

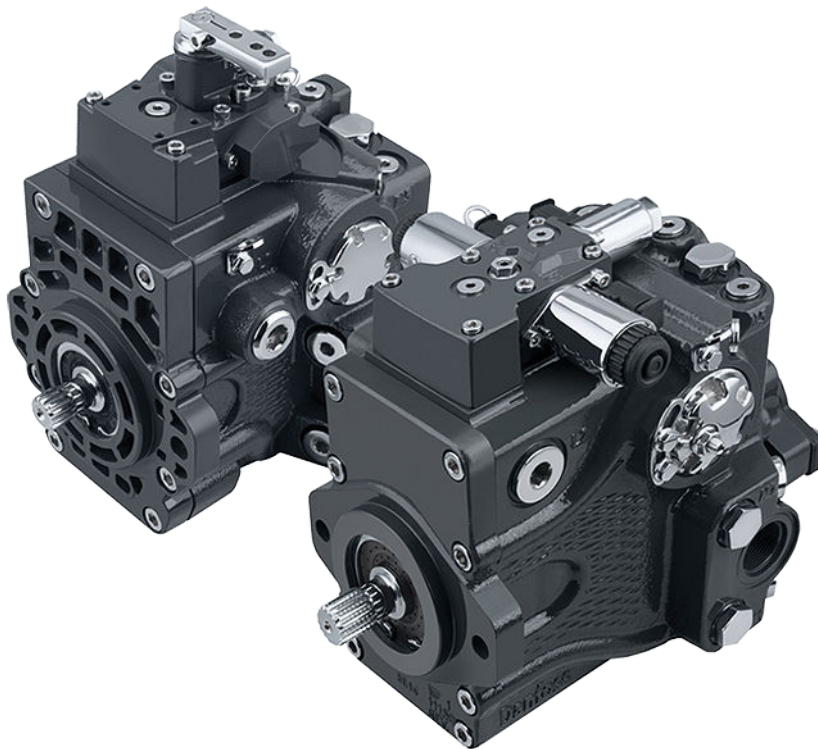
ENGINEERING  
TOMORROW



Service Manual

# Variable Displacement Pumps

## MP1



## Revision history

*Table of revisions*

Date	Changed	Rev
October 2017	Remove HDC	0104
July 2017	update ports and plugs	0103
April 2017	Add HDC	0102
August 2016	First edition	0101

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## Introduction

### Overview

This manual includes information on installation, maintenance, and minor repair of these 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](http://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 variable displacement 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 with 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 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. Take the following general precautions whenever servicing a hydraulic system:

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 **Warning**

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**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.

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 **Warning**

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**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.

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 **Warning**

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**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.

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 **Warning**

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**Personal safety**

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

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 **Warning**

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**Hazardous material**

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

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## Introduction

### Symbols used in Danfoss literature

	WARNING may result in injury		Tip, helpful suggestion
	CAUTION may result in damage to product or property		Lubricate with hydraulic fluid
	Reusable part		Apply grease / petroleum jelly
	Non-reusable part, use a new part		Apply locking compound
	Non-removable item		Inspect for wear or damage
	Option - either part may exist		Clean area or part
	Superseded - parts are not interchangeable		Be careful not to scratch or damage
	Measurement required		Note correct orientation
	Flatness specification		Mark orientation for reinstallation
	Parallelism specification		Torque specification
	External hex head		Press in - press fit
	Internal hex head		Pull out with tool – press fit
	Torx head		Cover splines with installation sleeve
	O-ring boss port		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.

## Technical Specification

### Design Specifications

Features	MP1
Design	Axial piston pump with variable displacement using compact servo piston control.
Direction of input rotation	Clockwise or counterclockwise
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 MDC control. Vertical input shaft installation is acceptable. 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.
Filtration configuration	Suction or charge pressure filtration

### Technical Data

Feature	28	32	38	45
Displacement (cm <sup>3</sup> /rev [in <sup>3</sup> /rev])	28.0 [1.71]	31.8 [1.94]	38.0 [2.32]	45.1 [2.75]
Flow at rated (continuous) speed (l/min [US gal/min])	95.3 [25.2]	108.1 [28.5]	125.3 [33.1]	149.5 [39.5]
Torque at maximum displacement (theoretical) (N·m/bar [lbf·in/1000psi])	0.45 [272.0]	0.51 [308.9]	0.60 [369.1]	0.72 [438.1]
Mass moment of inertia of rotating components (kg·m <sup>2</sup> [slug·ft <sup>2</sup> ])	0.0020 [0.0015]		0.0030 [0.0022]	
Mass (Weight) dry (kg [lb])	29.6 [65.3]		38 [83.8]	
Oil volume (liter [US gal])	1.5 [0.40]		2.0 [0.53]	
Mounting flange	ISO 3019-1 flange 101-2 (SAE B)			
Input shaft outer diameter, splines and tapered shafts	ISO 3019-1, outer Ø22mm - 4 (SAE B, 13 teeth) ISO 3019-1, outer Ø25mm - 4 (SAE B-B, 15 teeth)			
	ISO 3019-1, outer Ø22mm - 1 (Straight Key)		ISO 3019-1, outer Ø31mm - 4 (19 teeth) ISO 3019-1, outer Ø25mm - 4 (Straight Key) ISO 3019-1, outer Ø25mm -3 (Conical keyed, taper 1:8)	
Auxiliary mounting flange with metric fasteners, shaft outer diameter and splines	ISO 3019-1, flange 82-2, outer Ø16mm - 4 (SAE A, 9 teeth) ISO 3019-1, flange 82-2, outer Ø19mm - 4 (SAE A, 11 teeth) ISO 3019-1, flange 101-2, outer Ø22mm - 4 (SAE B, 13 teeth) ISO 3019-1, flange 101-2, outer Ø25mm - 4 (SAE B-B, 15 teeth)			
Main port configuration <b>A, B</b>	ISO 11926-1 - 1 1/16 - 12 (Inch O-ring boss)		ISO 11926-1 - 1 5/16 - 12 (Inch O-ring boss)	
	ISO 6149-1, M27x2 (Metric o-ring boss)		ISO 6162, Ø19mm, (Split flange boss, M10x1.5)	
			ISO 6149-1 - M33x2 (Metric O-ring boss)	
Case drain ports <b>L1, L2</b>	ISO 11926-1, 1 1/16 -12 (Inch O-ring boss) ISO 6149-1, M27x2 (Metric O-ring boss)			
Suction ports <b>S</b>	ISO 11926-1 - 1 1/16-12 (Inch O-ring boss) ISO 6149-1 - M27x2 (Metric O-ring boss)		ISO 11926-1 - 1 5/16-12 (Inch O-ring boss) ISO 6149-1 - M33x2 (Metric O-ring boss)	
Other ports	ISO 11926-1, (Inch O-ring boss) ISO 6149 -1, (Metric O-ring boss)			
Customer interface threads	Metric fasteners			

## Technical Specification

### Operating Parameters

For definitions of the following specifications, see [Operating Parameters](#) on page 26

Features		Units	28/32	38/45
Input speed	Minimum <sup>1</sup>	min <sup>-1</sup> (rpm)	500	500
	Rated		3400	3300
	Maximum		4000	3900
System pressure	Maximum working pressure	bar [psi]	350 [5000]	350 [5000]
	Maximum pressure		380 [5429]	380 [5429]
	Minimum low loop (above case)		10 [143]	10 [143]
Charge pressure (minimum)		bar [psi]	16 [232]	16 [232]
Charge pump inlet pressure	Minimum (continuous)	bar (absolute) [in Hg vacuum]	0.8 [6]	0.8 [6]
	Minimum (cold start)		0.2 [24]	0.2 [24]
	Maximum		2.0	2.0
Case pressure	Rated	bar [psi]	3 [43]	3 [43]
	Maximum		5 [71]	5 [71]

<sup>1</sup> No load condition. Refer to System Design Parameters/Charge Pump for details.

### Fluid Specifications

Features		Units	28/32/38/45
Viscosity	Intermittent <sup>1</sup>	mm <sup>2</sup> /sec. [ SUS]	5 [42]
	Minimum		7 [49]
	Recommended range		12 - 80 [66 - 370]
	Maximum (cold start) <sup>2</sup>		1600 [7500]
Temperature range <sup>3</sup>	Minimum (cold start)	°C [°F]	-40 [-40]
	Recommended range		60 - 85 [140 - 185]
	Maximum continuous		104 [220]
	Maximum intermittent		115 [240]
Filtration (recommended minimum)	Cleanliness per ISO 4406	β-ratio	22/18/13
	Efficiency (charge pressure filtration)		β <sub>15-20</sub> =75(β <sub>10</sub> ≥10)
	Efficiency (suction filtration)		β <sub>35-45</sub> =75(β <sub>10</sub> ≥2)
	Recommended inlet screen mesh size		100 - 125

<sup>1</sup> Intermittent=Short term t < 1 min per incident and not exceeding 2 % of duty cycle based load-life.

<sup>2</sup> Cold start = Short term t < 3 min, p < 50 bar [725 psi], n < 1000 min<sup>-1</sup> (rpm)

<sup>3</sup> At the hottest point, normally case drain port.

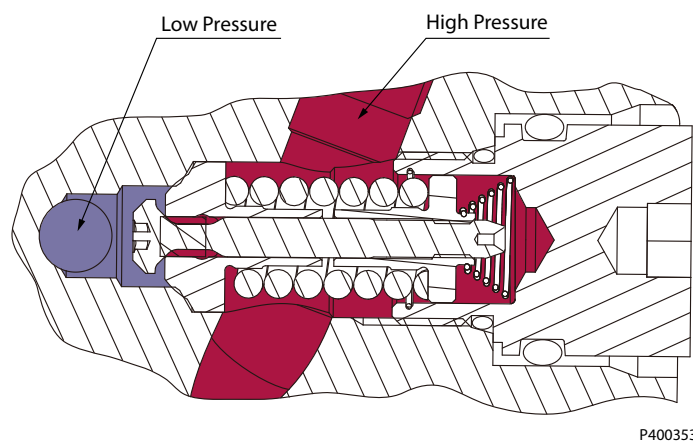
## Operation

### High Pressure Relief Valve (HPRV) and charge check

All MP1 pumps are equipped with a combination high pressure relief and charge check valve. The high-pressure relief function is a dissipative (with heat generation) pressure control valve for the purpose of limiting excessive system pressures. The charge check function acts to replenish the low-pressure side of the working loop with charge oil. Each side of the transmission loop has a dedicated HPRV valve that is non-adjustable with a factory set pressure. When system pressure exceeds the factory setting of the valve, 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 order code allows for different pressure settings to be used at each system port. The system pressure order code for pumps with only HPRV is a reflection of the HPRV setting.

HPRV's are factory set at a low flow condition. Any application or operating condition which leads to elevated HPRV flow will cause a pressure rise with flow above a valve setting. Consult factory for application review. Excessive operation of the HPRV will generate heat in the closed loop and may cause damage to the internal components of the pump.



### Bypass Function

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

#### ! Caution

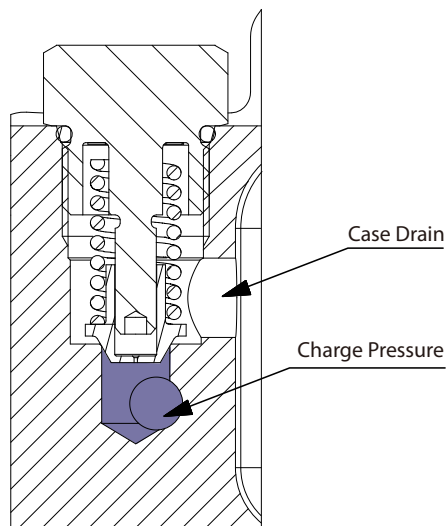
Excessive speeds and extended load/vehicle movement must be avoided. The load or vehicle should be moved not more than 20 % of maximum speed and for a duration not exceeding 3 minutes. Damage to drive motor(s) is possible. When the bypass function is no longer needed care should be taken to reseal the HPRV internal hex plugs to the normal operating position.

## Operation

### Charge Pressure Relief Valve (CPRV)

An internal charge pressure relief valve (CPRV) regulates charge pressure within the hydraulic circuit. The CPRV is a direct acting poppet valve that regulates charge pressure at a designated level above case pressure.

The charge pressure relief valve setting is specified within the model code of the pump. MP1 pumps with charge pump have the CPRV set at 1800 rpm while MP1 pumps without charge pump have the CPRV set with 18.9 l/min [5.0 US gal/min] of external supply flow. The charge pressure rise rate, with flow, is approximately 1 bar/10 liter [5.4 psi/US gal].



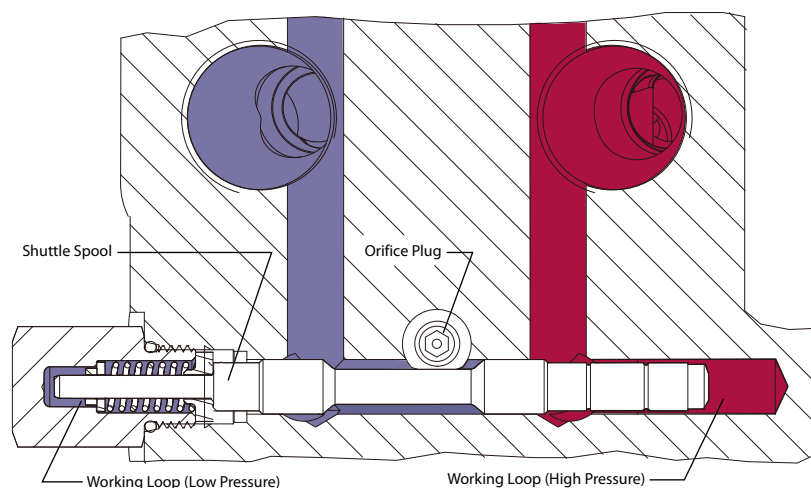
P400341

## Operation

### Loop Flushing Valve

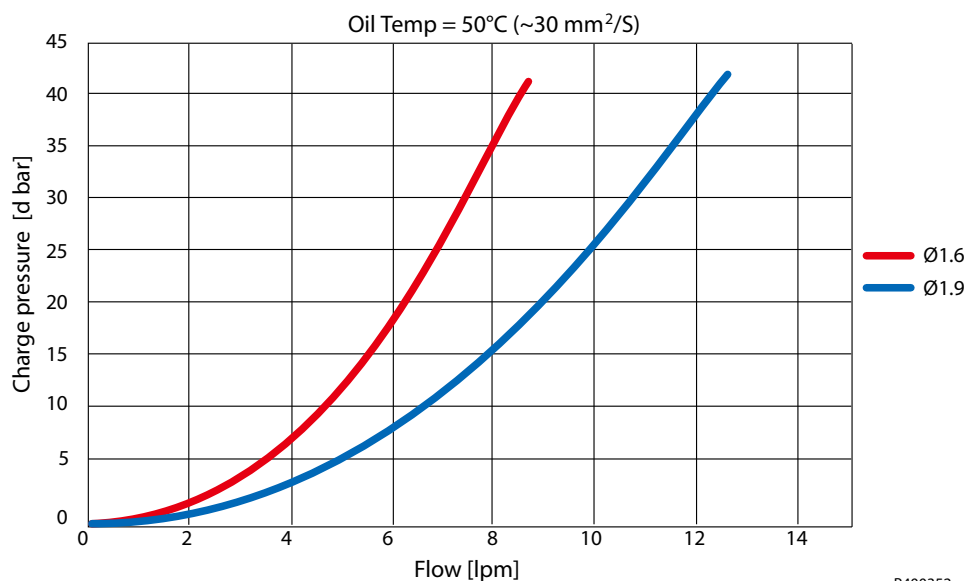
MP1 pumps are available with an optional integral loop flushing. A loop flushing valve will remove heat and contaminants from the main loop at a rate faster than otherwise possible.

The MP1 loop flushing design is a simple spring centered shuttle spool with an orifice plug. The shuttle shifts at approximately 3.9 bar [55.7 psi]. The flushing flow is a function of the low loop system pressure (charge) and the size of the plug.



P400342

### Loop flushing performance



P400352

### ! Caution

When a MP1 pump is used with an external loop flushing shuttle valve, ensure that the charge setting of the pump matches the setting of the loop flushing shuttle valve. Contact your Danfoss representative for the availability of additional charge relief settings.

## Operation

### Electrical Displacement Control (EDC)

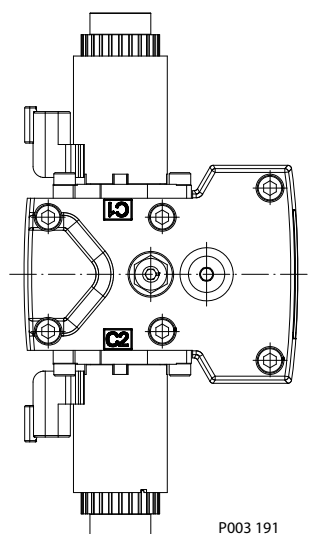
#### EDC principle

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.

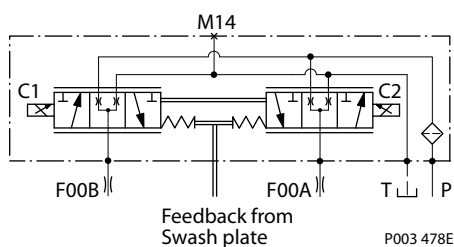
The Electrical Displacement Control (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure 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.

A serviceable 125  $\mu$ m screen is located in the supply line immediately before the control porting spool.

#### EDC control



#### EDC schematic



#### EDC operation

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.

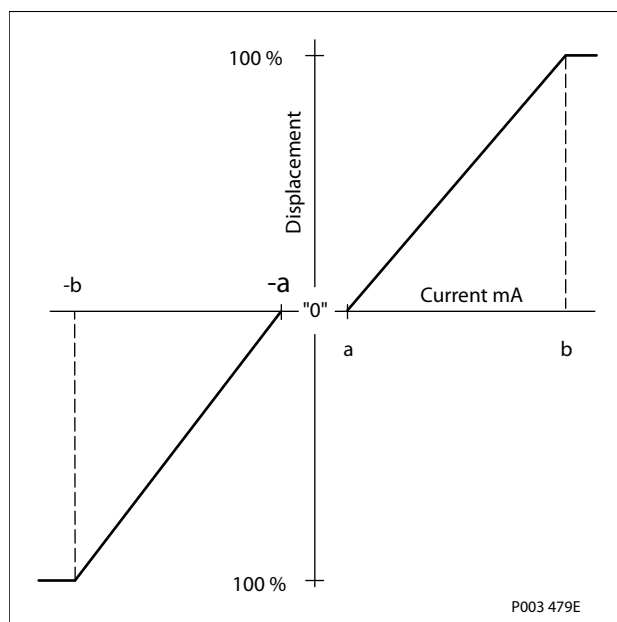
## Operation

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.

*Pump displacement vs. control current*

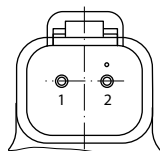


## EDC Control Signal Requirements

*Control minimum current to stroke pump*

Voltage	a*	b	Pin connections
12 V	640 mA	1640 mA	any order
24 V	330 mA	820 mA	

\* Factory test current, for vehicle movement or application actuation expect higher or lower value.



P003 480

*Connector ordering data*

Description	Quantity	Ordering data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S

## Operation

### Connector ordering data (continued)

Description	Quantity	Ordering data
Socket contact (16 and 18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

### EDC Solenoid Data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	200 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

\* PWM signal required for optimum control performance.

### Pump output flow direction vs. control signal

Shaft rotation	CW		CCW	
Coil energized*	C1	C2	C1	C2
Port A	out	in	in	out
Port B	in	out	out	in
Servo port pressurized	M4	M5	M4	M5

\* For coil location see Installation drawings.

### Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

**MP1 pumps are limited in mechanical orificing combinations. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.**

Typical response times shown below at the following conditions:

<b>Δp</b>	250 bar [3626 psi]
<b>Viscosity and temperature</b>	30 mm <sup>2</sup> /s [141 SUS] and 50 °C [122 °F]
<b>Charge pressure</b>	20 bar [290 psi]
<b>Speed</b>	1800 min <sup>-1</sup> (rpm)

## Operation

### Response time, EDC

Stroking direction	0.8 mm [0.03 in] orifice		1.0 mm [0.04 in] orifice		1.3 mm [0.05 in] orifice		No orifice	
	28/32	38/45	28/32	38/45	28/32	38/45	28/32	38/45
Neutral to full flow	1.3 s	2.1 s	0.9 s	1.3 s	0.6 s	0.9 s	0.4 s	0.6 s
Full flow to neutral	1.0 s	1.5 s	0.7 s	0.9 s	0.4 s	0.6 s	0.2 s	0.3 s

### Manual Over Ride (MOR)

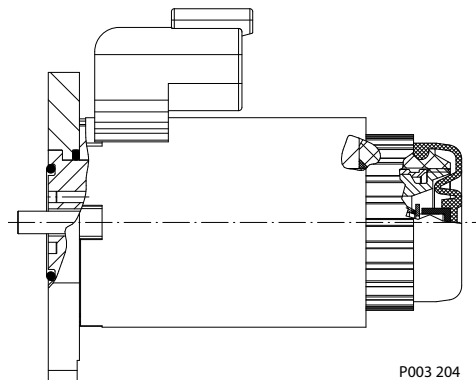
Electro-hydraulic controls are available with a Manual Over Ride (MOR) either standard or as an option for temporary actuation of the control to aid in diagnostics.

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.

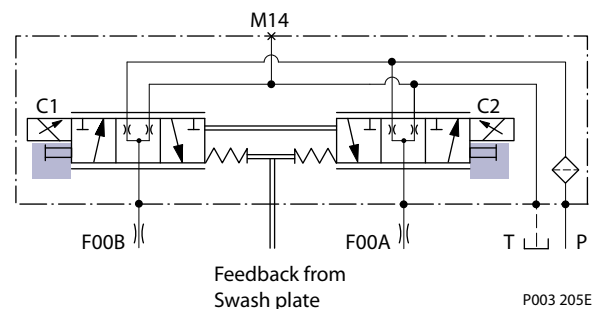
### Warning

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.

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)



## Operation

### Manual Displacement Control (MDC)

#### MDC principle

An MDC is a Manual proportional Displacement Control (MDC). The MDC consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

This design provides a travel feedback without spring. When turning the shaft the spool moves thus providing hydraulic pressure to either side of a double acting servo piston of the pump.

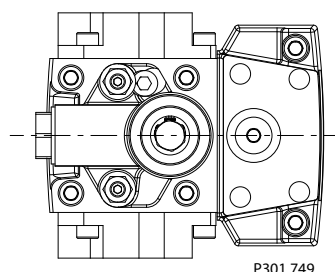
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swashplate rotation.

The MDC changes the pump displacement between no flow and full flow into opposite directions. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

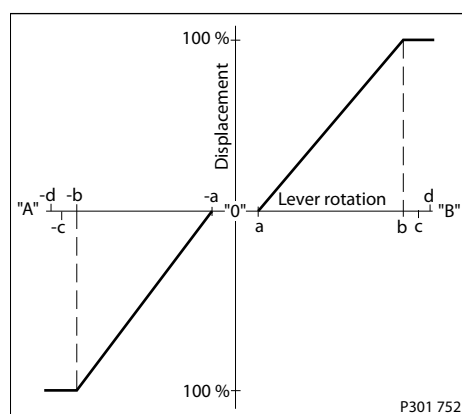
A serviceable 125  $\mu\text{m}$  screen is located in the supply line immediately before the control porting spool.

The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

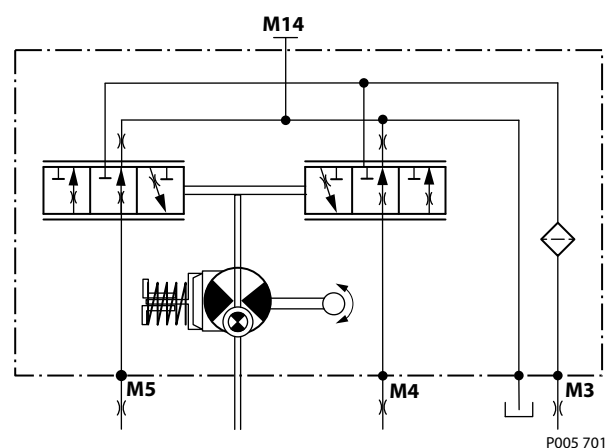
Manual Displacement Control



Pump displacement vs. control lever rotation



MDC schematic diagram



Where:

Deadband on **B** side –  $a = 3^\circ \pm 1^\circ$

Maximum pump stroke –  $b = 30^\circ +2/-1^\circ$

Required customer end stop –  $c = 36^\circ \pm 3^\circ$

Internal end stop –  $d = 40^\circ$

Volumetric efficiencies of the system will have impacts on the start and end input commands.

#### MDC torque

Torque required to move handle to maximum displacement	1.4 N·m [12.39 lbf·in]
Torque required to hold handle at given displacement	0.6 N·m [5.31 lbf·in]
Maximum allowable input torque	20 N·m [177 lbf·in]

## Operation

### MDC General Information

In difference to other controls the MDC provides a mechanical deadband. This is required to overcome the tolerances in the mechanical actuation.

The MDC contains an internal end stop to prevent over travel. The restoring moment is appropriate for turning the MDC input shaft back to neutral only. Any linkages or cables may prevent the MDC from returning to neutral.

The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3 bar. If the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. In addition a high case pressure can cause the NSS to indicate that the control is not in neutral. High case pressure may cause excessive wear.

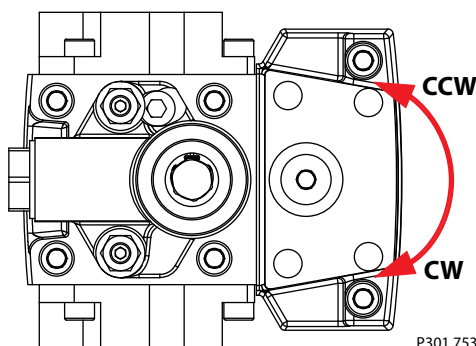
Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.

Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control but the kinematic of the linkages must ensure that either control shaft is protected from torque overload. To avoid an overload of the MDC, customers must install any support to limit the setting range of the Bowden cable.

### ⚠ Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral.

### MDC Shaft Rotation



MDC shaft rotation data

Pump shaft rotation*	Clock Wise (CW)		Counter Clock Wise (CCW)	
MDC shaft rotation	CW	CCW	CW	CCW
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

\* As seen from shaft side.

### Control Response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements. The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

## Operation

Typical response times shown below at the following conditions:

<b>Δp</b>	250 bar [3626 psi]
<b>Viscosity and temperature</b>	30 mm <sup>2</sup> /s [141 SUS] and 50 °C [122 °F]
<b>Charge pressure</b>	20 bar [290 psi]
<b>Speed</b>	1800 min <sup>-1</sup> (rpm)

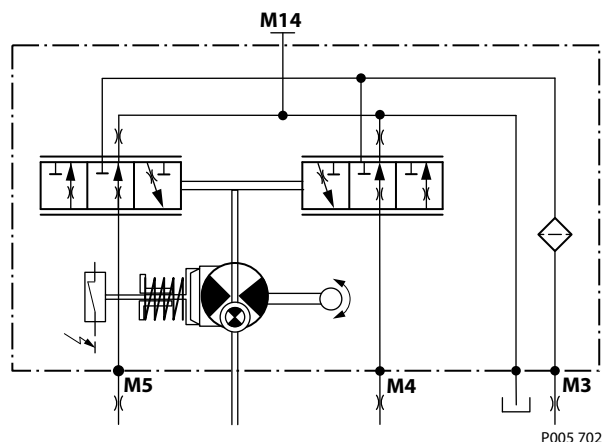
### Response time, MDC

Code	Orifice description (mm)				Stroking direction (sec)			
	P	A	B	Tank (A+B)	Neutral to full flow		Full flow to neutral	
					28/32	38/45	28/32	38/45
<b>C3</b>	–	–	–	–	0.3	0.3	0.3	0.3
<b>C6</b>	–	–	–	1.0	0.5	1.0	0.5	0.7
<b>C7</b>	–	–	–	1.3	0.4	0.7	0.5	0.5
<b>C8</b>	0.8	–	–	0.6	1.5	2.6	1.4	1.9
<b>C9</b>	1.0	–	–	0.6	1.3	2.4	1.1	1.8
<b>D1</b>	1.0	–	–	0.8	0.9	1.6	0.8	1.1
<b>D2</b>	1.3	–	–	0.8	0.8	1.5	0.7	1.1
<b>D3</b>	1.3	–	–	1.0	0.6	1.1	0.6	0.8
<b>D4</b>	1.3	1.3	1.3	1.0	0.8	1.3	0.7	0.9
<b>D5</b>	0.6	0.8	0.8	0.6	3.2	4.0	2.0	2.9

### Neutral Start Switch (NSS)

The Neutral Start Switch (**NSS**) contains an electrical switch that provides a signal of whether the control is in neutral. The signal in neutral is Normally Closed (**NC**).

Neutral Start Switch schematic



### Neutral Start Switch data

<b>Max. continuous current with switching</b>	8.4 A
<b>Max. continuous current without switching</b>	20 A

## Operation

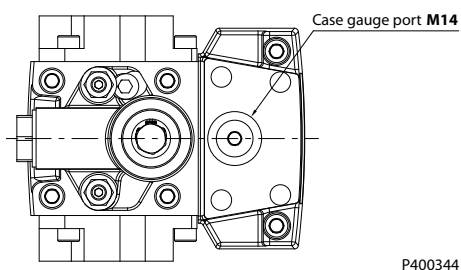
### Neutral Start Switch data (continued)

<b>Max. voltage</b>	36 V <sub>DC</sub>
<b>Electrical protection class</b>	IP67 / IP69K with mating connector

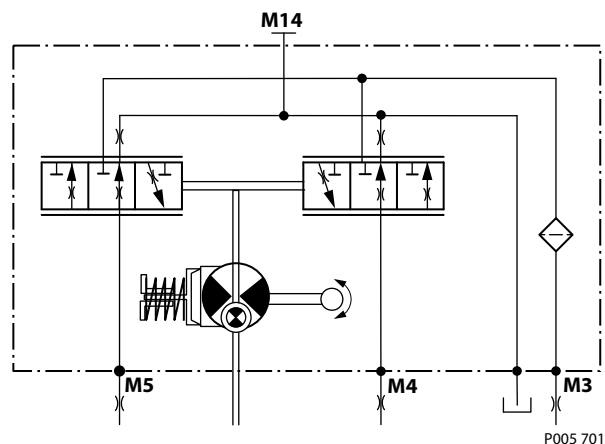
### Case gauge port M14

The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

MDC w/h drain port shown



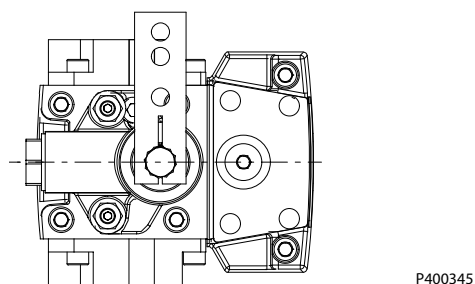
MDC schematic diagram



### Lever

MDC controls are available with optional lever/handle. Standard orientation is 90° from input shaft as shown below.

Align with Settings (Y) module in the model code.



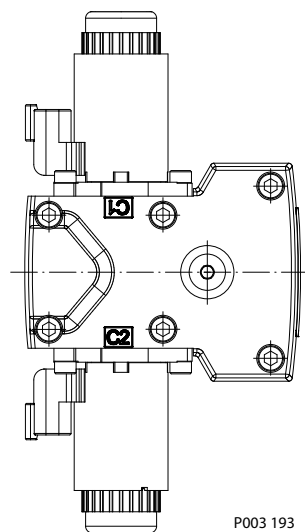
## Operation

### Forward-Neutral-Reverse electric control (FNR)

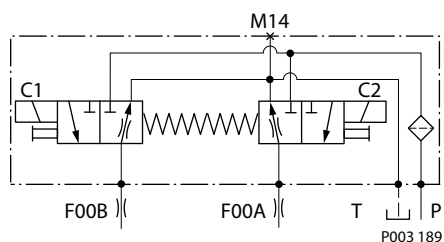
#### FNR principle

The 3-position **FNR** control uses an electric input signal to switch the pump to a full stroke position. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

#### Forward-Neutral-Reverse electric control (FNR)

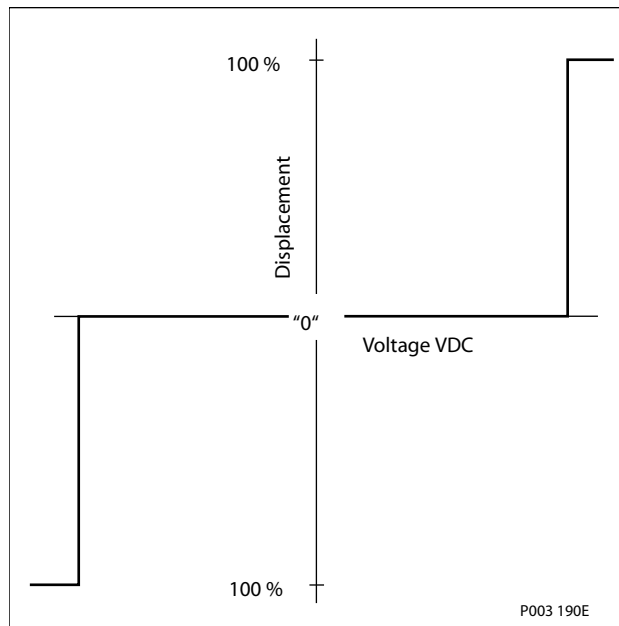


#### FNR hydraulic schematic



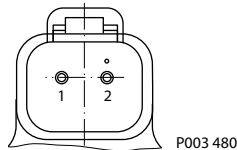
## Operation

*Pump displacement vs. electrical signal*



*Control current*

Voltage	Min. current to stroke pump	Pin connections
12 V	750 mA	any order
24 V	380 mA	



*Connector ordering data*

Description	Quantity	Ordering data
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16 and 18 AWG)	2	DEUTSCH 0462-201-16141
Danfoss mating connector kit	1	K29657

*Solenoid data*

Voltage	12 V	24 V
Minimum supply voltage	9.5 V <sub>DC</sub>	19 V <sub>DC</sub>
Maximum supply voltage (continuous)	14.6 V <sub>DC</sub>	29 V <sub>DC</sub>
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20 °C [70 °F]	8.4 Ω	34.5 Ω
PWM Range	70-200 Hz	
PWM Frequency (preferred)*	100 Hz	

## Operation

### Solenoid data (continued)

Voltage	12 V	24 V
IP Rating (IEC 60 529) + DIN 40 050, part 9	IP 67 / IP 69K (part 9 with mating connector)	
Bi-directional diode cut off voltage	28 V <sub>DC</sub>	53 V <sub>DC</sub>

\* PWM signal required for optimum control performance.

### Pump output flow direction vs. control signal

Shaft rotation	CW		CCW	
Coil energized*	C1	C2	C1	C2
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4

\* For coil location see Installation Drawings.

## Control Response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements. The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

Typical response times shown below at the following conditions:

<b>Δp</b>	250 bar [3626 psi]
<b>Viscosity and temperature</b>	30 mm <sup>2</sup> /s [141 SUS] and 50 °C [122 °F]
<b>Charge pressure</b>	20 bar [290 psi]
<b>Speed</b>	1800 min <sup>-1</sup> (rpm)

## Response time, FNR

Stroking direction	0.8 mm [0.03 in] orifice		1.0 mm [0.04 in] orifice		1.3 mm [0.05 in] orifice		No orifice	
	28/32	38/45	28/32	38/45	28/32	38/45	28/32	38/45
Neutral to full flow	2.1 s	2.6 s	1.1 s	1.6 s	0.8 s	1.1 s	0.7 s	0.7 s
Full flow to neutral	1.1 s	1.8 s	0.9 s	1.0 s	0.6 s	0.7 s	0.3 s	0.3 s

## Operation

### Control-Cut-Off valve (CCO valve)

The pump offers an optional control cut off valve integrated into the control. This valve will block charge pressure to the control, allowing the servo springs to de-stroke the pump regardless of the pump's primary control input. There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

In the normal (de-energized) state of the solenoid charge flow is prevented from reaching the controls. At the same time the control passages and the X7 logic port are connected and drained to the pump case. The pump will remain in neutral, or return to neutral, independent of the control input signal. Return to neutral time will be dependent on oil viscosity, pump speed, swashplate angle, and system pressure.

When the solenoid is energized, charge flow and pressure is allowed to reach the pump control. The X7 logic port will also be connected to charge pressure and flow.

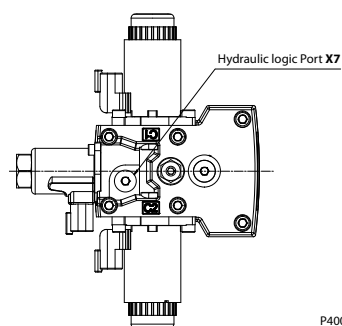
The solenoid control is intended to be independent of the primary pump control making the control cut off an override control feature. It is however recommended that the control logic of the CCO valve be maintained such that the primary pump control signal is also disabled whenever the CCO valve is de-energized. Other control logic conditions may also be considered.

EDC controls are available with a CCO valve.

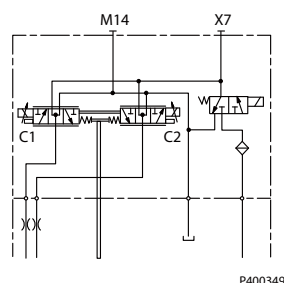
The response time of the unit depends on the control type and the control orifices used.

The CCO-valve is available with 12 V or 24 V solenoid.

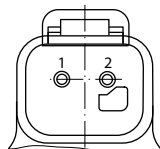
*EDC+CCO*



*EDC+CCO schematic*



### CCO connector



#### Connector ordering data

Description	Quantity	Ordering number
Mating connector	1	DEUTSCH DT06-2S
Wedge lock	1	DEUTSCH W2S
Socket contact (16 and 18 AWG)	2	DEUTSCH 0462-201-16141

## Operation

### CCO solenoid data

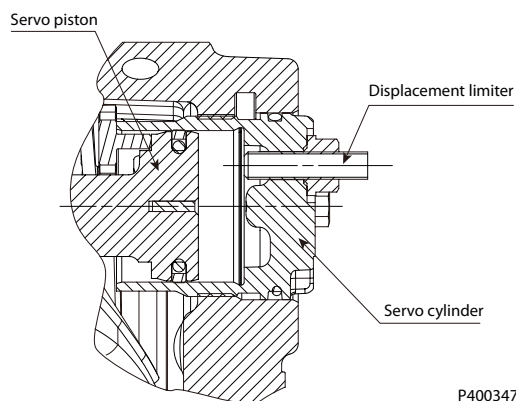
Nominal supply voltage		12 V	24 V
Supply voltage	Maximum	14.6 V	29 V
	Minimum	9.5 V	19 V
Nominal coil resistance at 20°C		10.7 $\Omega$	41.7 $\Omega$
Supply current	Maximum	850 mA	430 mA
	Minimum	580 mA	300 mA
PWM frequency	Range	50-200 Hz	50-200 Hz
	Preferred	100 Hz	100 Hz
Electrical protection class		IP67 / IP69K with mating connector	
Bi-directional diode cut off voltage		28 V	53 V

### Displacement limiter

All pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement.

The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws to mechanically limit the travel of the servo piston. Adjustment procedures are found in the Service Manual. Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.

#### Displacement limiter



### Displacement change (approximate)

Parameter	28	32	38	45
1 Turn of displacement limiter screw	2.9 cm <sup>3</sup> [0.18 in <sup>3</sup> ]	3.3 cm <sup>3</sup> [0.20 in <sup>3</sup> ]	3.56 cm <sup>3</sup> [0.22 in <sup>3</sup> ]	4.22 cm <sup>3</sup> [0.26 in <sup>3</sup> ]
Internal wrench size	4 mm			
External wrench size	13 mm			
Torque for external hex seal lock nut	23 N•m [204 lbf•in]			

## Operating Parameters

### Overview

This section defines the operating parameters and limitations with regard to input speeds and pressures.

### Input Speed

**Minimum speed** is the lowest input speed recommended during engine idle condition. Operating below minimum speed limits 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.

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.

### System Pressure

**System pressure** is the differential pressure between system ports A and B. 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 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.

**Maximum pressure** is the highest allowable Application pressure under any circumstance. Application pressures above Maximum Working Pressure will only be considered with duty cycle analysis and factory approval. Pressure spikes are normal and must be considered when reviewing maximum working pressure.

All pressure limits are differential pressures referenced to low loop (charge) pressure. Subtract low loop pressure from gauge readings to compute the differential.

**Minimum low loop pressure** (above case pressure) is the lowest pressure allowed to maintain a safe working condition in the low side of the loop.

## Operating Parameters

### Charge Pressure

An internal charge relief valve regulates charge pressure. Charge pressure maintains a minimum pressure in the low side of the transmission loop.

The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating at  $1800 \text{ min}^{-1}$  [rpm], and with a fluid viscosity of  $32 \text{ mm}^2/\text{s}$  [150 SUS]. Pumps configured with no charge pump (external charge supply) are set with a charge flow of  $15.0 \text{ l/min}$  [4.0 US gal/min] and a fluid viscosity of  $32 \text{ mm}^2/\text{s}$  [150 SUS].

The charge pressure setting is referenced to case pressure.

### Charge Pump Inlet Pressure

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

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 until the fluid warms up.

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.

#### **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.

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### 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 rated temperature.

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

Cold oil will 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  $16 \text{ }^{\circ}\text{C}$  [ $30 \text{ }^{\circ}\text{F}$ ] 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.

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Ensure fluid temperature and viscosity limits are concurrently satisfied.

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## Operating Parameters

### Viscosity

**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.

## Fluid and Filter Maintenance

### Filtration System

To prevent premature wear, ensure that 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 cannot be applied for hydraulic fluid residing in the component housing/case or any other cavity after transport.

Filtration strategies include suction or pressure filtration. The selection of a filter depends on a number of factors including the contaminant ingress 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 ( $\beta_x$ ). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a  $\beta$ -ratio within the range of  $\beta_{35-45} = 75$  ( $\beta_{10} \geq 2$ ) 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 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  $\beta$ -ratio in the range of  $\beta_{15-20} = 75$  ( $\beta_{10} \geq 10$ ) 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 $\beta_x$ -ratio <sup>1</sup>			
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	$\beta$ -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	$\mu\text{m}$	100 – 125

<sup>1</sup> Filter  $\beta_x$ -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

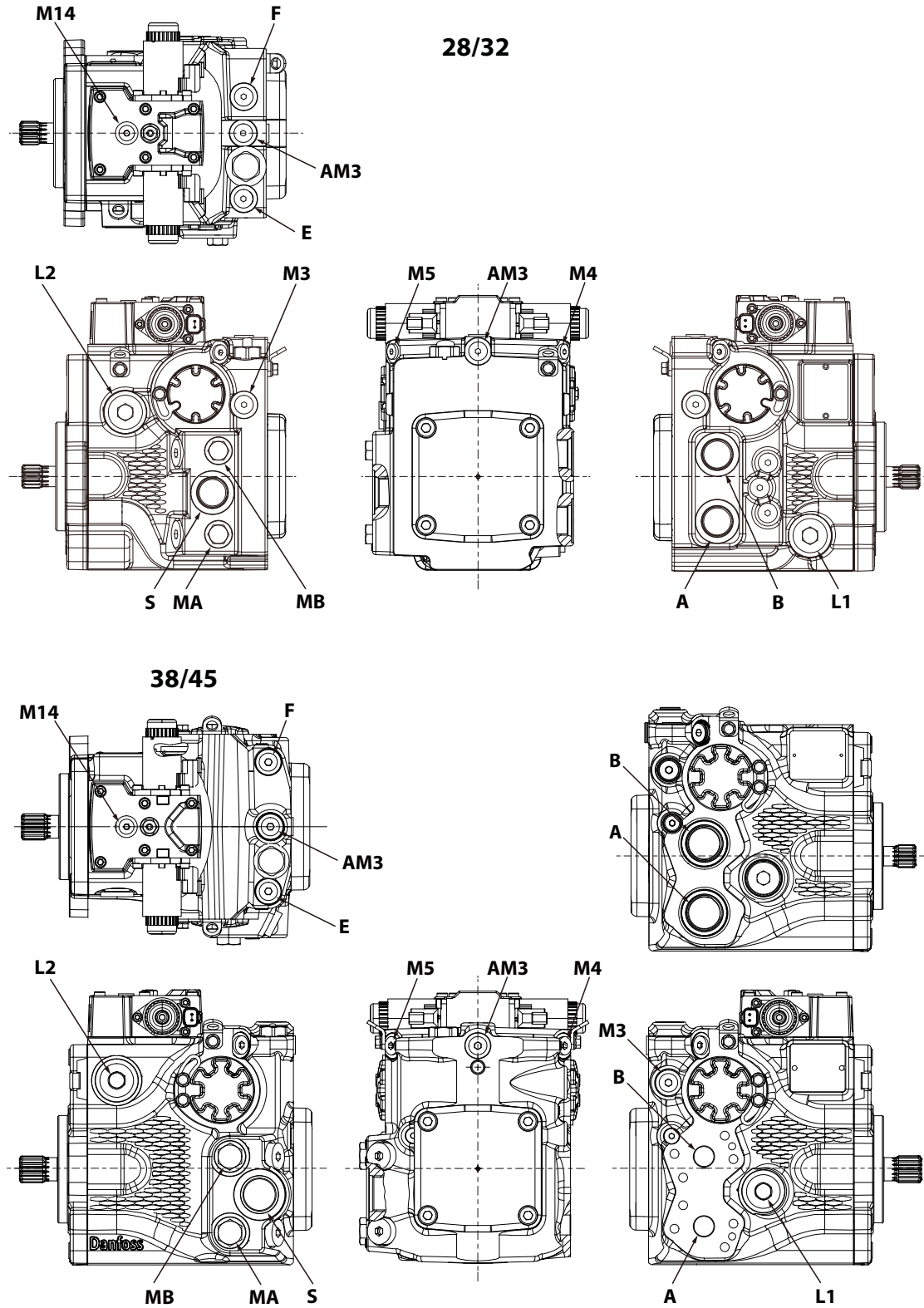
The following table and drawing show the port locations and gauge sizes needed. When testing system pressures, calibrate pressure gauges frequently to ensure accuracy. Use snubbers to protect gauges.

#### Port description

Port	Pressure obtained	Gauge Size	Inch/Metric	Size Port	Wrench size
<b>AM3</b>	Alternative Charge Gauge	50 bar [1000 psi]	inch	9/16-18	1/4 internal hex
			metric	M14x1.5	6 mm
<b>E/F</b>	Filtration Inlet/Outlet		inch	9/16-18	1/4 internal hex
			metric	M14x1.5	6 mm
<b>L1/L2</b>	Case Drain	10 bar [100 psi]	inch	1 1/16-12	9/16 internal hex
			metric	M27x2	12 mm
<b>MA/MB (28/32)</b>	System Gauge	600 bar [10,000 psi]	inch	9/16-18	11/16 inch
			metric	M14x1.5	19 mm
<b>MA/MB (38/45)</b>	System Gauge	600 bar [10,000 psi]	inch	3/4-16	7/8 inch
			metric	M18x1.5	24 mm
<b>M3</b>	Charge Gauge	50 bar [1000 psi]	inch	9/16-18	1/4 internal hex
			metric	M14x1.5	6 mm
<b>M4/M5 (28/32)</b>	Servo Gauge	50 bar [1000 psi]	inch	7/16-20	3/16 internal hex
			metric	M12x1.5	6 mm
<b>M4/M5(38/45)</b>	Servo Gauge	50 bar [1000 psi]	inch	9/16-18	1/4 internal hex
			metric	M14x1.5	6 mm
<b>M14</b>	Case drain	10 bar [100 psi]	inch	7/16-20	1/4 internal hex
			metric	M12x1.5	6 mm internal hex
<b>S</b>	Charge Pump Inlet	-	inch	1 1/16-12	9/16 internal hex
			metric	M27x2	12 mm internal hex

**Pressure measurements**

*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 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 any 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.

#### **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 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 ohms (24V) or 3.66 ohms (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 ohms, closed resistance=122 ohms

## Troubleshooting

### System Operating Hot

Item	Description	Action
Oil level in reservoir.	Insufficient hydraulic fluid will 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 will overwork system.	Measure charge pressure. Inspect and adjust or replace charge relief valve. Inspect charge pump. Repair or replace charge pump.
Charge pump inlet vacuum.	High inlet vacuum will overwork system. A dirty filter will increase 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 will be overworked.	Verify settings of high pressure relief valves and replace valves as necessary.
System pressure.	Frequent or long term operation over system relief setting will create 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.
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 <b>AX00000303</b> MP1 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 <b>AX00000303</b> MP1 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.

## Troubleshooting

Item	Description	Action
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).
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 valves cause slow system pressure.	Repair or replace high pressure relief 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 leak. Check that inlet line is not restricted and is the proper size.
Cold oil	If oil is under cold conditions, it may be too viscous for proper function and pump cavitates	Allow the oil to warm up to it's 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 the proper size. Check filter and bypass valve.
Shaft couplings	A loose shaft coupling will cause excessive noise.	Replace loose shaft coupling. Replace pump shaft.
Shaft alignment	Misaligned shafts creates noise	Align shafts.
Charge/system relief valves	Unusual noise may indicate sticking valves. Possible contamination.	Clean/replace valves and test pump. May be a normal condition.

## 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. If no: balance the washplate (see <i>Mechanical/hydraulic neutral adjustment</i> ). If you still cannot set neutral, replace the control.

## Troubleshooting

### 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.
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](#) on page 30, for location of gauge ports and suggested gauge size.

### Standard Procedures

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 **Caution**

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

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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

This procedure explains how to check and adjust the charge pressure relief valve. Refer to model code located on serial number plate for charge relief setting.

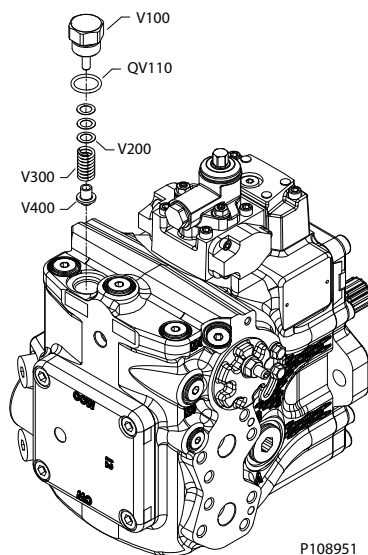
1. Install a 50 bar [1000 psi] pressure gauge in charge pressure gauge port M3. Install a 10 bar [100 psi] gauge at case pressure port L1, L2. Operate the system with the pump in neutral (zero displacement) when measuring charge pressure.

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Listed pressures assume a pump speed of 1800 min<sup>-1</sup> (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.

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## Adjustments



2. Add or remove shims (V200) until the desired setting is achieved.
3. Remove the gauges and plug the open ports.

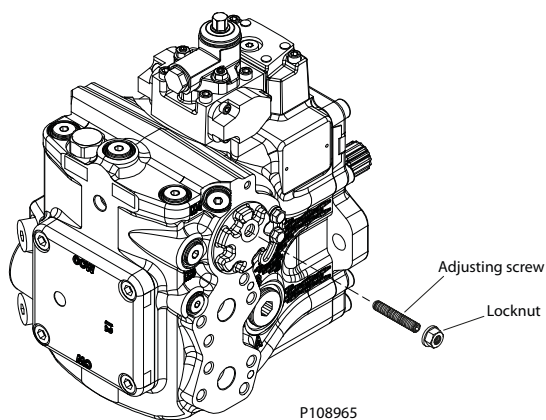
## Displacement Limiter

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

### **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 locknut.
2. Rotate the adjusting screw to achieve the desired displacement.
3. After establishing the desired maximum displacement setting, hold the adjusting screw while torquing the locknut to the value shown.



## Adjustments

### Displacement limiter adjustment data

Displacement	Locknut wrench size and torque	Adjusting screw size	Approximate displacement change per revolution of adjusting screw
28	13 mm 23 N·m [17 lbf·ft]	4 mm internal hex	2.9 cm <sup>3</sup> [0.18 in <sup>3</sup> ]
32	13 mm 23 N·m [17 lbf·ft]	4 mm internal hex	3.3 cm <sup>3</sup> [0.20 in <sup>3</sup> ]
38	13 mm 23 N·m [17 lbf·ft]	4 mm internal hex	3.56 cm <sup>3</sup> [0.22 in <sup>3</sup> ]
45	13 mm 23 N·m [17 lbf·ft]	4 mm internal hex	4.22 cm <sup>3</sup> [0.26 in <sup>3</sup> ]

### Control Neutral Adjustment

All functions of the control 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**

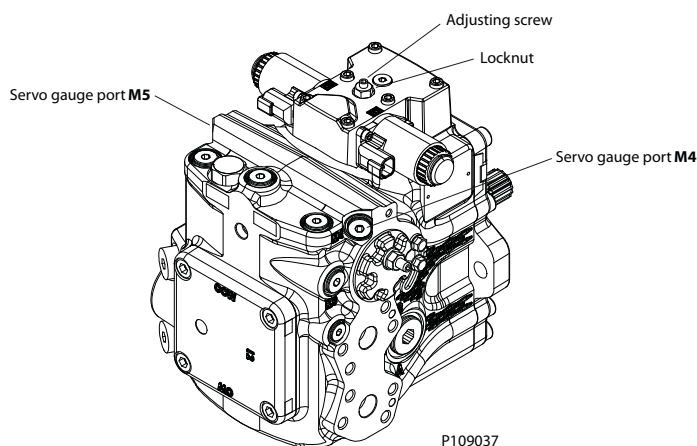
Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable/disconnect the mechanism while servicing.

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/hydraulic 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 stationary while loosening the locknut with a 13mm wrench.
3. Observe pressure gauges. If necessary, turn adjusting screw to reduce any pressure differential.

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

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.

#### Control adjustment



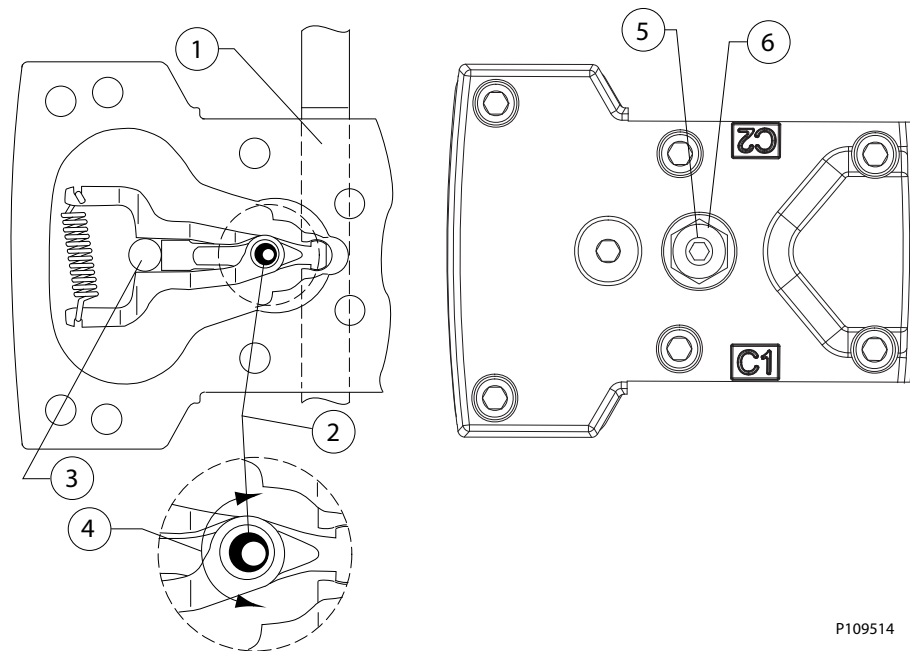
4. Rotate the neutral adjusting screw clockwise until the pressure increases on the gauge. Note the angular position of the wrench. Then rotate the neutral adjusting screw counter clockwise until the

## Adjustments

pressure increases by an equal amount on the other gauge. Again note the angular position of the wrench.

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

*Neutral adjustment (EDC bottom view)*



P109514

1. Control spool
  2. Adjusting screw (cam)
  3. Feedback pin
  4. Maximum adjustment less than 120 deg.
  5. Adjusting screw
  6. Lock nut
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. Torque to 10 Nm [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. Achieving zero differential is usually not possible.

## Mechanical/Hydraulic Neutral Adjustment

### Servo Adjustment

1. Run prime mover at 1800 min<sup>-1</sup>(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].

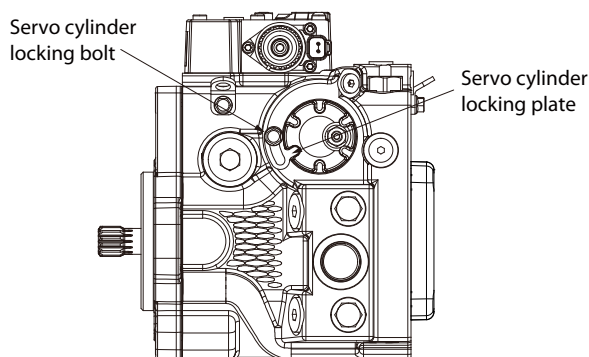
## Adjustments

3. Unthread both servo cylinders 2-3 turns using servo can tool (Tool ID DLD-6247). This step ensures the servo cylinders have no contact with the servo piston.
4. Stroke the pump by turning the adjusting 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.

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

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 adjusting screw in the opposite direction, or by supplying current/hydraulic pressure 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*



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### Verify neutral setting

1. If using a PWM signal to set mechanical neutral, check that servo pressure differential is less than 1.5 bar [22 psi]. Refer to TS-422 or Control neutral adjustment.
2. To verify mechanical neutral, provide current to solenoid C1, or turn neutral adjusting 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-422.
4. If using neutral adjusting screw to set mechanical neutral, reset control neutral.

### 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/hydraulic pressure to either solenoid). Check to be sure the servo pressure differential is less

## Adjustments

than 1.5 bar [22 psi]. Reference Danfoss testing specifications TS-422 or *Control Neutral Adjustment* instructions.

3. Turn neutral adjusting screw (or supply current/hydraulic pressure to solenoid C2) until the servo pressure at port M5 is less than 1.5 bar [22 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 less than 1.5 bar [22 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.

## EDC Control

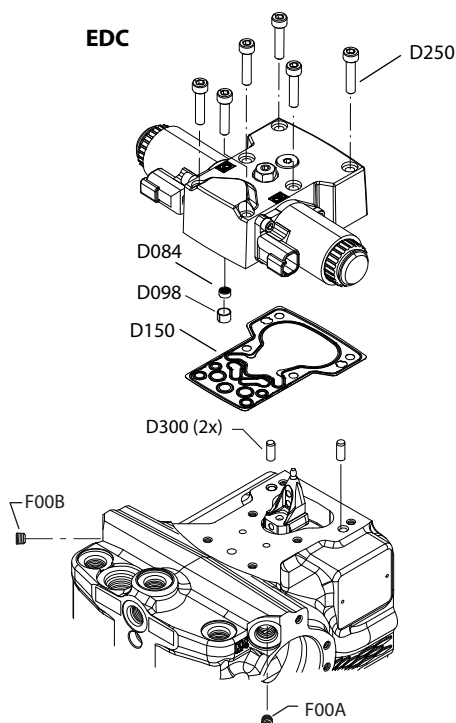
### Removal

Refer to removal illustration.

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 (F00A and F00B) using a 3 mm internal hex wrench. Tag and number them for reinstallation.
4. If necessary, remove ring (D098) and screen (D084). Discard the screen.

If dowel pins (D300) are removed, ensure they are replaced before reinstalling the control.

## Minor Repair



### Legend

Item	Description	Wrench size	Torque
D084	Filter screen	-	-
D098	Retaining ring	-	-
D150	Control gasket	-	-
D300	Dowel pins	-	-
D250	Cap screw	5 mm internal hex	13 Nm [9.8 lbf·ft]
F00B	Servo orifice	3 mm internal hex	7.9 Nm [5.8 lbf·ft]
F00A	Servo orifice	3 mm internal hex	7.9 Nm [5.8 lbf·ft]

### Inspection

Inspect the machined surfaces on the control and top of the pump. If you find any nicks or scratches, replace the component.

### Reassembly

Ensure you install dowel pins (D300) in the housing before installing the control.

1. Install a new gasket (D150).
2. Install dowel pins (D300) in the housing.

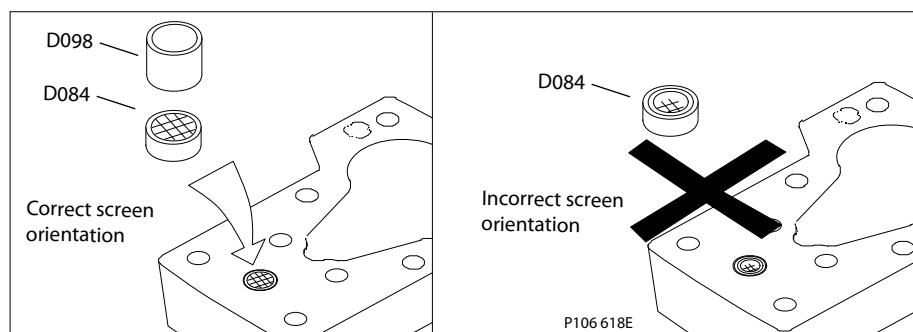
### **Warning**

If the feedback pin comes off during operation, the pump will lose controllability causing a potentially hazardous situation. Insure feedback pin is properly torqued before continuing with reassembly.

## Minor Repair

- 3. EDC only** - If you removed screen (D084), install a new one. Install it with the mesh facing outward. Install retaining ring (D098).

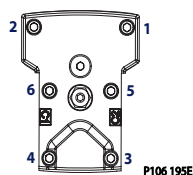
*EDC only - Proper screen orientation*



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

- 4.** Install the control module and six cap screws (D250).

*Torque sequence*



- 5.** Using a 5 mm internal hex wrench, torque the cap screws (D250) to 13.3 Nm [9.8 lbf ft].

## Replace Control Solenoids/Actuator Housing - MP1

- 1.** Disconnect electrical/hydraulic connection and remove the three cap screws (D050) using a 4 mm internal hex wrench.
- 2.** Remove the solenoid/actuator housing (D025/QD77) and O-ring (D025A/QD26). Discard the O-ring.

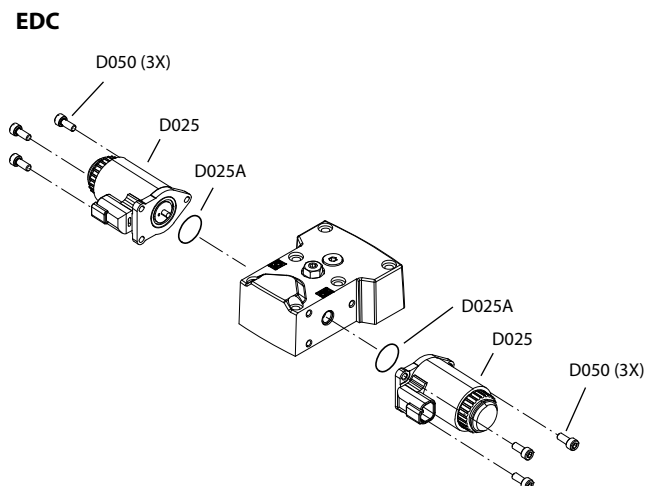
Individual coils may be replaced. Use a 12 point 26 mm socket. Torque the coil nut to to 5 N•m [3.7 lbf•ft].

- 3.** Inspect the machined surface on the control. If you find any nicks or scratches, replace the component.
- 4.** Lubricate new O-ring (D025A/QD26) using petroleum jelly and install.
- 5.** Install solenoid/actuator housing with three cap screws (D050) using a 4 mm internal hex wrench. Torque screws to 5 N•m [4 lbf•ft].
- 6.** Reconnect electrical/hydraulic connections and test the pump for proper operation.

For repair part information, see the *Parts Manual* for your model.

## Minor Repair

### Replace control solenoids



### Legend

Item	Description	Wrench size	Torque
D025	Solenoid	-	-
D025A	O-ring	-	-
D050	Cap screw	4 mm internal hex	5 Nm [4 lbf·ft]
QD26	O-ring	-	-
QD77	Actuator housing	-	-
QD72	Actuator pin	-	-

## MDC Control

### Removal

Refer to exploded diagram, below.

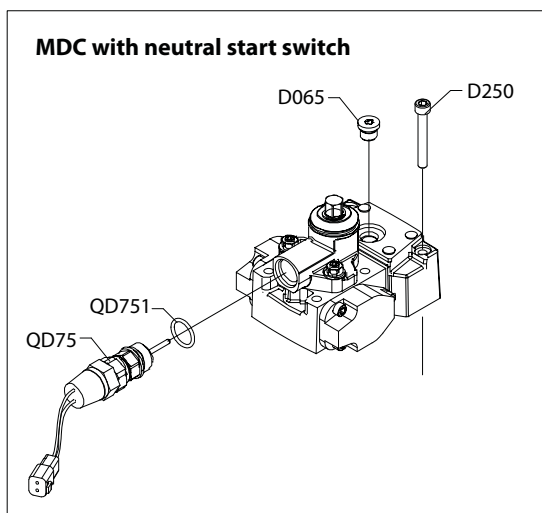
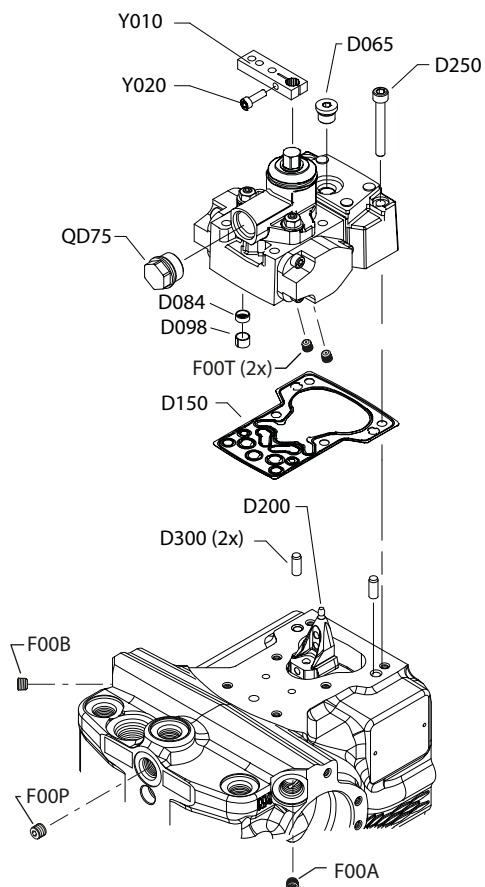
1. Using a 5 mm internal hex wrench, remove the six cap screws (D250).
2. Remove the control module and gasket (D150). Discard the gasket.
3. If necessary, remove servo orifices (F00A, F00B), supply orifice (F00P), and tank orifices (F00T) using a 3 mm internal hex wrench. Tag and number them for reinstallation.
4. If screen (D084) is clogged, use a hook to remove the retaining ring (D098) and the screen. Discard the screen and replace with a new screen.
5. Before removing the control, note the position of the control lever for reassembly.

### **Caution**

Do not disassemble the control, otherwise the functionality of the control and the neutral position of the pump can be lost!

## Minor Repair

### MDC Illustration



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### MDC Legend

#### Wrench size and torque

Item	Description	Wrench size	Torque
D065	O-ring plug	3/16 internal hex	12 N•m [9 lbf•ft]
D084	screen	-	-
D098	ring	-	-
D200	feedback pin	5 mm internal hex	13.3 Nm [9.8 lbf•ft]
D250	cap screw	5 mm internal hex	13.3 Nm [9.8 lbf•ft]
D80	solenoid	-	-
D81	Oring	-	-
QD75	neutral start switch	-	-
D751	Oring	-	-
QD73	plug	3/4 inch	
F00A	servo orifice	7/16 inch hex	7.9 Nm [5.8 lbf•ft]
F00B	servo orifice	7/16 inch hex	7.9 Nm [5.8 lbf•ft]
F00P	supply orifice	1/4 inch hex	14 Nm [10.8 lbf•ft]
F00T	tank orifice	3 mm internal hex	2.5 Nm [1.8 lbf•ft]
Y020	cap screw	5 mm internal hex	13.3 Nm [9.8 lbf•ft]

## Minor Repair

### Inspection

Inspect the machined surfaces on the control and top of the pump. If you find any nicks or scratches, replace the component.

### Reassembly

Ensure you install dowel pins (D300) in the housing before installing the control.

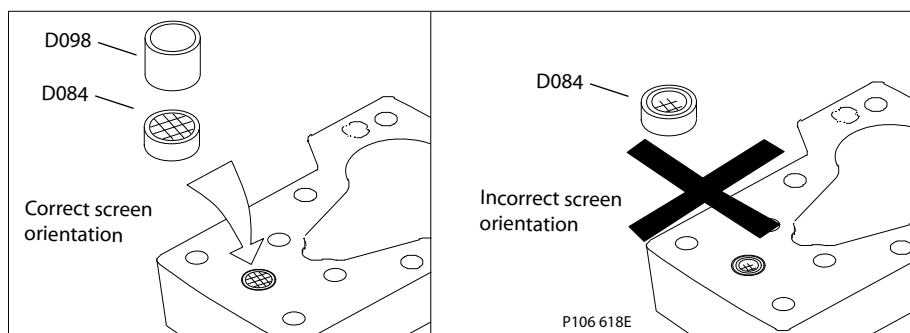
1. Install a new gasket (D150).
2. Install dowel pins (D300) in the housing.

#### **Warning**

If the feedback pin comes off during operation, the pump will lose controllability causing a potentially hazardous situation. Insure feedback pin is properly torqued before continuing with reassembly.

3. If you removed screen (D084), install a new one. Install it with the mesh facing outward (see drawing). Install retaining ring (D098).

*MDC - Proper screen orientation*

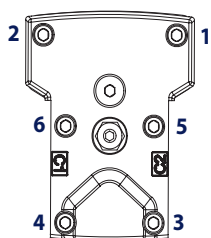


4. If previously removed, install orifices using a 3 mm internal hex wrench. Torque to 2.5 Nm [1.8 lbf ft].

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

5. Install the control module and six cap screws (D250).

*Torque sequence*



6. Using a 5 mm internal hex wrench, torque the cap screws (D250) to 13.3 Nm [9.8 lbf ft].

## Charge pump

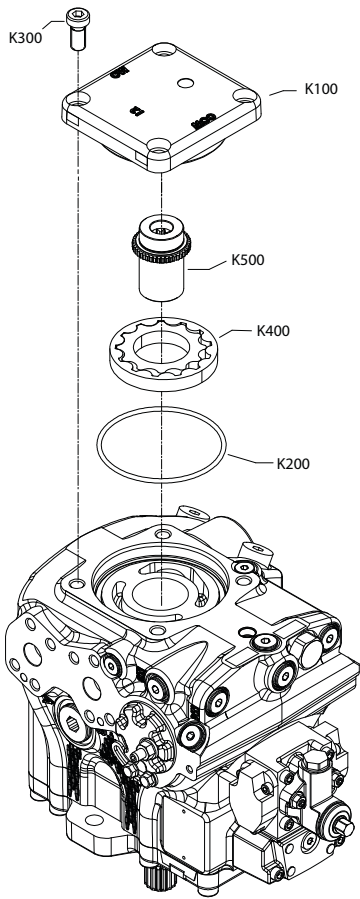
If the pump has an auxiliary pump attached, remove the auxiliary pump and connecting shaft before removing the auxiliary pad.

# Minor Repair

## Charge Pump Removal

1. Position pump so end cover or auxiliary pad (K100) is on top.
2. Remove end cover/auxiliary pad screws (K300) using an 8 mm internal hex wrench.
3. Remove and discard O-ring (K200).
4. Remove coupling (K500). Use a small hook if necessary.
5. Remove the charge pump (K400).

*Charge pump removal (38/45 shown)*



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*Cover Screw (K300)*

Item	Wrench size	Torque
Screw	8 mm internal hex	111 N·m [81.9 lbf·ft]

## Charge Pump Inspection

Inspect the components for wear, scratches or pitting. Scratches on these components will cause a loss of charge pressure. If any component shows signs of wear, scratching or pitting, replace it.

## Charge Pump Reassembly

## Minor Repair

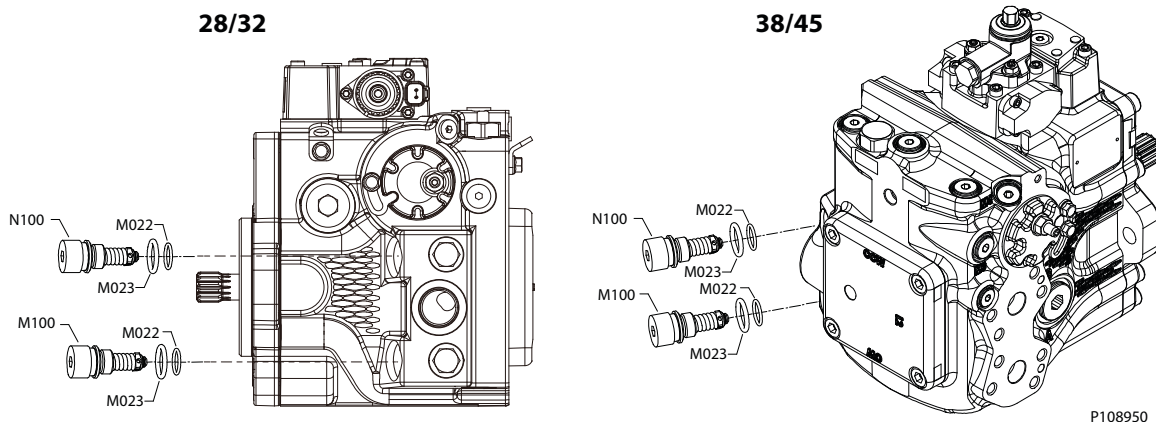
1. Lubricate and install charge pump (K400).
2. Install coupling (K500).
3. Lubricate and install a new O-ring (K200).
4. Install cover/auxpad (K100).
5. Install screws (K300). Torque screws per table.

## High Pressure Relief Valve (HPRV)

### HPRV Valve Removal

1. Using a 5/16 inch internal hex, remove the HPRV's (N100/M100).
2. Remove and discard the O-rings (M023) and backup rings (M022).

Remove HPRV valves



HPRV valve (N100/M100)

Item	Wrench size	Torque
HPRV Valve	5/16 inch internal hex	81 N·m [51.7 lbf·ft]

### HPRV Valve Inspection

Inspect the sealing surfaces in the pump for nicks or scratches. Check the valves for damage. Replace any damaged components.

### HPRV Valve Reassembly

1. Lubricate and install new O-rings (M022) and backup rings (M023).
2. Install the HPRV valves. Torque to the value shown in the table.
3. Operate the vehicle/machine through its full range of control to ensure proper operation. Check for leaks.

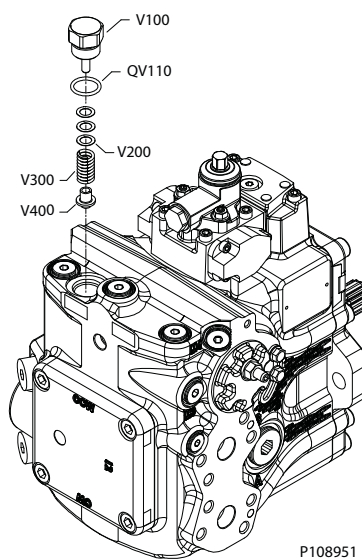
## Minor Repair

### Charge Pressure Relief Valve (CPRV)

#### CPRV Removal

1. Using a 1 inch wrench, remove the charge pressure relief valve (V100).
2. Remove and discard O-ring (QV110).
3. Use a small hook or magnet to remove washer(s) (V200), spring (V300), and seat (V400).

*Remove CPRV valve (38/45 shown)*



*CPRV valve (V100)*

Item	Wrench size	Torque
CPRV Valve	1 inch	78.6 N•m [58.0 lbf•ft]

#### CPRV Inspection

Inspect washer, spring, and seat. Replace CPRV valve if damage is found. Inspect the sealing surfaces of the pump for nicks or scratches.

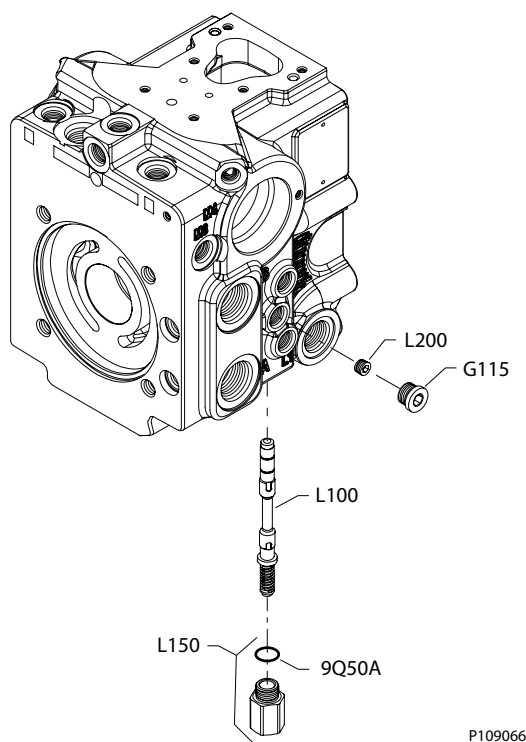
#### CPRV Reassembly

1. Install seat (V400), spring (V300), and washer (V200) into the housing.
2. Install new O-ring (QV110) onto the valve nut (V100).
3. Install valve nut in housing. Torque per table.

## Minor Repair

### Loop Flushing (28/32)

1. Using an 11/16 inch wrench, remove plug (L150).
2. Using a ¼ inch internal hex, remove plug (G115).
3. Remove and discard O-ring (9Q50A).
4. Remove loop flushing spool (L100)
5. Using a 3 mm internal hex, remove orifice (L200).



Item	Wrench size	Torque
Plug (L150)	11/16 inch	45 N•m [33 lbf•ft]
Orifice (L200)	3 mm internal hex	2.5 N•m [1.8 lbf•ft]
Plug (G115)	1/4 inch	40 N•m [30 lbf•ft]

### Loop Flushing Spool

Inspect loop flushing spool and spring. If damage or wear is found, replace spool and spring.



### Reassembly

## Minor Repair

1. Lubricate and install loop flushing spool (L100).
2. Lubricate and install new O-ring (9Q50A).
3. Using a 11/16 inch wrench, torque plug (L150) to 45 N•m [33 lbf•ft].
4. Using a 3 mm internal hex, torque orifice (L200) to 2.5 N•m [1.8 lbf•ft].
5. Using a ¼ inch internal hex, torque plug (G115) to 40 N•m [30 lbf•ft].

## Shaft Removal

The shaft assembly is serviceable without disassembling the pump.

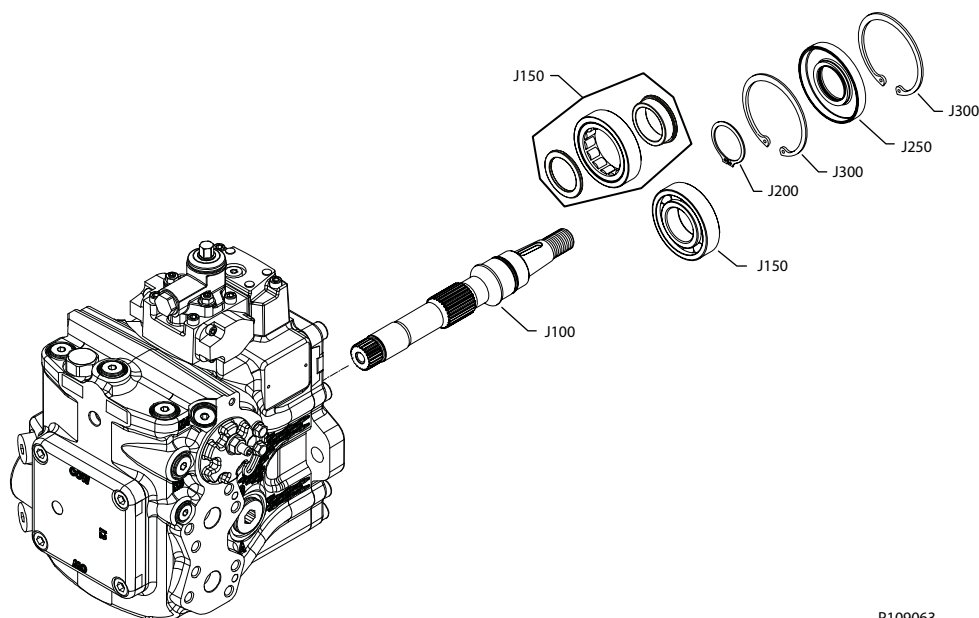
1. Position the pump with the shaft pointing up.
2. Remove the first spring clip (J300).
3. Carefully remove and discard the shaft seal (J250)

### **Caution**

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

4. Remove the second spring clip (J300).
5. Pull the shaft and bearing out of the housing.
6. Remove the retaining ring (J200). Press the bearing (J150) off the shaft (J100).

*Shaft removal (38/45 shown)*



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## Inspection

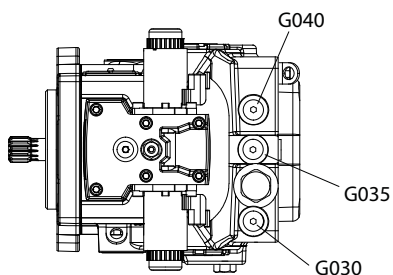
Inspect the shaft journals for wear, scratching, and pits. Check the splines for fretting; replace if damaged. Rotate the bearing, if it does not rotate smoothly, replace it.

## Shaft Reassembly

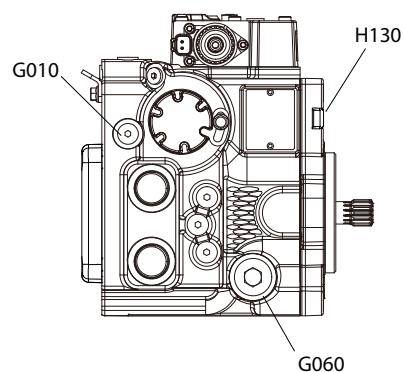
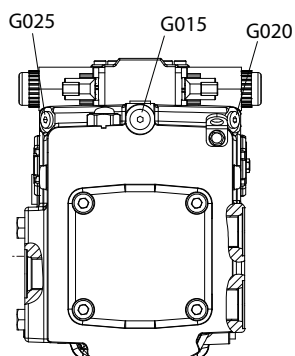
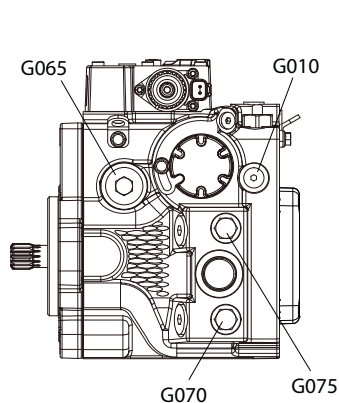
## Minor Repair

1. Press the bearing (J150) onto the shaft (J100) and replace the retaining ring (J200).
2. Install the shaft/bearing assembly into the pump.
3. Install first spring clip (J300).
4. Cover the shaft with a protective sleeve while installing the seal. Lubricate and install the seal.
5. Install the second spring clip (J300).

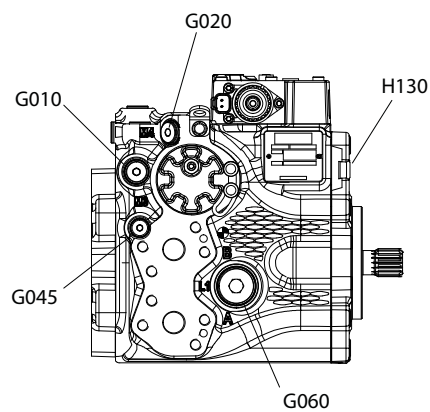
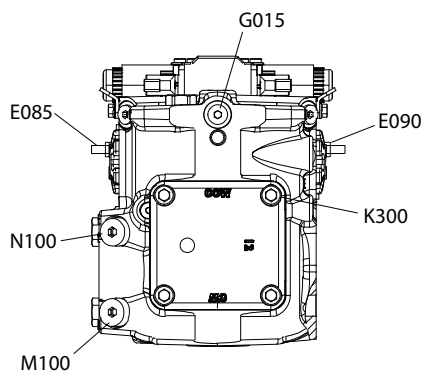
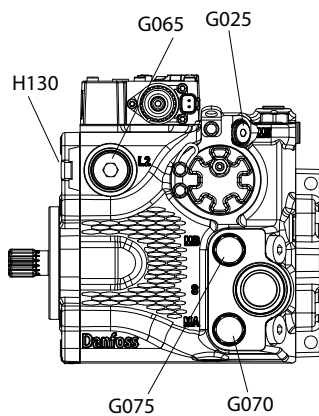
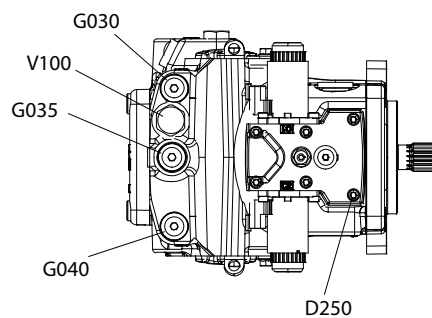
## Fastener Size and Torque Chart



**28/32**



**38/45**



## Fastener Size and Torque Chart

### Fastener Size and Torque

Item	Fastener	Wrench size	Torque
D250	Electric control mounting bolt	5 mm internal hex	13 N•m [10 lbf•ft]
E085	Displacement limiter screw	4 mm internal hex	NA
E090	Displacement limiter sealnut	13 mm	23 N•m [17 lbf•ft]
H130	Front cover bolt	8 mm internal hex	28/32 cc - 50 N•m [37 lbf•ft]
			38/45 cc - 64 N•m [47 lbf•ft]
K300	Rear cover/aux pad mounting bolt	8 mm internal hex	111 N•m [82 lbf•ft]

### Plug Size and Torque

Item	O-ring plug	Wrench size	Torque
G010/G035	Charge pressure gauge	6 mm or 1/4 inch internal hex	40 N•m [29.5 Ft-lbs] for 9/16 35.3 N•m [26 Ft-lbs] for M14
G030/G040	Filtration inlet/outlet	6 mm or 1/4 inch internal hex	40 N•m [29.5 Ft-lbs] for 9/16 35.3 N•m [26 Ft-lbs] for M14
G020/G025	Servo gauge (28/32)	6 mm or 3/16 inch internal hex	25 N•m [18.4 Ft-lbs] for 7/16 25 N•m [18.4 Ft-lbs] for M12
G020/G025	Servo gauge (38/45)	6 mm or 1/4 inch internal hex	40 N•m [29.5 Ft-lbs] for 9/16 35.3 N•m [26 Ft-lbs] for M14
G060/065	Case drain	12 mm or 9/16 in internal hex	48 N•m [36 Ft-lbs]
G070/075	System gauge (28/32)	19 mm or 11/16 inch wrench	38 N•m [28 Ft-lbs] for 9/16 24 N•m [17.7 lbf•ft] for M14
	System gauge (38/45)	24 mm or 7/8 inch wrench	81 N•m [59.7 Ft-lbs] for 3/4 67 N•m [49.4 lbf•ft] for M18
M100/N100	High pressure relief	5/16 inch internal hex	81.0 N•m [59.7 Ft-lbs]
V100	Charge pressure relief	1 inch	78.6 N•m [58 Ft-lbs]



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