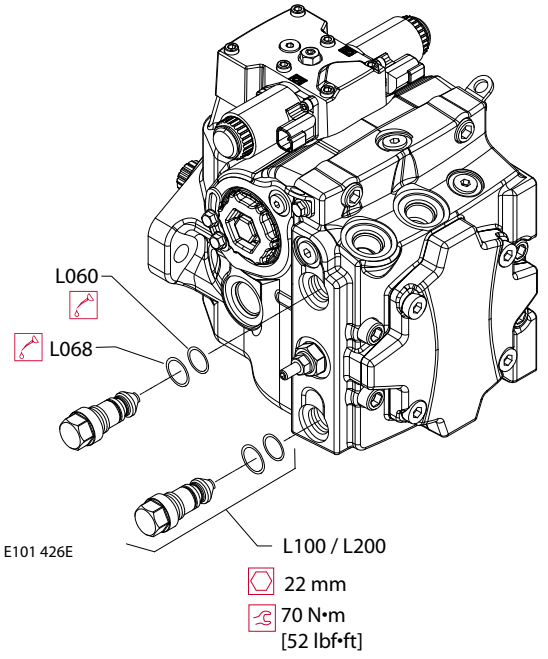
Cover Pad	Wrench size and torque
A	17 mm 48 N•m [35 lbf•ft]
B	18 mm 77 N•m [58 lbf•ft]

Charge Check / HPRV

1. Using a hex wrench shown in the table below, remove the HPRVs (L150). Remove and discard the O-rings (L060) and backup rings (L068).
2. Inspect the sealing surfaces in the pump for nicks or scratches. Check the valves for damage. Replace any damaged components.
3. Lubricate and install new backup rings (L068) and O-rings (L060).
4. Install HPRVs. Torque to the value in the table below.
5. Operate the vehicle/machine through full range of controls to ensure proper operation. Check for leaks.

Minor Repair

High pressure relief valves



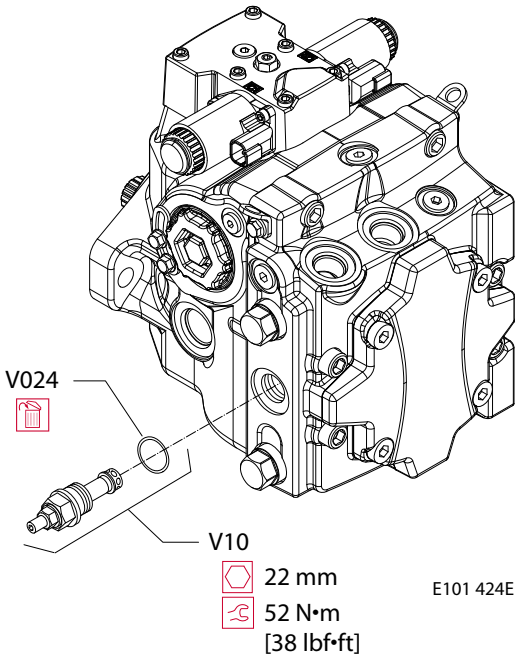
Charge Pressure Relief Valve

Replace the charge pressure relief valve (V010) as a complete unit. Do not attempt to repair the internal components of the valve. Torque to 52 N•m [38 lbf•ft] See *Charge pressure relief valve adjustment* for adjustment instructions.

1. Using a 22 mm wrench, remove the charge pressure relief valve (V010). Discard seal (V024).
2. Inspect the sealing surfaces of the pump for nicks or scratches.
3. Lubricate and install new seal (V024).
4. Install the charge pressure relief valve. Torque to 52 N•m [38 lbf•ft].
5. Operate vehicle/machine through full range of controls to ensure proper operation.

Minor Repair

Charge pressure relief valve



Pressure Limiter Valve Replacement

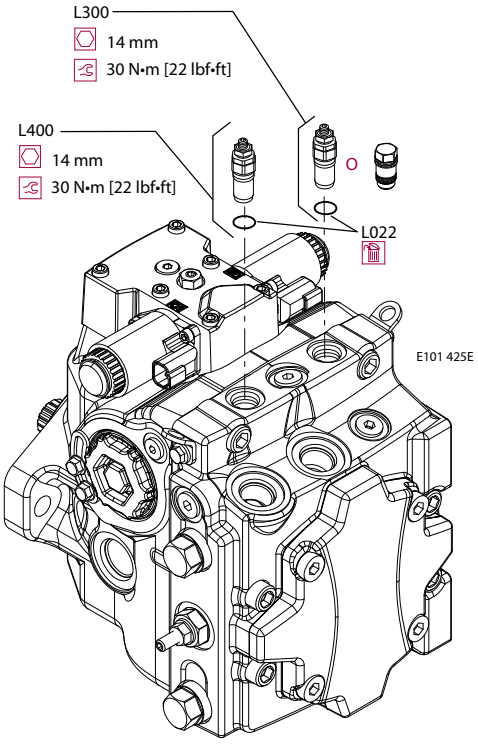
Replace the pressure limiter valve as a complete unit. Do not attempt to repair individual components. See *Pressure limiter adjustment* for adjustment instructions.

1. Using a 14 mm wrench, remove the pressure limiter valve (L100). Discard O-ring.
2. Inspect the sealing surfaces of the pump for nicks or scratches.
3. Install new O-ring. Lubricate 0-ring with petroleum jelly.
4. Replace pressure limiter valve. Torque to 30 N•m [22 lbf•ft].
5. Operate pump at full range of controls to ensure proper machine operation.

Pressure limiter is available as complete unit only. O-ring is available separately.

Minor Repair

Pressure limiter



Torque Chart

Fastener Size and Torque Chart

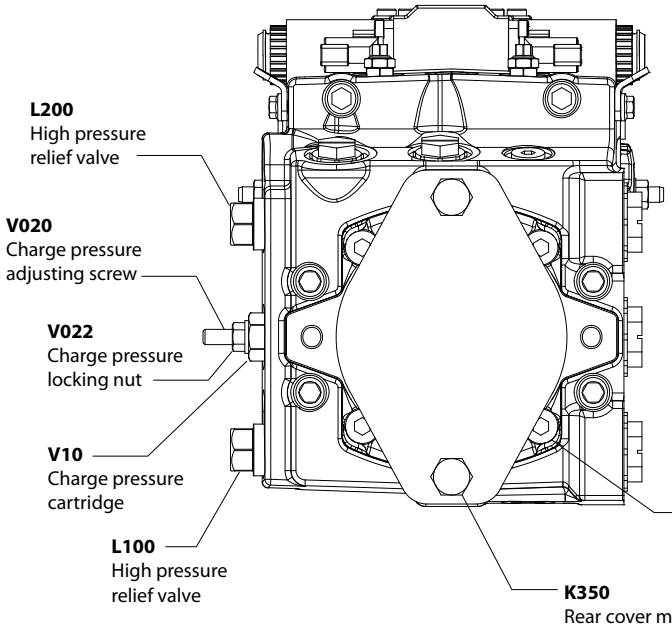
Item	Fastener	Wrench size	Torque
D015	Neutral adjust screw	4 mm internal hex	NA
D050	Coil mounting bolt	4 mm internal hex	8 N•m [9 lbf•ft]
D060	Neutral adjust locking nut	13 mm	10 N•m [7 lbf•ft]
D250	Electric control mounting bolt	5 mm internal hex	13 N•m [10 lbf•ft]
E350	Servo cylinder locking bolt	11 mm	14.5 N•m [11 lbf•ft]
K350 A pad	Shipping cover mounting bolt	17 mm	8.7 N•m [6.4 lbf•ft]
K350 B pad	Shipping cover mounting bolt	18 mm	12 N•m [8.9 lbf•ft]
K400	Rear cover/aux pad mounting bolt	8 mm internal hex	92 N•m [68 lbf•ft]
L010	Pressure limiter adjust screw	8 mm	NA
L300/L400	Pressure limiter cartridge	14 mm	30 Nm [22 lbf•ft]
L024	Pressure limiter locking nut	14 mm	20 N•m [15 lbf•ft]
L100/L200	High pressure relief valve	22 mm	70 N•m [52 lbf•ft]
V10	Charge pressure cartridge	22 mm	52 N•m [38 lbf•ft]
V020	Charge pressure adjusting screw	4 mm internal hex	NA
V022	Charge pressure locking nut	13 mm	12 Nm [9 lbf•ft]

Plug Size and Torque Chart

Item	O-ring plug	Wrench size	Torque
B015	7/16 - 20	3/16 in internal hex	19 N•m [14 lbf•ft]
B020	1-1/16 - 12	9/16 in internal hex	49 N•m [36 lbf•ft]
D065	7/16 - 20	3/16 in internal hex	19 N•m [14 lbf•ft]
G250	9/16 - 18	7 mm internal hex	22-26 N•m [16-20 lbf•ft]
G300/G302	9/16-18 UNF	1/4 in internal hex	42 N•m [30 lbf•ft]

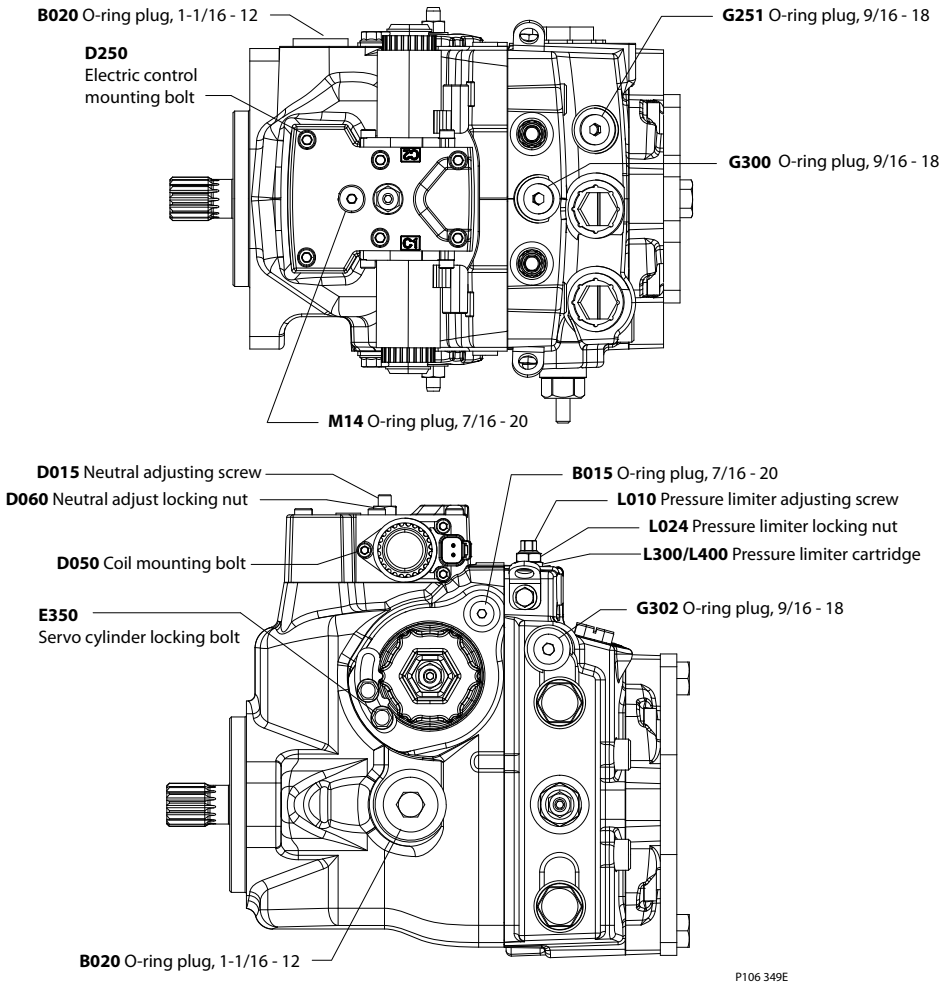
Torque Chart

Fasteners and Plugs



P106 348E

Torque Chart



Notes

Products we offer:

- Bent Axis Motors
- Closed Circuit Axial Piston Pumps and Motors
- Displays
- Electrohydraulic Power Steering
- Electrohydraulics
- Hydraulic Power Steering
- Integrated Systems
- Joysticks and Control Handles
- Microcontrollers and Software
- Open Circuit Axial Piston Pumps
- Orbital Motors
- PLUS+1® GUIDE
- Proportional Valves
- Sensors
- Steering
- Transit Mixer Drives

Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electronic 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. Building on our extensive applications expertise, we work closely with our customers to ensure exceptional performance for a broad range of off-highway vehicles.

We help OEMs around the world speed up system development, reduce costs and bring vehicles to market faster.
Danfoss – Your Strongest Partner in Mobile Hydraulics.

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

Wherever off-highway vehicles are at work, so is Danfoss.

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

Please contact the Danfoss Power Solution representative nearest you.

Comatrol
www.comatrol.com

Schwarzmüller-Inverter
www.schwarzmueller-inverter.com

Turolla
www.turollaocg.com

Valmova
www.valmova.com

Hydro-Gear
www.hydro-gear.com

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

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
(Shanghai) Co. Ltd.
Building #22, No. 1000 Jin Hai Rd
Jin Qiao, Pudong New District
Shanghai, China 201206
Phone: +86 21 3418 5200