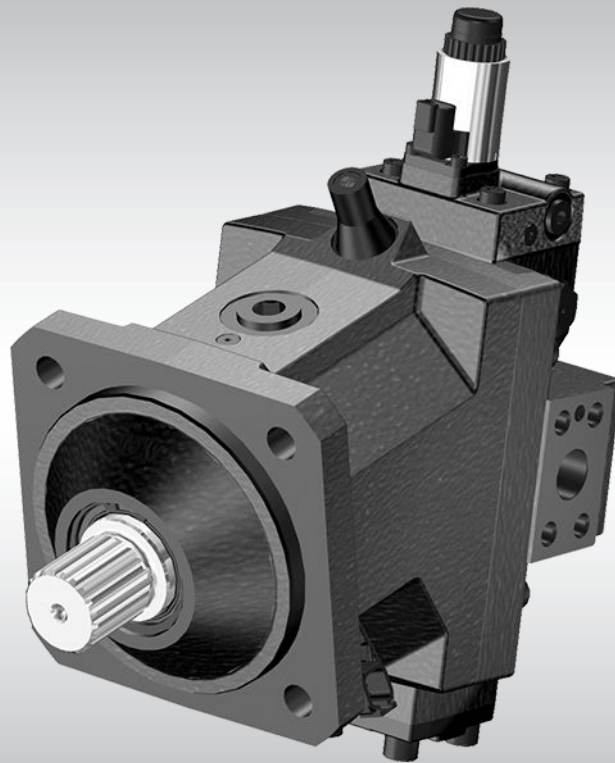




Service Manual

# Bent Axis Motors

# H1B 060/080/110/160/210/250



**Revision history***Table of revisions*

<b>Date</b>	<b>Changed</b>	<b>Rev</b>
December 2015	Add 210 frame size	0500
November 2015	Model code change	0400
July 2015	correct torque values, pages 61, 62	0301
June 2015	add hydraulic controls THHA, THHB	0300
February 2015	add hydraulic controls	CB
January 2015	Danfoss Layout	CA
March 2013	added 250 frame size	BC

**Contents**

**Introduction**

Overview.....5  
 Warranty.....5  
 General instructions.....5  
 Safety precautions.....6  
 Symbols used in Danfoss literature.....7

**H1 general information**

Design of H1 bent axis motor.....8  
 General description.....10  
 H1 pictorial diagram.....11  
 H1 system schematic.....12

**Technical specifications**

General specifications.....13  
 Physical properties.....13  
 Operating parameters.....14  
 H1B speed range diagrams for open and closed circuit.....15  
 H1B pressure requirements for open and closed circuit.....16  
 Open circuit requirements.....19  
 Fluid specifications.....20  
 Determination of nominal motor sizes.....20

**Operation**

Shaft rotation direction.....21  
 Loop flushing shuttle spool.....22  
 Loop flushing relief valve.....22  
 Speed sensor.....23  
 Displacement limiter.....25

**Operating parameters**

Output speed.....26  
 System pressure.....26  
 Case pressure.....27  
 External shaft seal pressure.....27  
 Temperature.....27

**Fluid and filter maintenance**

Fluid and filter recommendations.....28

**Pressure measurements**

Port locations and gauge installation.....29

**Initial startup procedures**

Procedure.....31

**Troubleshooting**

Overview.....33  
 Electrical troubleshooting.....33  
 Sluggish operation.....33  
 System operating hot.....33  
 Excessive noise or vibration.....34  
 Motor operates normally in one direction only.....34  
 Improper output speed.....34  
 Low output torque.....35

**Required tools and standard procedures**

**Adjustments**

Minimum displacement limiter.....37  
 Optional threshold adjustment - electric proportional controls.....38  
 Optional threshold adjustment - hydraulic proportional controls.....39  
 Pressure compensator OVERRIDE (PCOR) adjustment.....40  
 PCOR adjustment for all except P1/P2.....40

**Contents**

Brake pressure defeat option.....	42
PCOR adjustment for P1/P2 controls.....	42

**Minor repair**

Shaft seal.....	43
Electric proportional solenoid replacement.....	44
Hydraulic proportional actuator replacement.....	45
Control module replacement.....	46
Electric proportional control module.....	47
Hydraulic proportional control module.....	49
Electric two-position control module.....	50
Hydraulic two-position control module.....	52
Hydraulic two-position control module with PCOR.....	53
Hydraulic two-position control module with PCOR and hydraulic BPD.....	54
Maximum displacement limiter two-position controls.....	56
Servo piston cover – proportional control.....	56
Replace speed sensor.....	58
Loop flushing spool.....	59
Loop flushing charge relief valve.....	60
Minimum Displacement limiter.....	62

**Torque chart**

Fasteners and plugs.....	63
Fastener size and torque chart.....	63
Plug size and torque chart.....	64

## Introduction

### Overview

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

Performing minor repairs may require removal 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 repair. 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.powersolutions.danfoss.com](http://www.powersolutions.danfoss.com). Click on the Sales and Service link.

### Warranty

Performing installation, maintenance, and minor repairs according to the procedures in this manual will not affect your warranty. Major repairs requiring the removal of a unit's rear cover voids the warranty unless done by a Danfoss Global Service Partner.

### General instructions

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

#### Remove the unit



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

#### Keep it clean



Cleanliness is a primary means of assuring satisfactory motor life, on either new or repaired units. Clean the outside of the motor 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.

Keep all parts free of foreign materials and chemicals. Protect all exposed sealing surfaces and open cavities from damage and foreign material. If left unattended, cover the motor with a protective layer of plastic.

#### Replace all O-rings and gaskets



Danfoss recommends you replace all O-rings and gaskets during repair. Lightly lubricate O-rings with clean petroleum jelly prior to assembly.

#### Secure the unit



## Introduction

For repair, place the unit in a stable position with the shaft pointing downward. Secure the motor while removing and torquing components and fasteners.

## 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**

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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**

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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.

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### Personal safety

 **Warning**

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

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### Hazardous material

 **Warning**





























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

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Introduction

Symbols used in Danfoss literature

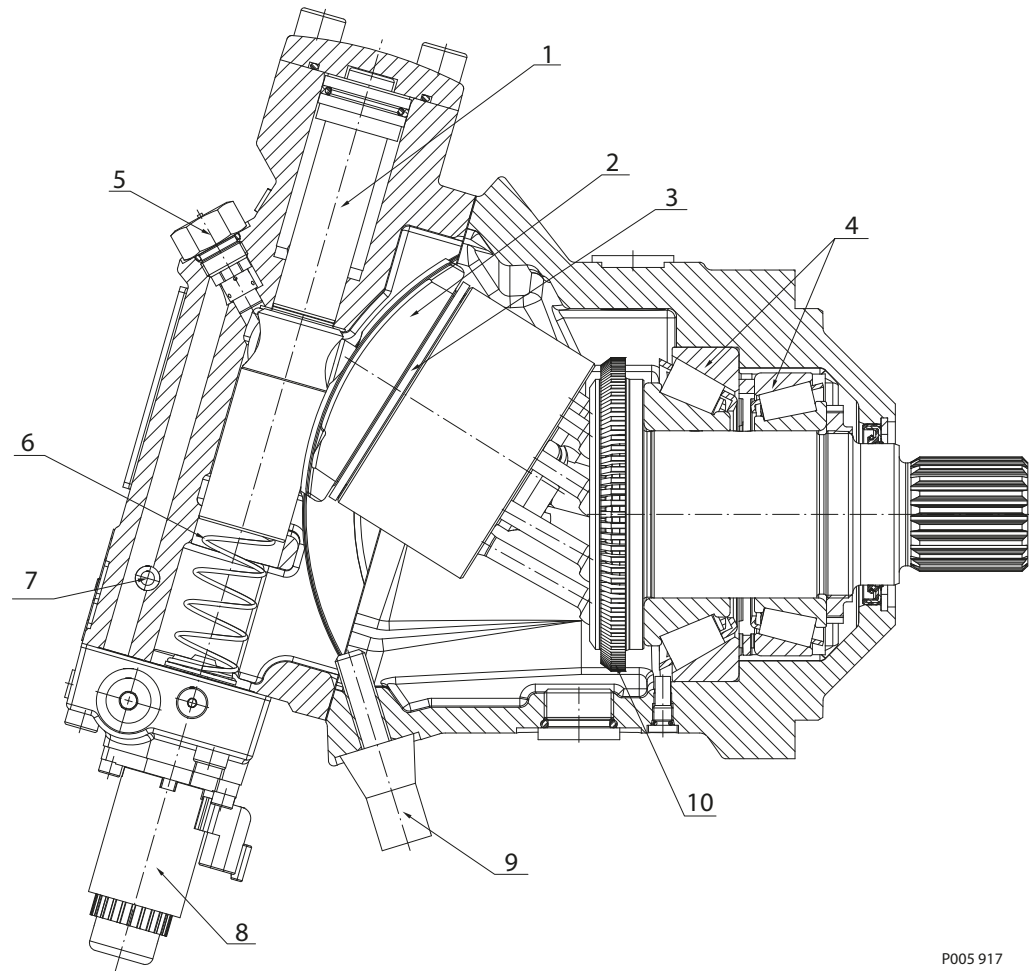
 WARNING may result in injury	 Tip, helpful suggestion
 CAUTION may result in damage to product or property	 Lubricate with hydraulic fluid
 Reusable part	 Apply grease / petroleum jelly
 Non-reusable part, use a new part	 Apply locking compound
 Non-removable item	 Inspect for wear or damage
 Option - 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.

H1 general information

Design of H1 bent axis motor

*Cross-section of H1 motor with electric proportional control*

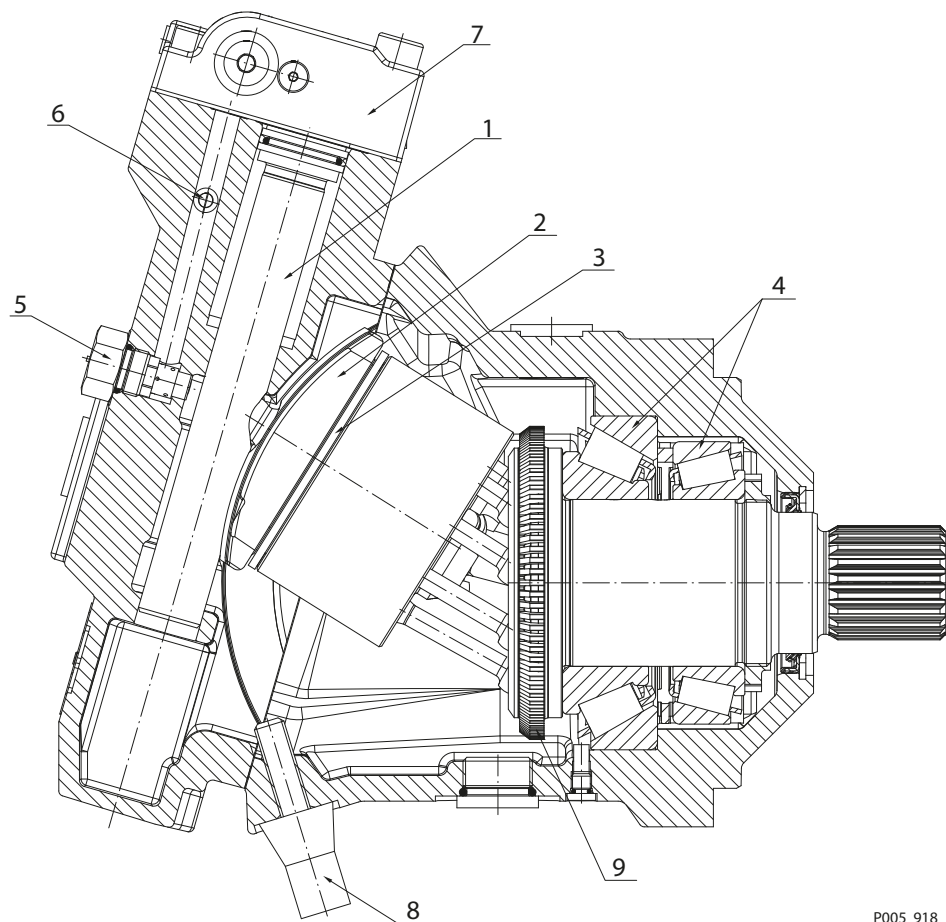


P005 917

- 1. Differential servo piston
- 2. Valve segment
- 3. Bearing plate
- 4. Tapered roller bearing
- 5. Loop flushing relief valve
- 6. Ramp spring
- 7. Loop flushing shuttle spool
- 8. Electric proportional control
- 9. Minimum displacement limiter
- 10. Speed ring (optional)

H1 general information

*Cross-section of H1 motor with electric two-position control*



P005 918

- 1. Differential servo piston
- 2. Valve segment
- 3. Bearing plate
- 4. Tapered roller bearing
- 5. Loop flushing relief valve
- 6. Loop flushing shuttle spool
- 7. Electric two-position control
- 8. Minimum displacement limiter
- 9. Speed ring (optional)

## H1 general information

### General description

Series H1 variable displacement motors are bent axis design, incorporating spherical pistons.

These motors are designed primarily to be combined with other products in closed circuit systems to transfer and control hydraulic power. Series H1 motors have a large maximum/minimum displacement ratio of 5:1 and high output speed capabilities.

The expanded function of zero degree capability, coupled with a high performance 32 degree maximum angle, creates opportunities to easily improve the machine performance for:

- Wheel assist on the steering axle of high inertia machines (i.e. combines) and could include Anti Slip Control
- Off-highway machines requiring Anti Slip Control (i.e. Ag. sprayer)
- Multi-motor applications requiring optimized work and transport modes (i.e. wheel loader, Ag sprayer) utilizing the zero degree position for maximum transport speed
- Improved machine (i.e. single drum roller) gradeability through precise Anti Slip Control

The Anti Slip Control reduces ground damage, increases traction control and improves machine controllability for the operator.

SAE, Cartridge (not available for 210 cm<sup>3</sup> and 250 cm<sup>3</sup>) and DIN (not available for 250 cm<sup>3</sup>) flange with radial or axial high pressure port configurations are available including the loop flushing device.

A complete family of controls and regulators are available to fulfill the requirements of a wide range of applications.

Motors normally start at maximum displacement. This provides maximum starting torque for high acceleration.

All controls utilize internally supplied servo pressure. This may be overridden by a pressure compensator which functions when the motor is operating in motor and pump modes. A defeat option is available to disable the pressure compensator override when the motor is running in pump mode during deceleration/braking.

The pressure compensator option features a low pressure rise to ensure optimal power utilization throughout the entire displacement range of the motor.

Speed sensor options are available to cover all frame sizes and flange styles.

They are capable of sensing the following, all in one package:

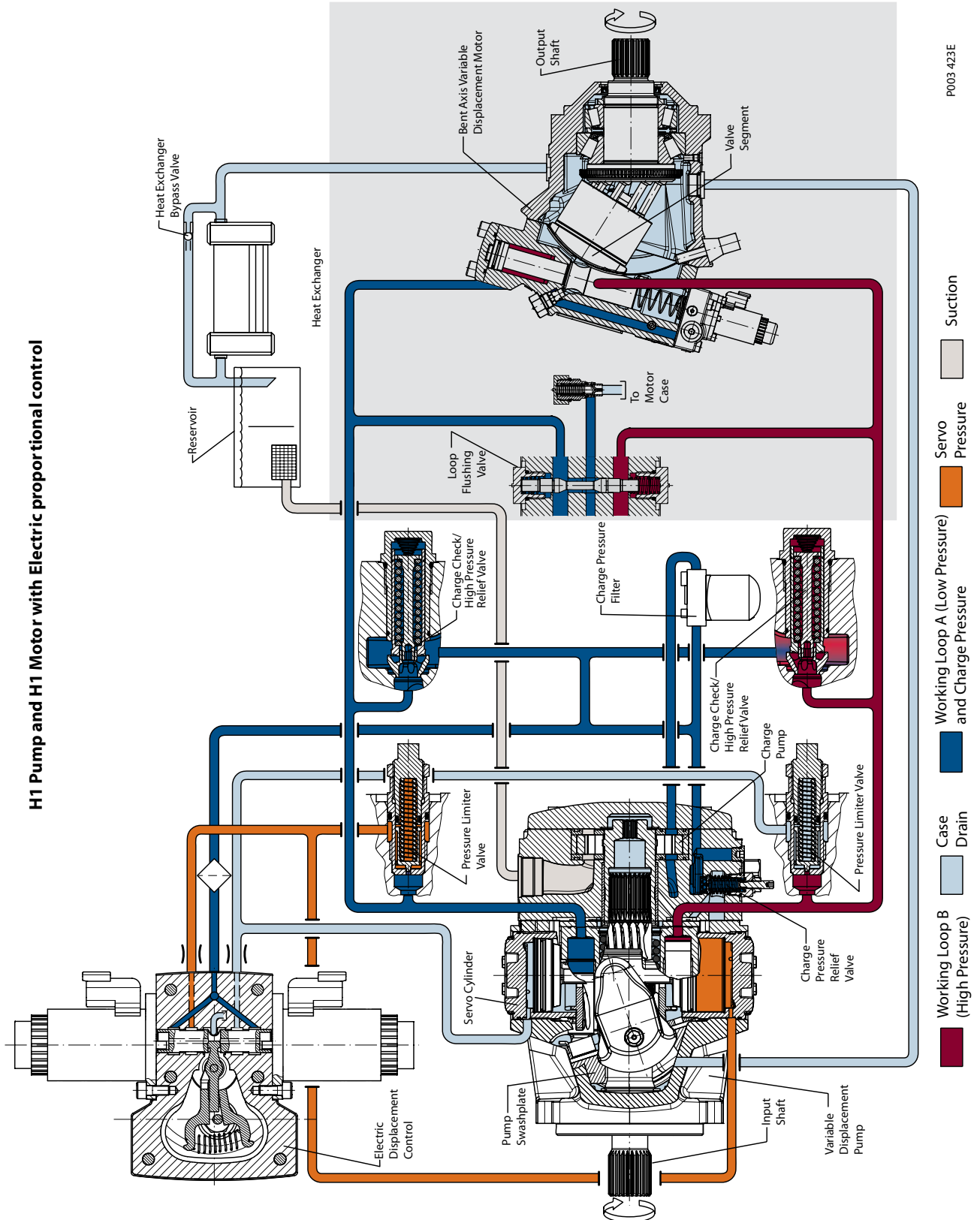
- Speed
- Direction (only group "J", option "S")
- Temperature (only group "J", option "S")

The electric controls are specifically designed for the Danfoss family of PLUS+1<sup>®</sup> microcontrollers for easy "Plug and Perform" installation.

H1 general information

H1 pictorial diagram

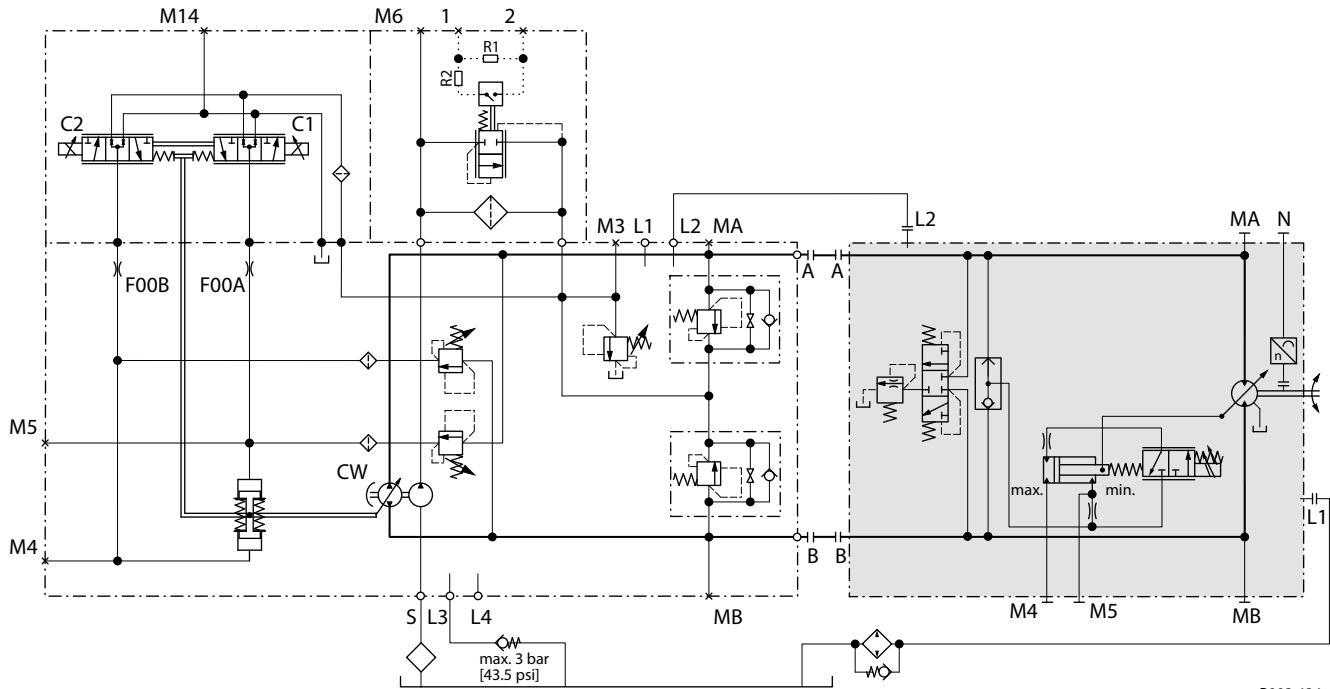
H1 pump and H1 motor with electric proportional control (EDC)



H1 general information

H1 system schematic

System schematic H1 pump and H1 motor with EDC



P003 424

The schematic above shows the function of a hydrostatic transmission using an H1 axial variable displacement pump with electric proportional displacement control (EDC) and an H1 bent axis variable displacement motor with electric proportional control (L\*) and integrated loop flushing device.

**Technical specifications**
**General specifications**
*General specifications*

<b>Design</b>	Piston motor with variable displacement bent axis design
<b>Direction of rotation</b>	Bi-directional
<b>Pipe connections</b>	<i>Main pressure ports:</i> ISO split flange boss <i>Remaining ports:</i> SAE straight thread O-ring boss
<b>Recommended installation</b>	Discretionary, the housing must always be filled with hydraulic fluid

**Physical properties**
*Physical properties*

Features		Unit	Size					
			060	080	110	160	210	250
<b>Displacement</b>	<b>maximum</b>	cm <sup>3</sup> [in <sup>3</sup> ]	60 [3.66]	80 [4.88]	110 [6.71]	160 [9.76]	210 [12.81]	250 [15.25]
	<b>minimum</b>		12 [0.73]	16 [0.98]	22 [1.34]	32 [1.95]	42 [2.56]	50 [3.05]
<b>Theoretical flow at max. displ.</b>	<b>at rated speed</b>	l/min [US gal/min]	216 [57]	256 [68]	319 [84]	416 [110]	504 [133]	550 [145]
	<b>at max. speed</b>		270 [71]	328 [87]	407 [108]	528 [139]	630 [166]	700 [185]
<b>Theoretical torque at max. displacement</b>		N·m/bar [lbf·in/1000 psi]	0.96 [583]	1.27 [777]	1.75 [1069]	2.55 [1555]	3.34 [2038]	3.98 [2426]
<b>Theor. corner power at rated speed and max. working pressure (Δp = 450 bar [6527 psi])</b>		kW [hp]	266 [357]	321 [430]	396 [531]	513 [689]	609 [817]	684 [917]
<b>Mass moment of inertia of rotating components</b>		kg·m <sup>2</sup> [slug·ft <sup>2</sup> ]	0.0038 [0.0028]	0.0062 [0.0046]	0.0108 [0.0080]	0.0211 [0.0156]	0.0306 [0.0226]	0.0402 [0.0296]
<b>Case volume</b>		l [US gal]	0.9 [0.24]	1.0 [0.26]	1.4 [0.37]	2.7 [0.71]	2.8 [0.74]	4.1 [1.08]

*Weight dry (Electric proportional control)*

Configuration	Unit	Size 060	Size 080	Size 110	Size 160	Size 210	Size 250
<b>SAE</b>	kg [lb]	29.8 [65.7]	34.8 [76.7]	48.8 [107.6]	61.9 [136.5]	81.0 [178.6]	87.0 [196.2]
<b>DIN</b>		28.3 [62.4]	34.4 [75.8]	45.0 [99.2]	59.3 [130.7]	75.0 [165.3]	–
<b>Cartridge</b>		26.9 [59.3]	33.0 [72.6]	41.8 [92.2]	54.7 [120.6]	–	–

*Mounting flange*

Size	060	080	110	160	210	250
<b>SAE ISO 3019/1</b>	127-4 (SAE C) 4-bolt		152-4 (SAE-D) 4-bolt		165-4 (SAE E)	
<b>DIN ISO 3019/2, B4</b>	125 HL 4-bolt	140 HL 4-bolt	160 HL 4-bolt	180 HL 4-bolt	200 HL 4-bolt	–
<b>Cartridge</b>	Pilot Ø160 mm 2-bolt (200 dist.) M16	Pilot Ø190 mm 2-bolt (224 dist.) M20	Pilot Ø200 mm 2-bolt (250 dist.) M20		–	–

**Technical specifications**
*Customer ports*

Size	060	080	110	160	210	250
<b>Axial and radial<sup>1)</sup></b>	DN19 typ I	DN25 typ I	DN25 typ I	DN32 typ I	DN32 typ I	DN32 typ I
<b>Case drain ports<sup>2)</sup></b>	0.875-14UN-2B [ $\frac{7}{8}$ -14UN-2B]		1.0625-12UN-2B [ $1\frac{1}{16}$ -12UN-2B]		1.313-12UN-2B [ $1\frac{5}{16}$ -12UN-2B]	
<b>Axial gauge ports<sup>2)</sup></b>	0.875-14UN-2B [ $\frac{7}{8}$ -14UN-2B]	1.0625-12UN-2B [ $1\frac{1}{16}$ -12UN-2B]				
<b>Gauge ports<sup>2)</sup></b>	0.5625-18UNF-2B [ $\frac{9}{16}$ -18UNF-2B]					

<sup>1)</sup> Split flange boss per ISO 6162, 40 MPa series.

<sup>2)</sup> SAE O-ring boss

**Operating parameters**
*Output speed*

Features		Unit	Size					
			060	080	110	160	210	250
<b>Rated output speed</b>	<b>max. displ. 32°</b>	min <sup>-1</sup> (rpm)	3600	3200	2900	2600	2350	2200
	<b>min. displ. 6°</b>		5900	5300	4800	4250	3850	3650
	<b>zero displ. 0°</b>		6600	5950	5350	4750	4300	4050
<b>Maximum output speed</b>	<b>max. displ. 32°</b>		4500	4100	3700	3300	3000	2800
	<b>min. displ. 6°</b>		7250	6600	5950	5250	4800	4500
	<b>zero displ. 0°</b>		7950	7200	6500	5750	5250	4900

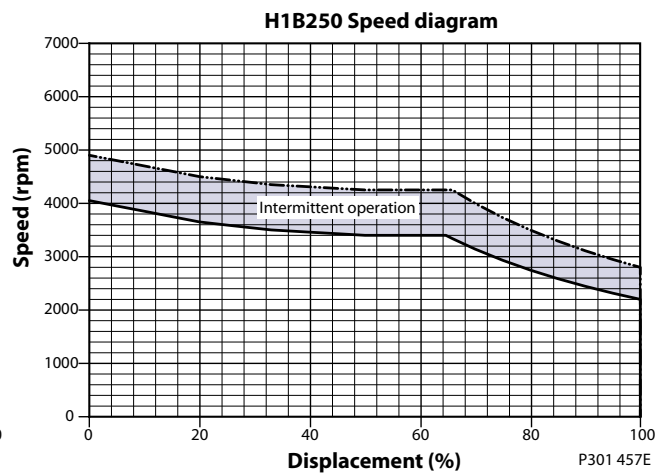
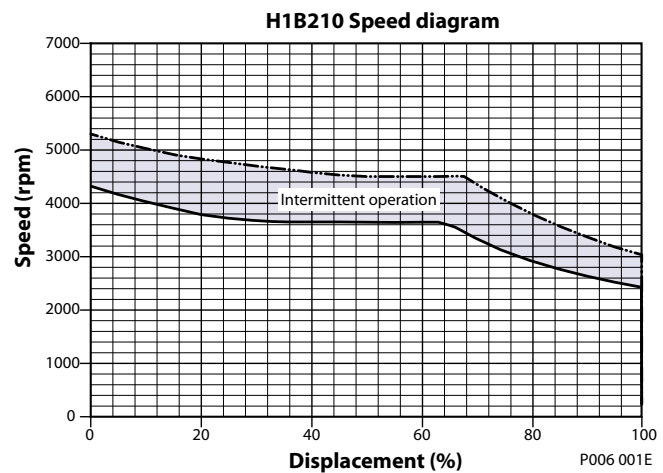
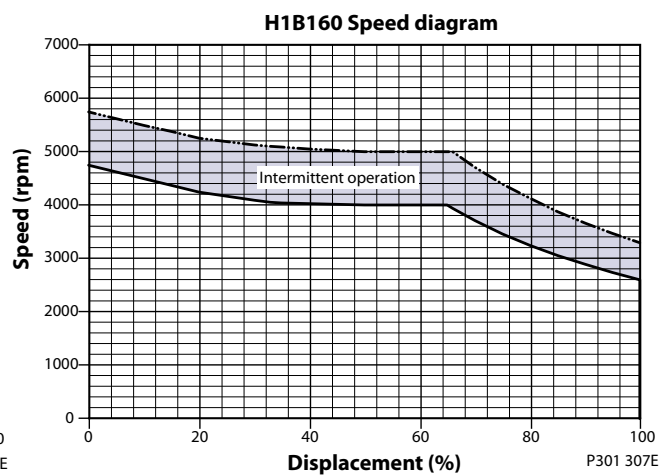
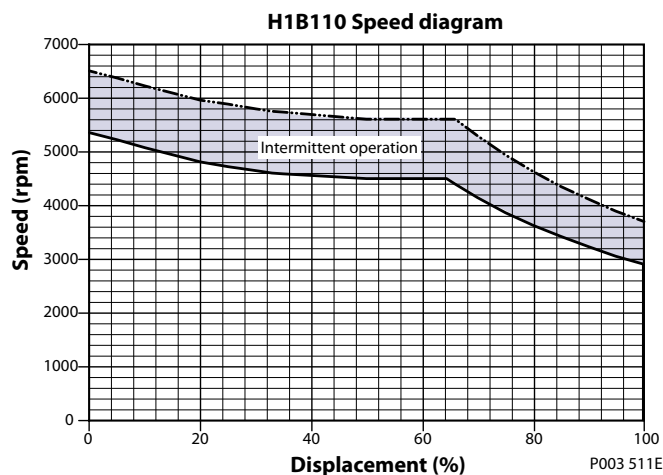
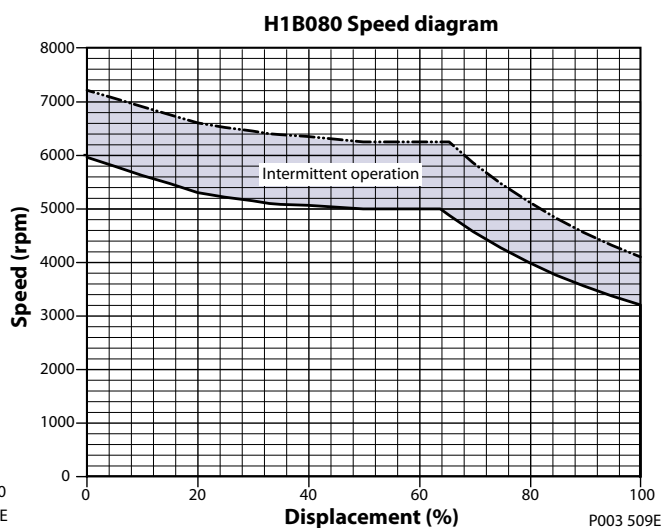
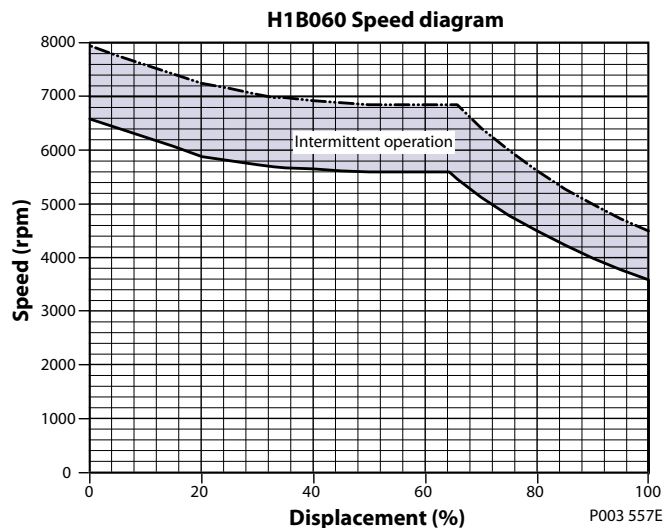
*System and case pressure, Ambient temperature*

Parameter		Unit	All sizes
<b>System pressure</b>	<b>Maximum working</b>	bar [psi]	450 [6527]
	<b>Maximum</b>		480 [6962]
	<b>Minimum above case pressure (open and closed circuit)</b>		See graphs in <a href="#">H1B pressure requirements for open and closed circuit</a> on page 16.
<b>Case pressure</b>	<b>Rated</b>		3 [44]
	<b>Maximum</b>		5 [73]
	<b>Minimum</b>		0.3 [4]
<b>Ambient temperature*</b>	<b>Maximum</b>	°C [°F]	70 [158]
	<b>Minimum</b>		-40 [-40]

\* Air temperature close to the unit

Technical specifications

H1B speed range diagrams for open and closed circuit



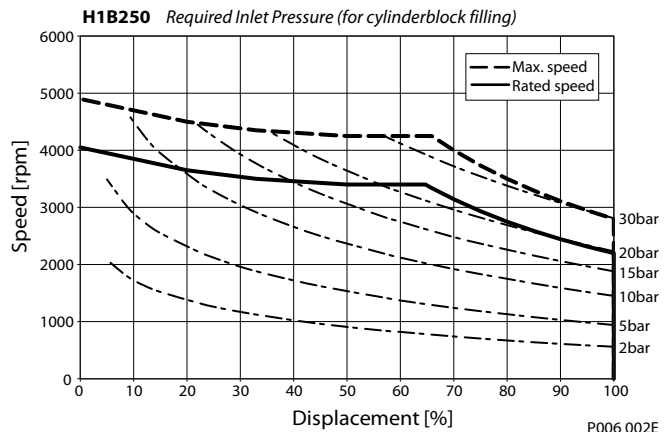
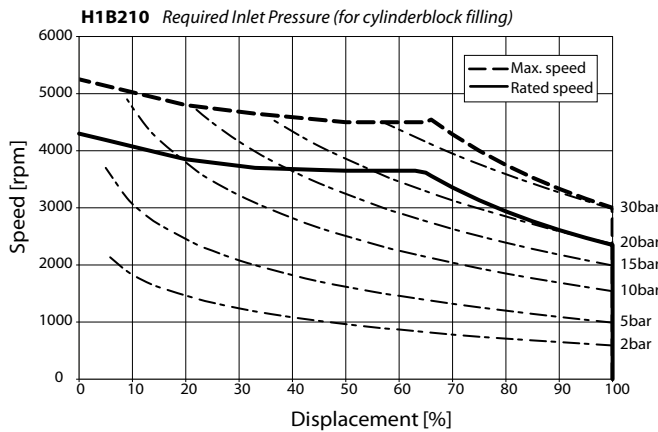
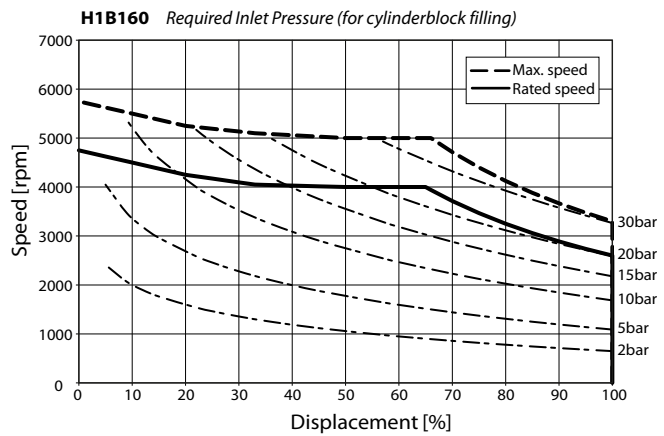
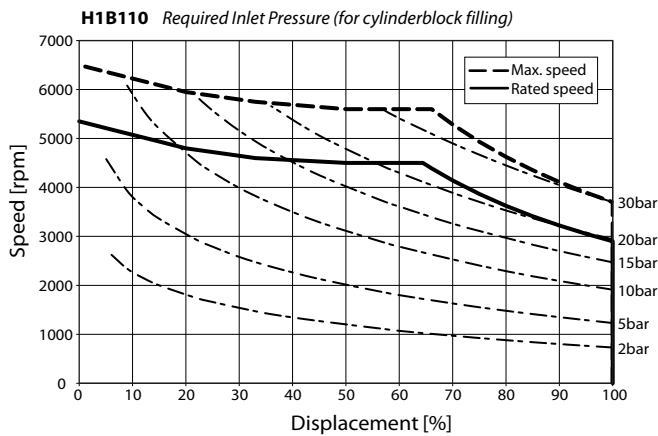
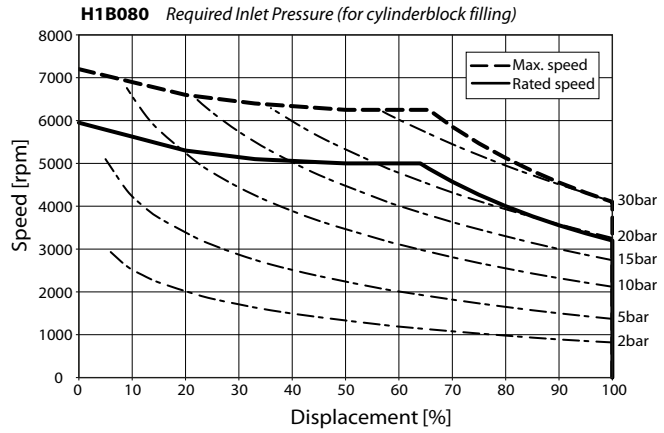
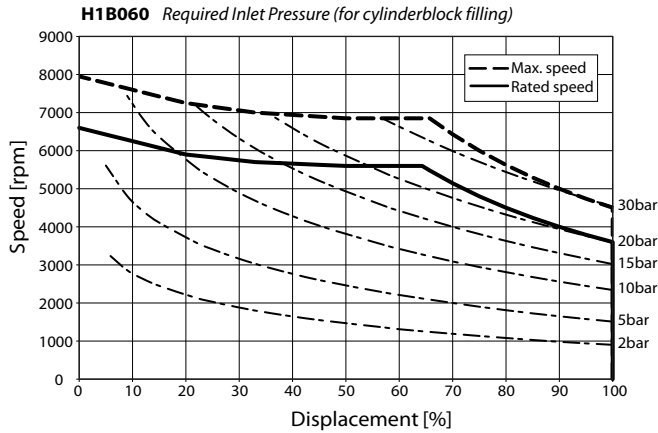
For **open circuit** applications it is not allowed to operate in the intermittent area.  
 For **closed circuit** applications operating in the intermittent area, please contact your local Danfoss Power Solutions representative.

Technical specifications

H1B pressure requirements for open and closed circuit

Required inlet pressure (for cylinder block filling)

This pressure ensures that the cylinder block will be properly filled and that there is no pulling between piston and shaft. The required pressure is 0 bar at 0 rpm and increases with rpm.



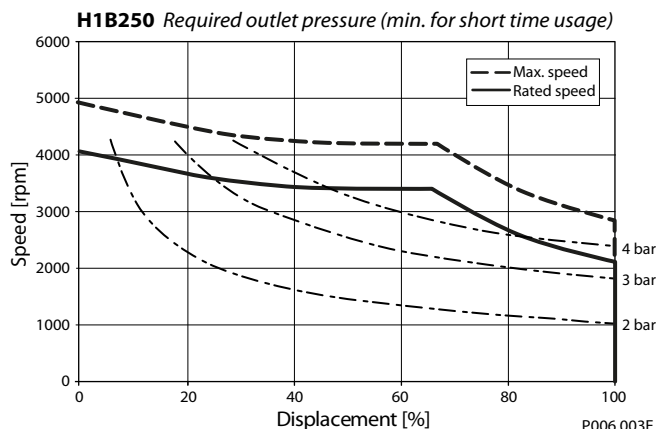
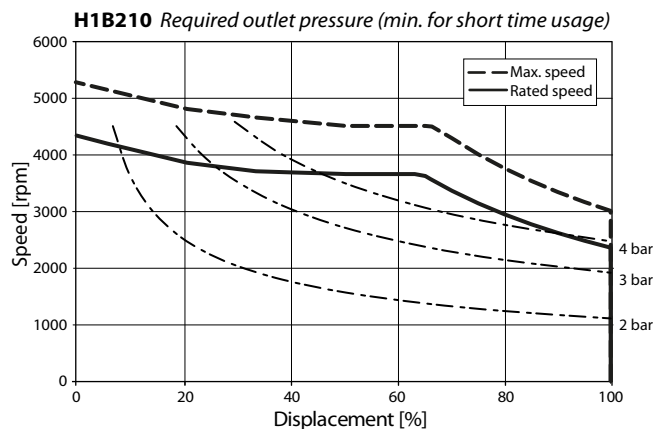
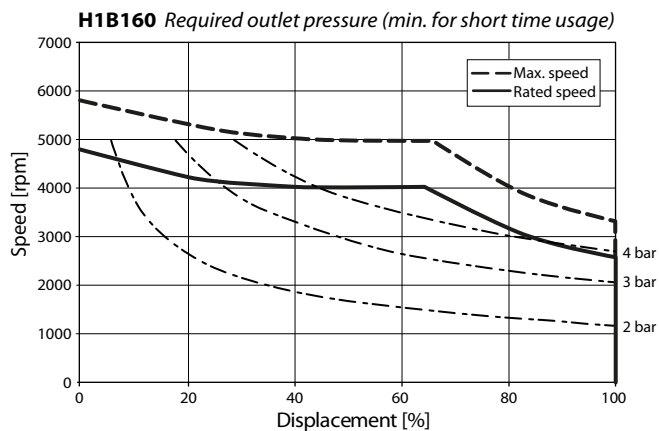
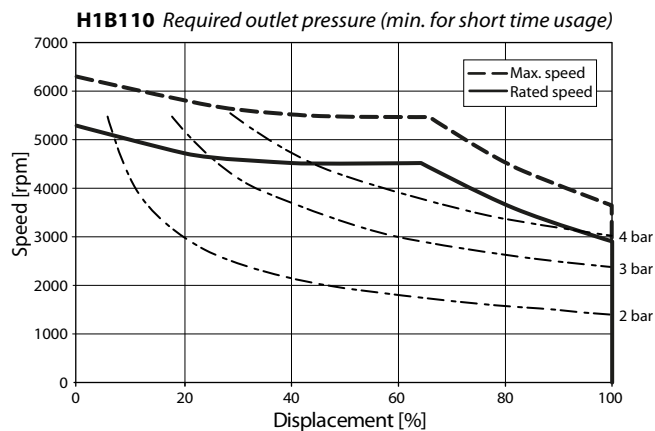
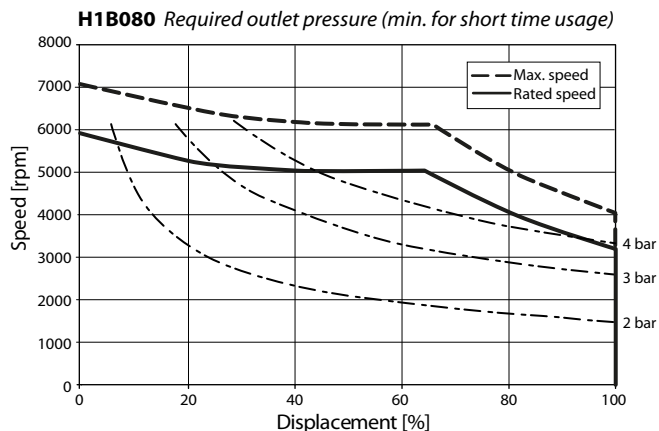
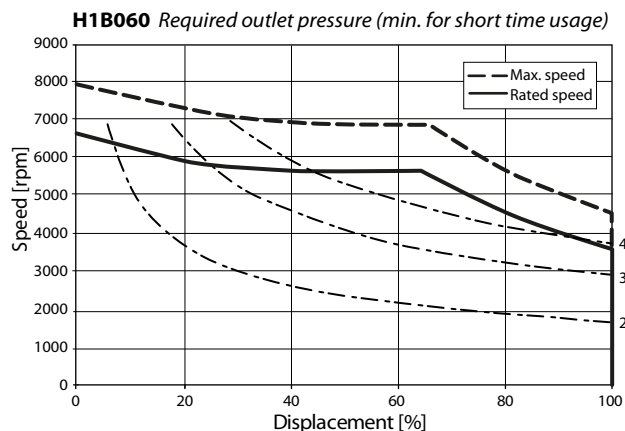
P006 002E

For **open circuit** applications it is not allowed to operate above rated speed.  
 For **closed circuit** applications operating between rated and max speed, please contact your local Danfoss Power Solutions representative.

Technical specifications

**Required outlet pressure (minimum for short time usage)**

The required outlet pressure (above case pressure) makes sure, that there is no pulling between piston and shaft.  
The required pressure is 0 bar at 0 rpm and increases with rpm.



P006 003E

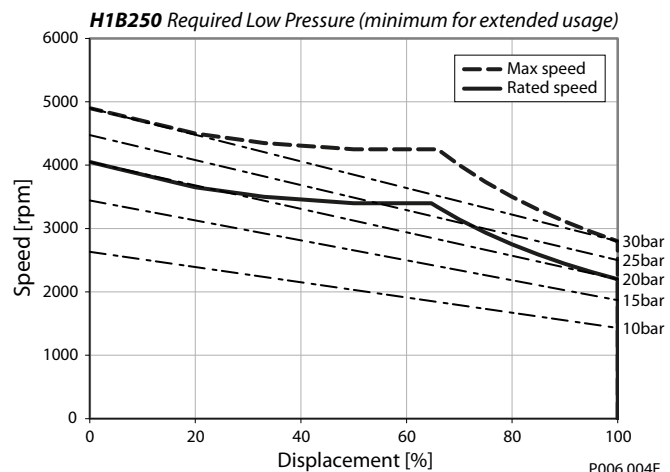
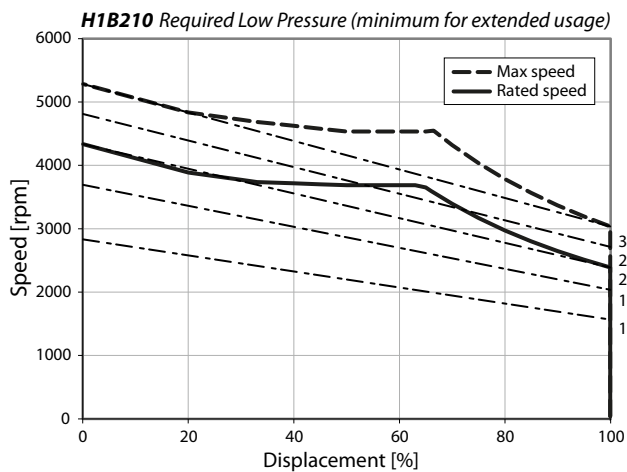
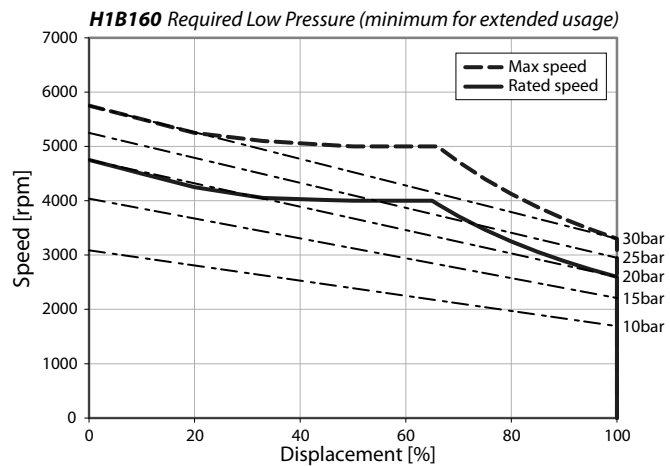
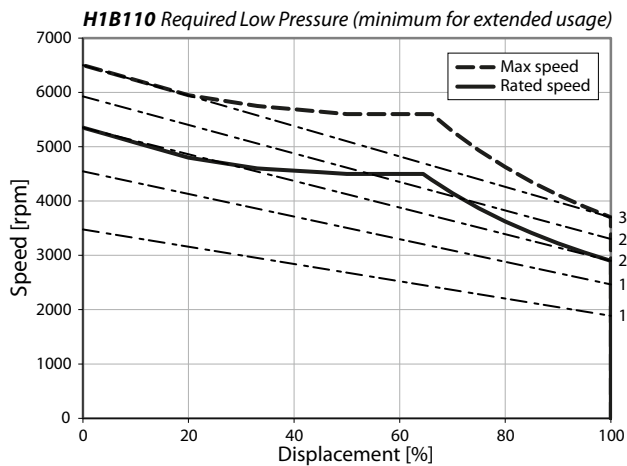
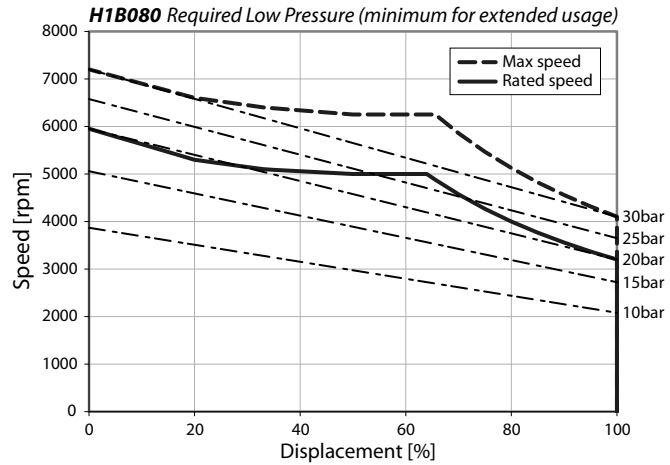
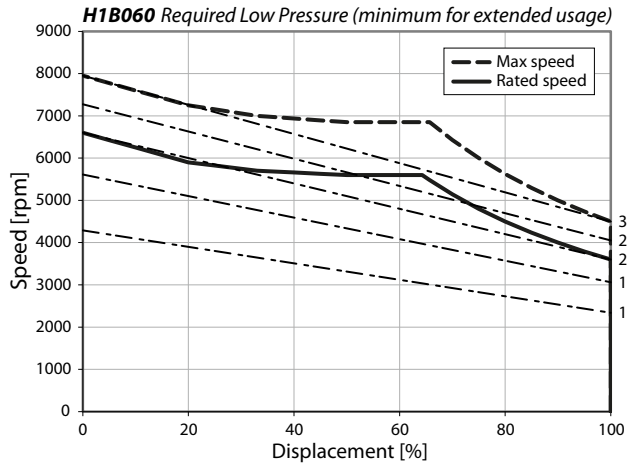
For **open circuit** applications it is not allowed to operate above rated speed.

For **closed circuit** applications operating between rated and max speed, please contact your local Danfoss Power Solutions representative.

Technical specifications

**Required low pressure (minimum for extended usage)**

These minimum pressures are required for a high duty cycle, defined as 200 hours at 350 bar. Similarly, a duty cycle of 200 hours at 250 bar requires 50% of these pressures. This low pressure (above case pressure) is required to prevent cavitation, which comes from the pressure change in the cylinder block. There is very high flow velocity in the porting grooves of the valve segment, which causes cavitation.



P006 004E

For **open circuit** applications it is not allowed to operate above rated speed. For **closed circuit** applications operating between rated and max speed, and for specific duty cycle interpretation or analysis, please contact your local Danfoss Power Solutions representative.

## Technical specifications

### Open circuit requirements

H1 Bent Axis Motors may be used in **Open Circuit (OC)** applications.

Since loop flushing is typically not used in OC-applications it is essential to provide sufficient cooling capacity. This can be done by motor case cross flushing.

The flow rate needs to be adjusted to the cooling demand.

The highest case drain outlet port must always be used for the return flow to the cooler or tank.

The motor case, the control system and the working lines connected to Port A and B must be kept full of oil at all times, whether in a dynamic or static condition.

The plumbing must not allow the oil to drain down and be replaced with air in the control or rotating group.

The minimum pressure in the inlet port and the outlet port, measured at gage ports MA and MB, must be equal or higher as shown in the graphs [H1B pressure requirements for open and closed circuit](#) on page 16.

Counter balance valves may be used to maintain the minimum pressure requirements. Also the Danfoss Power Solutions Meter-in / Meter-out PVG technology may be used.

Check valves and sufficient charge pressure supply are also possible.

At no time shall the motor be allowed to operate above the rated speed limits. If flow limiter valves are used, they must be selected accordingly. Select Motor controls which use the high loop system pressure to shift the servo piston. This will ensure proper function under all conditions.

Valve blocks, such as counter balance valves attached to the inlet and/or outlet ports, must not interfere with any part of the motor. A review of the outline drawings or appropriate 3D models must be completed.

**Technical specifications**
**Fluid specifications**
*Fluid specifications*

Features		Unit	All sizes
Viscosity	Minimum intermittent	mm <sup>2</sup> /s [SUS]	7 [49]
	Recommended range		12-80 [66-366]
	Maximum intermittent		1600 [7416]
Temperature range <sup>1)2)</sup>	Minimum	°C [°F]	-40 [-40]
	Rated		104 [220]
	Maximum intermittent		115 [240]
Cleanliness and Filtration	Required cleanliness per ISO 4406	-	22/18/13
	Efficiency (charge pressure filtration)	β-ratio	β <sub>15-20</sub> = 75 (β <sub>10</sub> ≥ 10)
	Efficiency (suction / return line filtration)		β <sub>35-45</sub> = 75 (β <sub>10</sub> ≥ 2)
	Recommended inlet screen mesh size	μm	100 – 125

<sup>1)</sup> At the hottest point, normally case drain port.

<sup>2)</sup> Minimum: cold start, short term t<3 min, p<50 bar, n<1000 rpm.

**Determination of nominal motor sizes**

	Based on SI units		Based on US units
Input flow:	$Q_e = \frac{V_g \cdot n}{1000 \cdot \eta_v}$	l/min	$Q_e = \frac{V_g \cdot n}{231 \cdot \eta_v}$ [US gal/min]
Output torque:	$M_e = \frac{V_g \cdot \Delta p \cdot \eta_{mh}}{20 \cdot \pi}$	N•m	$M_e = \frac{V_g \cdot \Delta p \cdot \eta_{mh}}{2 \cdot \pi}$ [lb•in]
Output power:	$P_e = \frac{M_e \cdot n}{9550} = \frac{Q_e \cdot \Delta p \cdot \eta_t}{600}$	kW	$P_e = \frac{V_g \cdot n \cdot \Delta p \cdot \eta_t}{396\,000}$ [hp]
Speed:	$n = \frac{Q_e \cdot 1000 \cdot \eta_v}{V_g}$	min <sup>-1</sup>	$n = \frac{Q_e \cdot 231 \cdot \eta_v}{V_g}$ min <sup>-1</sup> (rpm)

Where:

V <sub>g</sub>	=	Motor displacement per rev.
p <sub>high</sub>	=	High pressure
p <sub>low</sub>	=	Low pressure
Δp	=	p <sub>high</sub> - p <sub>low</sub>
n	=	Speed
η <sub>v</sub>	=	Motor volumetric efficiency
η <sub>mh</sub>	=	Mechanical-hydraulic efficiency
η <sub>t</sub>	=	Motor total efficiency (η <sub>v</sub> • η <sub>mh</sub> )

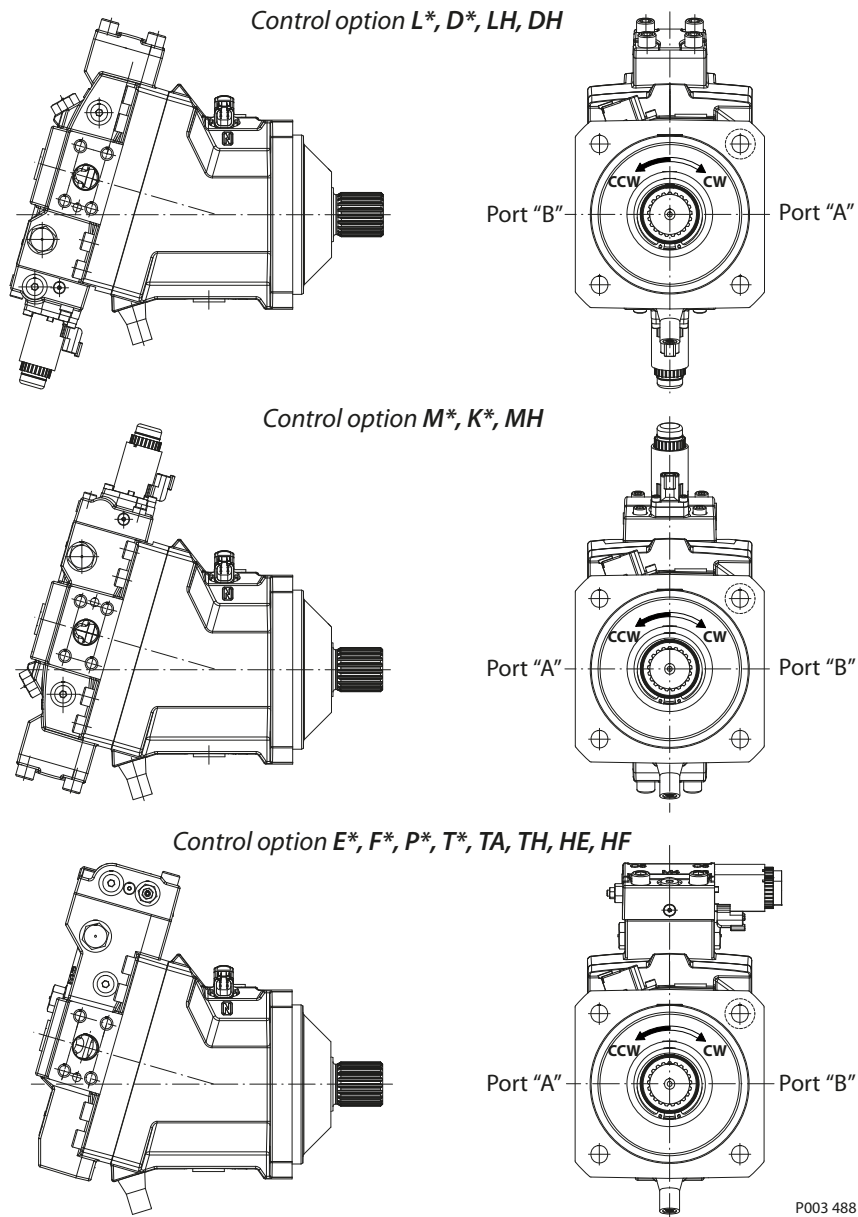
*SI units [US units]*

cm <sup>3</sup> /rev [in <sup>3</sup> /rev]
bar [psi]
bar [psi]
bar [psi]
min <sup>-1</sup> (rpm)

Operation

Shaft rotation direction

Shaft rotation direction is determined with a view to the shaft end. Rotation direction of the motor will be dependent on the control option used as illustrated below and summarized in the table.



Direction of rotation (view from the shaft end)

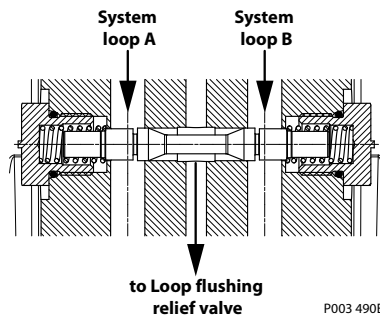
Control options	Flow into port	Direction of rotation
<b>L*, D*, LH, and DH*</b>	A	CW
	B	CCW
<b>M*, K*, MH, E*, F*, P*, T*, TA, TH, HE, and HF</b>	A	CCW
	B	CW

\* 1 = 12 V<sub>DC</sub> OR 2 = 24 V<sub>DC</sub>.

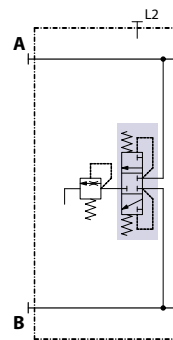
Operation

Loop flushing shuttle spool

An integral loop flushing shuttle spool is used to separate system A and system B pressures. System delta pressure will cause the shuttle spool to shift, allowing the low side system pressure to flow to the loop flushing relief valve.



P003 490E



P003 437

**Warning**

**Unintended vehicle or machine movement hazard.**

Excessive motor loop flushing flow may result in the inability to build required system pressure in some conditions. Maintain correct charge pressure under all conditions of operation to maintain pump control performance in hydrostatic systems.

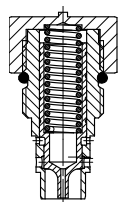
Loop flushing relief valve

The loop flushing relief valve is incorporated into all H1 motors. Use the loop flushing option in installations that require fluid to be removed from the low pressure side of the system circuit due to cooling requirements.

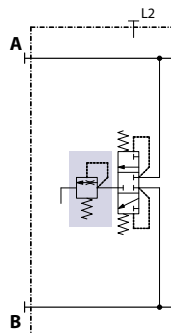
The loop flushing relief valve is also used to facilitate the removal of contaminants from the loop.

The loop flushing valve is equipped with an orificed charge pressure relief valve designed with a cracking pressure of 16 bar [232 psi].

Valves are available with several orifice sizes to meet the flushing flow requirements of all system operating conditions.

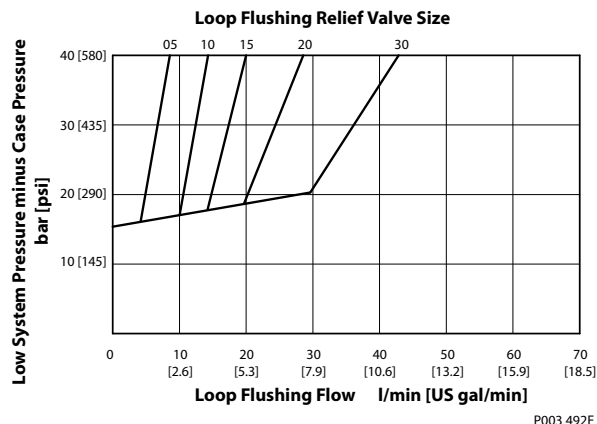


P003 491



P003 487

Operation



Speed sensor

Two optional speed sensors are available. The speed sensor is designed for rugged outdoor, mobile or heavy industrial speed sensing applications. The detection of the speed is contactless and does not need any calibration or adjustments.

	Order number	
	149055	11102032
Supply voltage	4.5 – 8 V <sub>DC</sub>	7 – 32 V
Speed signals	two, 90° phase shift	one
Direction signal	one	–
Temperature signal	one	–

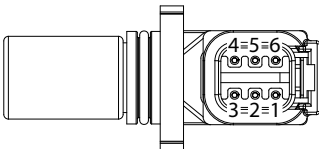
Temperature ratings

Parameter	Min	Max	Note
Operating Temperature-Range	-40°C	104°C	115°C Intermittent = Short term t < 1min per incident and not exceeding 2 % of duty cycle based load-life

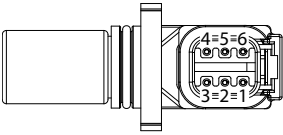
Protection characteristics

Parameter		Note
Protection code IP-Class	IP67 and IP69k according IEC 60529 & DIN 40050	<ul style="list-style-type: none"> <li>• IP67 w/o connector installed</li> <li>• IP69k with connector installed</li> </ul>
EMC-Emission	EN 61000-6-3	
EMC- Immunity (EMI)	100 V/m incl. 1 kHz AM 80 %, ISO 11452-5 and ISO 11452-2	
ESD: Air discharge Contact discharge	EN 61000-4-2: 15 kV 8 kV	
Vibration	30 G (294 m/s <sup>2</sup> )	
Shock	50 G (490 m/s <sup>2</sup> )	
Case pressure	5 bar maximum	

**Operation**
*Technical data*

		Min.	Max.	Note														
Supply voltage range		4.5 V <sub>DC</sub>	8 V <sub>DC</sub>															
Supply protection		-	30 V <sub>DC</sub>	30 V over voltage protection. Shuts off above 9 V.														
Max. required supply current		-	25 mA															
Max. output current		-	50 mA															
Operation mode		<b>NPN &amp; PNP</b>		Push-Pull amplifier														
Output signal range	Low & clockwise	5%	12%															
	High & counterclockwise	88%	95%															
Temperature signal		-40°C = 2.203V	104°C = 0.734V	$V_o = 1.795V - [0.0102 \cdot T]$														
Detectable frequency range		1 Hz	10 000 Hz															
Speed and temperature sensor		Order number <b>149055</b>																
Connector terminals		 <table border="1" data-bbox="1107 863 1249 1002"> <thead> <tr> <th colspan="2">Sensor pinout</th> </tr> </thead> <tbody> <tr><td>1</td><td>Speed signal 2</td></tr> <tr><td>2</td><td>Direction signal</td></tr> <tr><td>3</td><td>Speed signal 1</td></tr> <tr><td>4</td><td>Supply</td></tr> <tr><td>5</td><td>Ground</td></tr> <tr><td>6</td><td>Temperature</td></tr> </tbody> </table>			Sensor pinout		1	Speed signal 2	2	Direction signal	3	Speed signal 1	4	Supply	5	Ground	6	Temperature
Sensor pinout																		
1	Speed signal 2																	
2	Direction signal																	
3	Speed signal 1																	
4	Supply																	
5	Ground																	
6	Temperature																	
Color of connector		Black																

*Technical data*

		Min.	Max.	Note														
Supply voltage range		7 V <sub>DC</sub>	32 V <sub>DC</sub>															
Supply protection		-	36 V <sub>DC</sub>	36 V over voltage protection and -36 V permanent reverse polarity protection														
Max. required supply current		-	30 mA															
Max. output current		-	50 mA															
Operation mode		<b>NPN open collector</b>		With internal 2k7 pull-up resistor to supply														
Output signal range	Low	2%	10%															
	High	55%	85%	Max. output voltage 24V														
Detectable frequency range		1 Hz	10.000 Hz															
Speed and temperature sensor		Order number <b>11102032</b>																
Connector terminals		 <table border="1" data-bbox="1062 1664 1189 1783"> <thead> <tr> <th colspan="2">Sensor pinout</th> </tr> </thead> <tbody> <tr><td>1</td><td>NC</td></tr> <tr><td>2</td><td>NC</td></tr> <tr><td>3</td><td>Speed signal 1</td></tr> <tr><td>4</td><td>Supply</td></tr> <tr><td>5</td><td>Ground</td></tr> <tr><td>6</td><td>NC</td></tr> </tbody> </table> <p style="text-align: right; margin-right: 20px;">P301 5</p>			Sensor pinout		1	NC	2	NC	3	Speed signal 1	4	Supply	5	Ground	6	NC
Sensor pinout																		
1	NC																	
2	NC																	
3	Speed signal 1																	
4	Supply																	
5	Ground																	
6	NC																	
Color of connector		White (natural plastic color)																

Operation

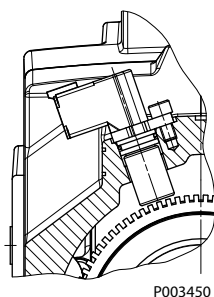
*Mating connectors*

Material Number	Name	Note
11033865	Assembly Bag, DEUTSCH, DTM06 6-SOCKET Black	(20-24 AWG) / 0.2 – 0.5 mm <sup>2</sup>
11033863	Assembly Bag, DEUTSCH, DTM06 6-SOCKET Grey	

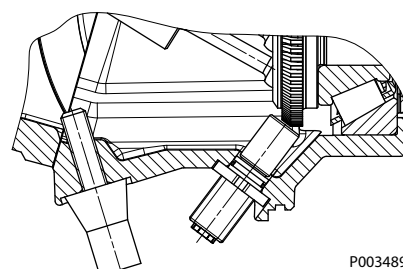
For more information, see *Speed and Temperature Sensor, Technical Information* [11046759](#).

**Sensor position**

*SAE and DIN housing*



*Cartridge housing*



**Target ring**

Target ring size	H1B 060	H1B 080	H1B 110	H1B 160	H1B 210	H1B 250
Number of teeth	71	78	86	95	104	108

**Displacement limiter**

All Series H1 motors incorporate mechanical displacement limiters.

The **minimum displacement** of the motor is preset at the factory with a set screw in the motor housing. A tamper-proof cap is provided.

## Operating parameters

### Output speed

**Start and low speed stability.** The motor produces maximum starting torque at maximum displacement. Stable operation can be achieved at 15–34 rpm,  $\pm 5\%$ , depending on system pressure, in applications that require low speed stability. Motor output speed becomes more stable as speed increases.

**Rated speed** is the highest output speed recommended at full power condition. Operating at, or below this speed will yield satisfactory product life.

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

Operation between rated and maximum speed is reserved for **intermittent operation** (see [H1B speed range diagrams for open and closed circuit](#) on page 15) not to exceed 5 minute durations. Speed above rated are anticipated to occur during downhill braking (negative power). Contact factory for any operation above Rated speed when negative power is not involved.

---

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**

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##### **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.

**Maximum pressure** is the highest allowable application pressure under any circumstance. For applications which are above the maximum working pressure, please contact Danfoss

**Minimum pressure** must be maintained under all operating conditions to avoid cavitation.

---

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

---

**Summing pressure** is the sum of both the low and high loop pressures. Summing pressure above 30 bar [435 psi] guarantees reliable use within the rated speed.

**Servo pressure** is the pressure in the servo system and is supplied from the high side of the loop to keep the motor at the required displacement.

## Operating parameters

### 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**

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**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 pressures are referenced to case pressure.

---

### External shaft seal pressure

In certain applications, the output shaft seal may be exposed to external pressures. The shaft seal is designed to withstand an external pressure up to 0.25 bar [3.6 psi] above the case pressure. The case pressure limits must also be followed to ensure the shaft seal is not damaged.

### 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 published **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 too keep the fluid within these limits. Danfoss recommends testing to verify that these temperature limits are not exceeded.

## Fluid and filter maintenance

### Fluid and filter recommendations

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

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

Inspect vehicle for leaks daily.

Change the fluid and filter per the vehicle/machine manufacturer's recommendations or at these intervals. We recommend first fluid change occur at 500 hours of operation. Change the fluid more frequently if it becomes contaminated with foreign matter (dirt, water, grease, etc) or if the fluid is subjected to temperature levels greater than the recommended maximum.

#### *Fluid and filter change interval*

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

#### **Caution**

---

High temperatures and pressures accelerate fluid aging. This may require more frequent fluid changes.

---

Change filters when changing fluid or when the filter indicator directs. Replace all fluid lost during filter change

#### **Warning**

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Hydraulic fluid contains hazardous material. Avoid contact with hydraulic fluid. Always dispose of used hydraulic fluid according to state, and federal environmental regulations. Never reuse hydraulic fluid.

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**Pressure measurements**
**Port locations and gauge installation**

The following table and drawing show the port locations and gauge sizes needed.

*Port Information*

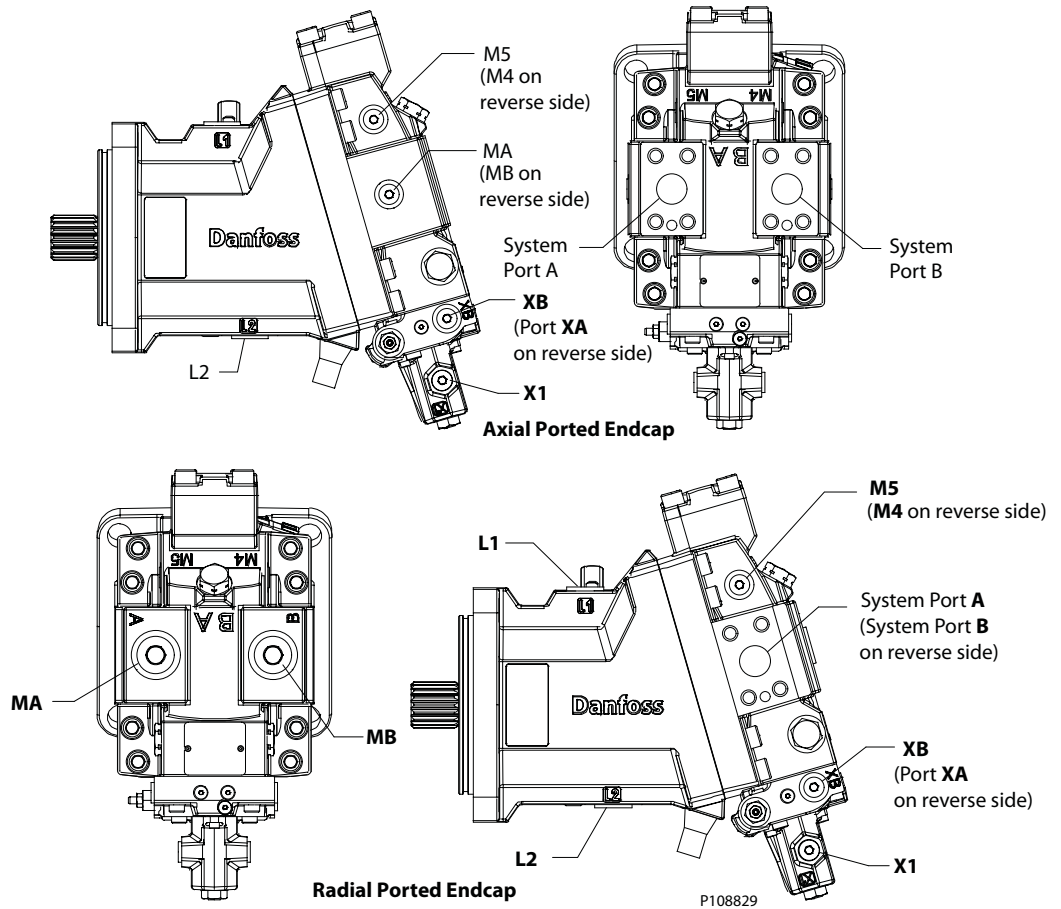
Port identifier	060		080		110/160		210/250		Pressure obtained	Gauge size, bar [psi]
	Port size	Wrench size int. hex	Port size	Wrench size int. hex	Port size	Wrench size int. hex	Port size	Wrench size int. hex		
L1, L2	7/8-14 UNF	3/8	7/8-14 UNF	3/8 in.	1 1/16-12UN	9/16 in.	1 5/16-12UN	5/8 in.	Case drain	10 [100]
MA, MB (Radial endcap)	7/8-14 UNF	3/8	1 1/16-12UN	9/16 in.	1 1/16-12UN	9/16 in.	1 1/16-12UN	9/16 in.	System pressure	600 [10,000]
MA, MB (Axial endcap)	9/16-18 UNF	1/4	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	System pressure	600 [10,000]
M4	9/16-18 UNF	1/4	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	Servo pressure rod end	600 [10,000]
M5	9/16-18 UNF	1/4	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	Servo pressure piston end	600 [10,000]
X1	9/16-18 UNF	1/4	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	Control pressure supply, hydraulic actuator	100 [1500]
XA	9/16-18 UNF	1/4	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	BPD, PCOR inactive at A	100 [1500]
XB	9/16-18 UNF	1/4	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	9/16-18 UNF	1/4 in.	BPD, PCOR inactive at B	100 [1500]

*System Ports*

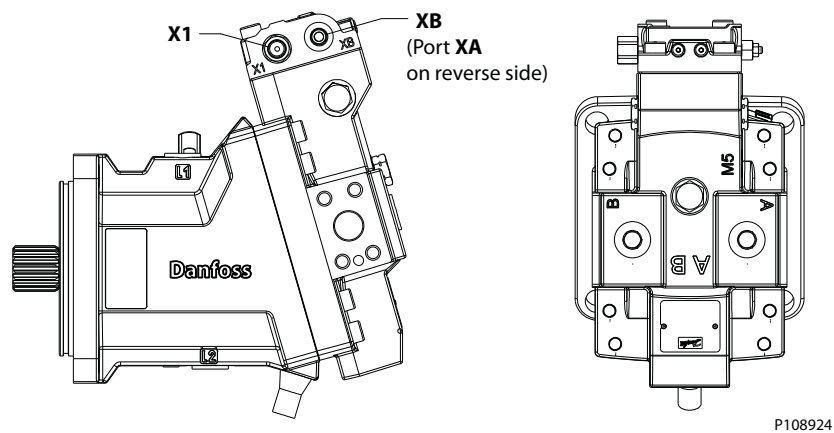
Port identifier	060	080, 110	160/210/250
	Split flange boss, thread M10 x 1.5	Split flange boss, thread M12 x 1.75	Split flange boss, thread M12 x 1.75
A	3/4 inch code 62 per ISO 6162 Type 1, min. thread 18mm [0.71 in]	1 inch code 62 per ISO 6162 Type 1, min. thread 23mm [0.91 in]	1 1/4 inch code 62 per ISO 6162 Type 1, min. thread 23mm [0.91 in]
B	3/4 inch code 62 per ISO 6162 Type 1, min. thread 18mm [0.71 in]	1 inch code 62 per ISO 6162 Type 1, min. thread 23mm [0.91 in]	1 1/4 inch code 62 per ISO 6162 Type 1, min. thread 23mm [0.91 in]

Pressure measurements

Port locations proportional control



Port locations hydraulic 2-position controls with PCOR (control specific ports only)



## Initial startup procedures

## Procedure

**⚠ Warning**

This service procedure may require disabling the vehicle / machine (raising the wheels off the ground, disconnecting work function) while performing, to prevent injury to the technician and bystanders. Take the necessary safety precautions.

---

Always follow this procedure when starting-up a new H1 installation or when the motor has been removed.

---

1. Before installing the motor, inspect the units for possible damage incurred during shipping and handling.
2. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, and so forth) are clean before filling with fluid.
3. Fill the reservoir with recommended hydraulic fluid. Pass this fluid through a 10 micron (nominal, no bypass) filter before it enters the reservoir.
4. Fill the inlet line leading from the reservoir to the pump.
5. Check inlet line for properly tightened fittings. Make sure the inlet line is free of restrictions and air leaks.
6. Fill the motor and pump housings with clean hydraulic fluid before start up. Fill by pouring filtered oil into the upper case drain port.

**⚠ Caution**

Never start the prime mover unless the motor and pump housings are filled completely with clean hydraulic fluid.

---

7. For closed loop systems, install a 0-60 bar [0-1000 psi] pressure gauge in the charge pressure gauge port of the pump to monitor the charge pressure during start-up.
- 

For open circuit systems, use gauges in system ports.

---

8. Disconnect any external control input signal from the pump control until after initial start-up. This ensures that the pump remains in its neutral position.
9. Jog (slowly rotate) prime mover until charge pressure starts to rise.
10. Start the prime mover and run at the lowest possible speed until charge pressure builds.

**⚠ Warning**

Do not start the prime mover unless the pump is in neutral position (swash plate at 0° angle). Take necessary precautions to prevent machine movement in case pump is actuated (in stroke) during initial start-up.

---

If necessary, bleed excess air from the high pressure lines through the high pressure system gauge ports.

---

11. Once charge pressure is established, increase to normal operating speed. Charge pressure should be as indicated in the pump model code. If charge pressure is low, shut down and determine cause.

**⚠ Caution**

Low charge pressure may affect ability to control the machine.

---

12. Shut down the prime mover.
13. Connect the external control input signal.

**Initial startup procedures**

- 14.** Reconnect the machine function if disconnected earlier.
- 15.** Start the prime mover, checking to ensure the pump remains in neutral.
- 16.** Check for forward and reverse machine operation, with the prime mover at normal operating speed.

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[Charge pressure may decrease slightly during forward or reverse operation.](#)

---

- 17.** Continue to cycle slowly between forward and reverse for at least five minutes.
  - 18.** Shut down prime mover.
  - 19.** Remove gauges. Replace plugs at the gauge ports.
  - 20.** Check reservoir level. Add filtered fluid if needed.
- The motor/transmission is now ready for operation.

## Troubleshooting

### Overview

This section provides general steps to follow if you observe undesirable system conditions. Follow the steps until you solve the problem. Some of the items are system specific. Always observe the safety precautions in the [Introduction](#) section.

**⚠ 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.

### Electrical troubleshooting

Item	Description	Action
Motor operates at one displacement only.	Control coil failure	Measure resistance at coil pins. Proportional controls: Resistance should be 14.20 Ohms (24V) or 3.66 Ohms (12V) at 20°C [70°F]. Two-position controls: Resistance should be 8.4 Ohms (24V) or 34.5 Ohms (12V) at 20°C [70°F]. Replace coil if necessary.
Erratic motor function	Electrical connection to motor is intermittent.	Disconnect connector, check wires and terminals, reconnect wires. Check terminals for corrosion and correct position.

### Sluggish operation

Check	Cause	Corrective action
1. Control orifices	Blocked or restricted orifice may cause sluggish response. Orifices installed in the wrong locations may cause PCOR control to be sluggish.	Remove, inspect and clean all orifices. Ensure the appropriate orifices are installed and in the correct location.
2. Threshold setting (proportional controls)	Inappropriately high or low threshold setting may shift the motor at the wrong time.	Check threshold setting. Adjust if necessary.
3. Control spool	A sticky control may cause sluggish response or no response.	Clean and inspect the control spool. Replace if necessary.
4. Pressure compensator setting	Low pressure compensator setting may shift motor to maximum displacement at lower pressure.	Check pressure compensator setting. Adjust if necessary.
5. Control input signal	An improper or erratic input signal to the control may cause sluggish response.	Check input signal and correct if necessary.
6. Internal leakage	Excessive leakage will cause lower charge pressure and affect performance.	Install loop flushing defeat option and measure case flow. If case flow is excessive, motor may require major repair. Contact your Danfoss authorized service center.

### System operating hot

Check	Cause	Corrective action
1. Oil level	Insufficient hydraulic fluid may cause overheating.	Fill reservoir to proper level.
2. Heat exchanger	Blocked heat exchanger or low air flow may cause system overheating.	Check temperature upstream and downstream of heat exchanger. Clean, repair, or replace heat exchanger if necessary.
3. Loop flushing flow	Restricted orifice in loop flushing cartridge reduces flow.	Measure case drain flow. Clean or replace orifice cartridge.

**Troubleshooting**

Check		Cause	Corrective action
4.	Loop flushing shuttle	Loop flushing shuttle may be sticking in one direction.	Ensure shuttle moves freely in its bore.
5.	Air in system	Entrained air generates heat under pressure	Look for foam or bubbles in reservoir. Check for leaks on inlet side of charge pump.
6.	Internal leakage	Excessive internal leakage may overheat the system.	Install loop flushing defeat option and monitor case flow. If case flow is excessive, motor may require major repair. Contact your Danfoss authorized service center.

**Excessive noise or vibration**

Check		Cause	Corrective action
1.	Oil level in reservoir	Insufficient hydraulic fluid may cause cavitation.	Fill reservoir to proper level.
2.	Air in system	Air bubbles may lead to cavitation.	Look for foam or bubbles in reservoir. Check for leaks on inlet side of charge pump.
3.	Shaft coupling	Loose shaft coupling may create excess noise.	Replace loose shaft coupling. Replace or repair motor if shaft splines show excessive wear.
4.	Shaft alignment	Misaligned shafts may create excessive noise and vibration and can damage motor.	Correct shaft misalignment.

**Motor operates normally in one direction only**

Check		Cause	Corrective action
1.	Charge pressure	If charge pressure is low in one direction, the loop flushing shuttle spool may be sticking to one side.	Measure charge pressure in forward and reverse. If pressure drops significantly lower in one direction, inspect and repair loop flushing shuttle spool.
2.	Pressure compensator control	If pressure compensator operates in one direction only, the motor may stay at minimum displacement in the opposite direction.	Check brake pressure defeat spool. It may be sticking or receiving an improper signal. Repair spool or correct input signal.

**Improper output speed**

Check		Cause	Corrective action
1.	Oil level in reservoir	Insufficient hydraulic fluid may reduce system efficiency.	Fill reservoir to proper level.
2.	Threshold setting	Improper threshold setting may cause motor to have wrong displacement for given signal.	Check threshold setting. Refer to Control Service Manual for adjustment procedure.
3.	Pressure compensator setting	Improper pressure compensator setting may shift motor displacement at wrong pressure.	Check pressure compensator setting. Adjust if necessary. Refer to Control Service Manual for adjustment procedure.
4.	PC spool	Pressure compensator spool sticking may shift motor to improper displacement.	Check pressure compensator spool. Repair or replace if needed. Refer to Control Service Manual for adjustment procedure.
5.	Control orifices	Blocked or restricted orifice may cause motor to shift improperly.	Remove, inspect and clean all orifices.
6.	Control spool	Sticky proportional control spool may cause motor to shift improperly.	Check control spool for proper operation. Repair if necessary. Refer to control adjustment procedure.

**Troubleshooting**

Check		Cause	Corrective action
7.	Control input signal	Improper input signal may cause motor to shift improperly.	Correct control input signal.
8.	Internal leakage	Excess internal leakage may cause lower charge pressure and affect motor performance including output speed.	Install loop flushing defeat option and measure case flow. If case flow is excessive, motor may require major repair. Contact your Danfoss authorized service center.

**Low output torque**

Check		Cause	Corrective action
1.	Pressure compensator setting	High pressure compensator setting may cause improper motor displacement for torque required.	Check and adjust pressure compensator setting.
2.	Control orifices	Blocked or restricted orifice may cause motor to shift improperly.	Remove, inspect and clean all orifices.
3.	Pressure compensator spool	Sticking pressure compensator spool may cause control to hold motor at minimum displacement.	Remove and inspect pressure compensating spool. Repair or replace control if necessary.
4.	Control spool	Sticking control spool may cause motor to shift improperly.	Remove and inspect control spool. Repair or replace control if necessary.
5.	Two position solenoid	Two position control not shifting motor to maximum displacement.	Inspect solenoid valve for bent stem or damaged coil. Repair or replace if necessary.
6.	Control input signal	Improper control input signal may cause motor to stay at minimum displacement.	Correct control input signal.
7.	Threshold setting (proportional control)	Improper threshold setting may cause improper motor displacement for torque required.	Check and adjust threshold setting.
8.	Internal leakage	Excess internal leakage may cause charge pressure to decay, reducing output torque.	Install loop flushing defeat option and monitor case flow. If case flow is excessive, motor may require major repair. Contact your Danfoss authorized service center.

## Required tools and standard procedures

### Required tools

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

### Standard procedures

 **Caution**

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Contamination can damage internal components and void the manufacturer's 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 all dirt and grime from the outside of the motor. Ensure the surrounding areas are clean and free of contaminants such as dirt and grime.
2. If removing the motor, tag each hydraulic line connected to the motor. If you disconnect hydraulic lines, plug each open port to keep dirt and contamination out of the motor.
3. Inspect the system for contamination. Look at the hydraulic fluid for signs of system contamination, such as oil discoloration, foam in the oil, sludge, or small metal particles.
4. Remove the motor as a single unit.

 **Caution**

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Be careful not to damage solenoids and electrical connections when using straps or chains to remove motor from machine.

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5. Perform motor function test.
6. Before re-installing the motor on the machine, drain the system, flush all lines, replace all filters, and fill with new hydraulic fluid.

Adjustments

Minimum displacement limiter

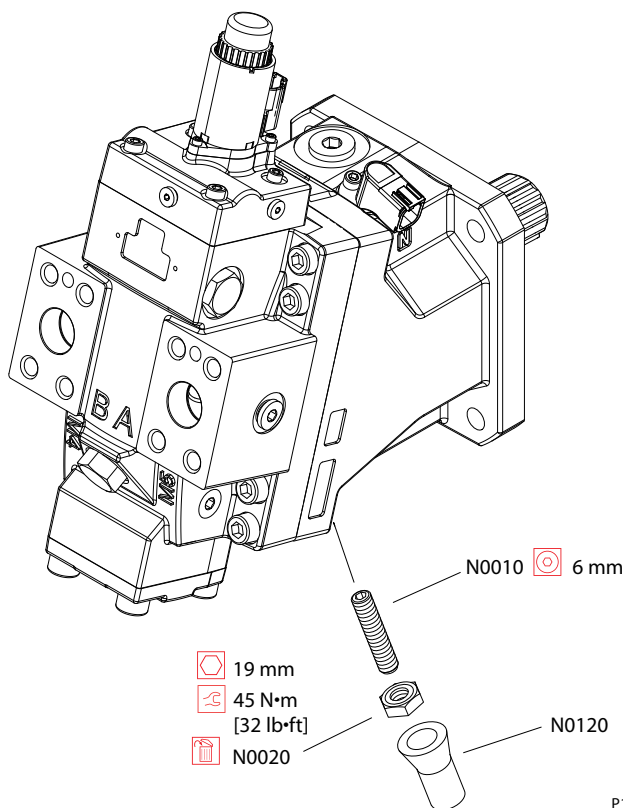
**Adjusting the minimum displacement limiter**

1. Remove cap (N0120).

Removing the cap destroys the caps locking mechanism. Replace with a new cap.

2. Using a 6 mm internal hex wrench, hold adjusting screw (N0010) in place.
3. Using a 19 mm hex wrench, loosen seal locknut (N0020).
4. Turn adjusting screw clockwise to increase minimum displacement or counterclockwise to decrease minimum displacement. Minimum displacement is inversely related to maximum shaft speed. To increase maximum speed, decrease minimum displacement. Adjusting displacement limits also affects output torque. Refer to table for displacement change per turn.
5. When properly adjusted, hold adjusting screw in place and torque seal locknut to 45 N•m [32 lbf•ft].
6. With motor on machine or test stand, verify correct motor function. Refer to [Port locations and gauge installation](#) on page 29 for location of gauge ports and suggested gauge sizes.
7. Install new cap (N0120).

Minimum displacement limiter



P106 547E

Displacement change per turn

Model	Displacement change
250	5.5 cm <sup>3</sup> [0.34 in <sup>3</sup> ]
210	5.1 cm <sup>3</sup> [0.31 in <sup>3</sup> ]
160	4.1 cm <sup>3</sup> [0.25 in <sup>3</sup> ]
110	3.2 cm <sup>3</sup> [0.20 in <sup>3</sup> ]

Adjustments

Displacement change per turn (continued)

Model	Displacement change
080	2.6 cm <sup>3</sup> [0.16 in <sup>3</sup> ]
060	2.1 cm <sup>3</sup> [0.13 in <sup>3</sup> ]

Optional threshold adjustment - electric proportional controls

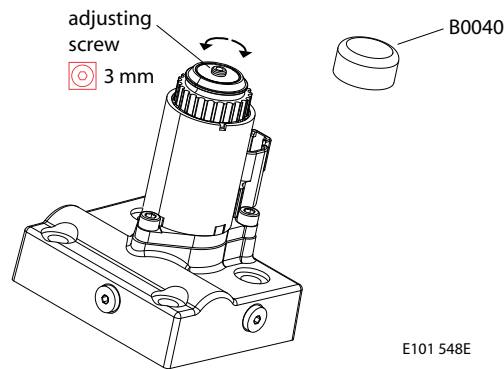
Adjusting threshold on test stand

1. Connect flow meter to A or B system port. Refer to *Port locations and gauge installation* on page 29 for port locations.
2. Connect solenoid to PWM signal generator at 100 Hz.

Threshold is the electric signal when the motor starts to change from maximum to minimum displacement.

3. Run prime mover at operating speed.

Threshold adjustment



E101 548E

4. Adjust PWM signal to current listed in model code. Note flow reading.
5. If adjustment is necessary, remove cap (B0040). Using a 3mm internal hex wrench, turn adjusting screw clockwise or counterclockwise until flow starts to change from maximum. Test your adjustment by lowering the current, then increasing the current until the displacement starts to change. Readjust the setting if necessary.
6. When threshold is adjusted correctly, stop prime mover, install cap (B0040), and install motor on vehicle. Run vehicle and test for proper motor operation.

Adjusting threshold on a machine or test stand without flow meter

1. Install 600 bar [10,000 psi] gauges to ports M5 and M4. Connect solenoid to PWM signal.
2. Raise wheels off ground, or disconnect the work function.

**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.

3. Run prime mover at operating speed. Stroke the pump to get some rotation of motor shaft.
4. Increase signal current until M4 pressure becomes 1/2 of the M5 pressure. Check the signal current at this point.
5. If adjustment is necessary, remove cap (B0040). Turn the adjusting screw until the signal current matches the model code setting.

Adjustments

6. When threshold is adjusted correctly, stop prime mover, install cap. Run vehicle and test for proper motor operation.
7. Remove from test stand.

Optional threshold adjustment - hydraulic proportional controls

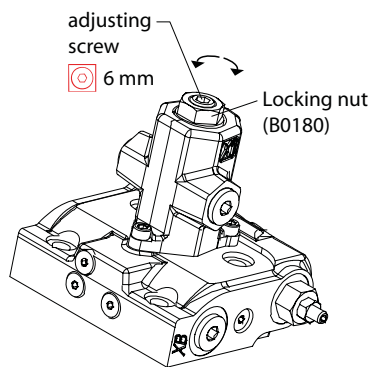
Adjusting threshold on test stand

1. Connect flow meter to A or B system port. Refer to [Port locations and gauge installation](#) on page 29 for port locations.
2. Connect a variable pressure supply to X1 port (0-50 bar).

Threshold is the pressure at which the motor starts to change from maximum to minimum displacement.

3. Run prime mover at operating speed.

Threshold adjustment



4. Adjust control pressure to pressure listed in model code. Note flow reading.
5. If adjustment is necessary, remove nut (B0180). Using a 6mm internal hex wrench, turn adjusting screw clockwise or counterclockwise until flow starts to change from maximum. Test your adjustment by lowering the pressure, then increasing the pressure until the displacement starts to change. Readjust the setting if necessary.
6. When threshold is adjusted correctly, stop prime mover, install nut (B0180), and install motor on vehicle. Run vehicle and test for proper motor operation.

Adjusting threshold on a machine or test stand without flow meter

1. Install 600 bar [10,000 psi] gauges to ports M5 and M4. Connect a variable pressure supply to X1 port (0-50 bar).
2. Raise wheels off ground, or disconnect the work function.

**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.

3. Run prime mover at operating speed. Stroke the pump to get some rotation of motor shaft.
4. Increase X1 pressure until M4 pressure becomes 1/2 of the M5 pressure. Check the X1 pressure at this point.

## Adjustments

5. If adjustment is necessary, remove nut (B0180). Turn the adjusting screw until the X1 pressure matches the model code setting.
6. When threshold is adjusted correctly, stop prime mover, install nut (B0180). Run vehicle and test for proper motor operation.
7. Remove from test stand.

## Pressure compensator OVERRIDE (PCOR) adjustment

### **Warning**

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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.

---

### PCOR adjustment for all except P1/P2

#### *Setup*

1. Install motor in machine.
2. Install 600 bar pressure gauge at system port MA or MB (whichever side is regulated by the PCOR). Optionally, the gauge can be installed in the system gauge port M5.
3. Install sensor to read engine speed.
4. Install sensor to read wheel speed.
5. Install data acquisition device which is able to record data over time using the sensors installed in steps 2 – 4 above.
6. Deactivate any inching systems connected to the brakes if applicable.
7. Prepare site for testing (two options are available).
  - a) Lift machine so wheels are no longer engaging the ground, or
  - b) Use a straight, flat surface to drive machine during testing.

#### *Testing*

1. Start machine engine.
2. Set engine to high idle (rated speed) and maintain for the duration of the testing.
3. Turn the machine wheels at a constant speed (motor will be at minimum displacement).
  - a) Allow wheels to turn at constant speed if using setup 7a.
  - b) Drive machine at constant speed if using setup 7b.
4. Begin data acquisition (system pressure, engine speed, and wheel speed).
5. Slowly apply the service brake to continuously increase the load on the system until the wheel speed (setup 7a) or driving speed (setup 7b) decreases by approximately 1/3.
6. Stop machine and turn off engine.
7. Stop data acquisition.

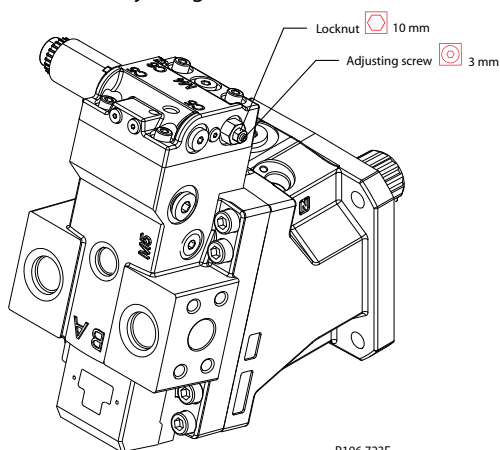
Adjustments

**Analysis**

1. Using appropriate software for the data acquisition device, plot the system pressure, wheel speed and engine speed versus time.
2. As the system pressure increases (from applying the brakes), the engine speed and wheel speed will start decreasing.
3. When the system pressure stops rising and remains constant, that pressure will be the PCOR setting. The engine speed should remain constant during this period while the wheel speed continues to decrease. See Graph below.

**Adjustment**

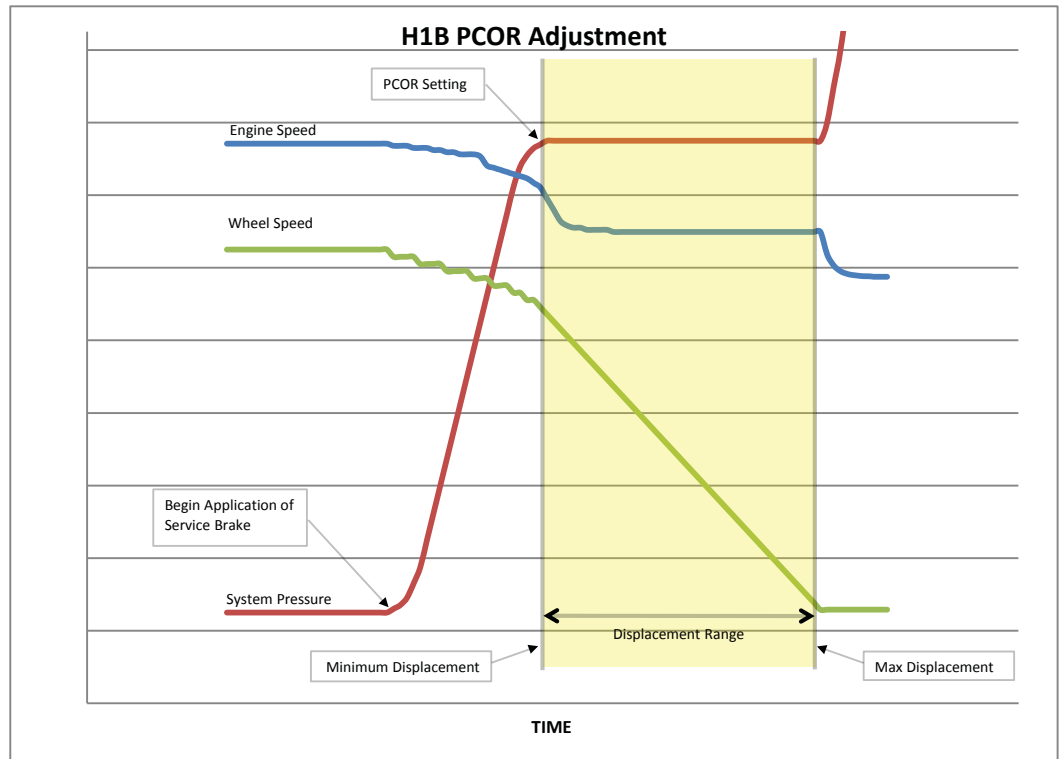
1. If adjustment is required, use a 3mm internal hex to hold the PCOR adjusting screw in place and use a 10mm wrench to loosen the PCOR lock nut. One full turn of the adjusting screw changes the PCOR setting by approximately 90 Bar.
  - a) Turn adjusting screw clockwise to increase the PCOR setting.
  - b) Turn adjusting screw counterclockwise to decrease the PCOR setting.



2. Use a 3mm internal hex to hold the PCOR adjusting screw in place and use a 10mm wrench to tighten the lock nut to 8 N-m [6 lbf-ft].

Adjustments

3. Repeat Testing, Analysis, and Adjustment steps as necessary to reach the desired PCOR setting.



**Brake pressure defeat option**

No adjustment is available for the brake pressure defeat option. Coil is either energized or de-energized, if coil is used.

**PCOR adjustment for P1/P2 controls**

PCOR setting is electrically adjusted using a proportional solenoid.

Nominal settings 240 bar [3500 psi] at 800 mA (12 V), 400 mA (24 V) or per model code.

## Minor repair

## Shaft seal

**Removal**

1. Using snap ring pliers, remove retaining ring (G0030).
2. Use a slide-hammer style puller to remove seal (G0020). Be careful not to damage the shaft or seal bore when removing. Discard seal.

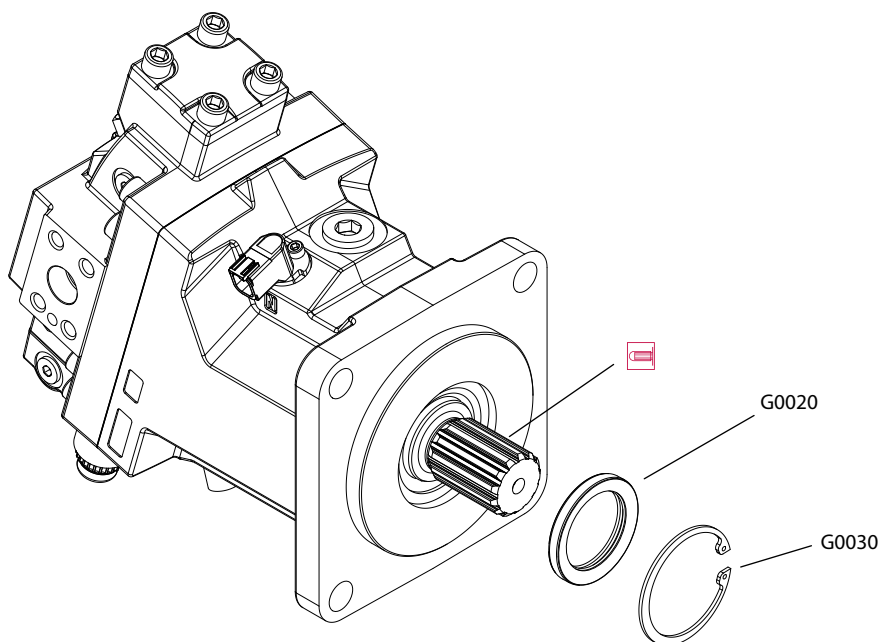
**Inspection**

Inspect retaining ring for wear or damage. Replace if necessary. Inspect shaft for wear or groove at seal area.

**Assembly**

1. Lubricate inside diameter of new seal. Cover the shaft splines with shaft cover or packing tape to avoid damaging the seal during installation.
2. Using seal installation tool, press seal into housing bore.
3. Using a snap ring pliers, install retaining ring (G0030).
4. Use seal installation tool to press seal and retaining ring into housing until retaining ring snaps into its groove.

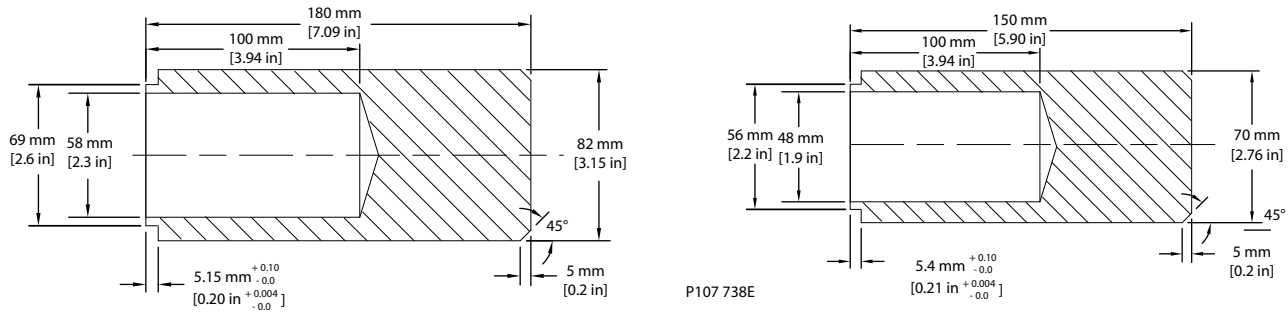
If not using seal installation tool: Do not press seal beyond snap-ring groove. Stop pressing just when you have room to install the retaining ring into the bore. Pressing the seal and snap-ring together ensures proper installation depth. Using the seal installation tool prevents pressing the seal too deeply.

*Shaft seal*

P106 548E

Minor repair

110/160/210/250 - Seal installation tool dimensions, 060/080 - Seal installation tool dimensions



Electric proportional solenoid replacement

Removal

1. Disconnect electrical connection and remove three cap screws (B0050) using a 4 mm internal hex wrench.
2. Remove the solenoid (B0010) and O-ring (B0035A). Discard the O-ring.
3. Remove valve spool (C0100).

Inspection

Clean and inspect valve spool and all machined surfaces for damage or wear. Replace parts if necessary.

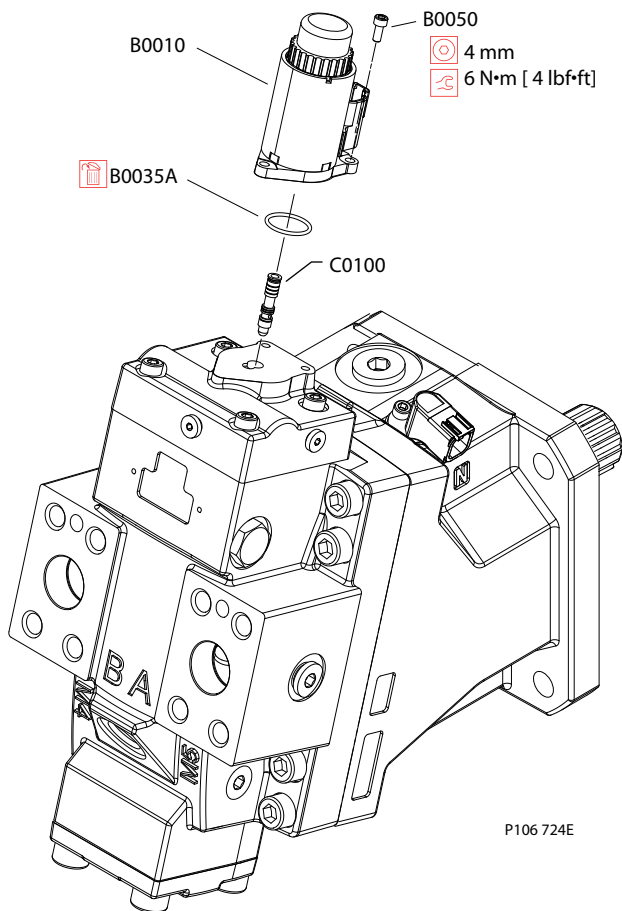
Assembly

1. Lubricate and install valve spool (C0100).
2. Using petroleum jelly, lubricate and install new O-ring (B0035A).
3. Install cap screws (B0050) using a 4 mm internal hex wrench. Torque screws to 6 N•m [4 lbf•ft].

Minor repair

4. Reconnect electrical connections and test the motor for proper operation.

*Replacing solenoid*



**Hydraulic proportional actuator replacement**

**Removal**

1. Remove three cap screws (B0050) using a 4 mm internal hex wrench.
2. Remove the actuator (B0010).

**Inspection**

Clean and inspect all machined surfaces for damage or wear. Replace parts if necessary.

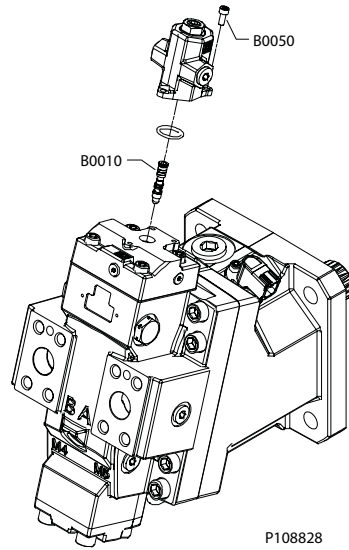
**Assembly**

1. Install cap screws (B0050) using a 4 mm internal hex wrench. Torque screws to 6 N·m [4 lbf·ft].

Minor repair

2. Test the motor for proper operation.

*Replacing actuator*



Control module replacement

**Removal**

1. Remove four cap screws (C0110 and/or C0120). Refer to table for wrench sizes.
2. Remove control (C0010) from motor. Remove and discard gasket (C0130).
3. Proportional control only - using a magnet, remove spring seat (F0030) and spring (F0040).

**Inspection**

Clean and inspect the machined surfaces on the control and the endcap. If you find any nicks or scratches, replace control or endcap. Inspect valve spool, washer, and spring. Replace if necessary.

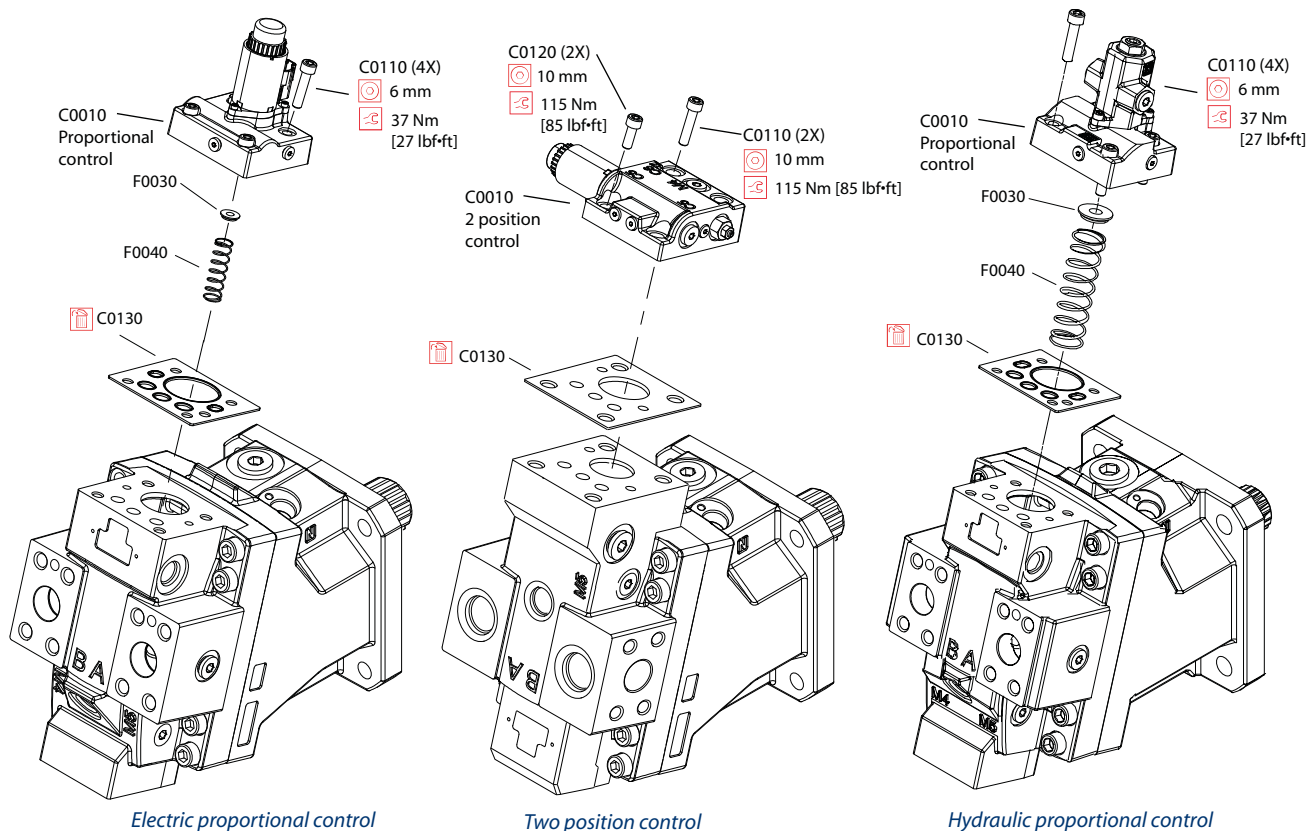
**Assembly**

1. Lubricate and install spring (F0040) and spring seat (F0030) into servo.
2. Install a new gasket (C0130). Position control on motor.

Minor repair

3. Install four cap screws (C0110 and/or C0120). Torque (C0110) to 37 N·m [27 lbf·ft] for proportional control. Torque (C0110) and (C0120) to 115 Nm [85 lbf·ft] for 2 position control.

Control module removal/installation



P106 520E

C0110 and C0120 Wrench Size

Control	Screw	Internal Hex Wrench
Electric and Hydraulic proportional	C0110	6 mm
Two-position	C0110 C0120	10 mm 10 mm

Electric proportional control module

Coil O-rings are not included in the overhaul seal kit. They may be purchased as a separate kit.

Disassembly

1. Remove the plastic cap (B0040) and O-ring (B0029). Discard the O-ring.
2. Remove the solenoid nut (B0027) using a 26mm 12-point socket. Remove and discard the O-ring (B0028).
3. Remove the coil (B0020A). Remove and discard the O-ring (B0025).
4. Use a 4 mm internal hex wrench to remove screws (B0050). Remove solenoid (B0010).
5. Remove and discard O-ring (B0035A).

**Minor repair**

6. Remove spool (C0100).
7. Using a 1/4 in internal hex wrench remove plug (C0050) and discard O-ring (C0050A).
8. Use a 5 mm internal hex to remove shuttle valve (C0025).
9. Using a 1/8 in internal hex wrench, remove 3 plugs (C0060) and discard O-rings (C0060A).
10. Using a 3 mm internal hex, remove 2 orifices (E00T3 and E00T2).

**Inspection**

Inspect the machined surfaces on the control and the endcap. If you find any nicks or scratches, replace the control or endcap assembly. Check that shuttle ball moves freely in housing (C0025).

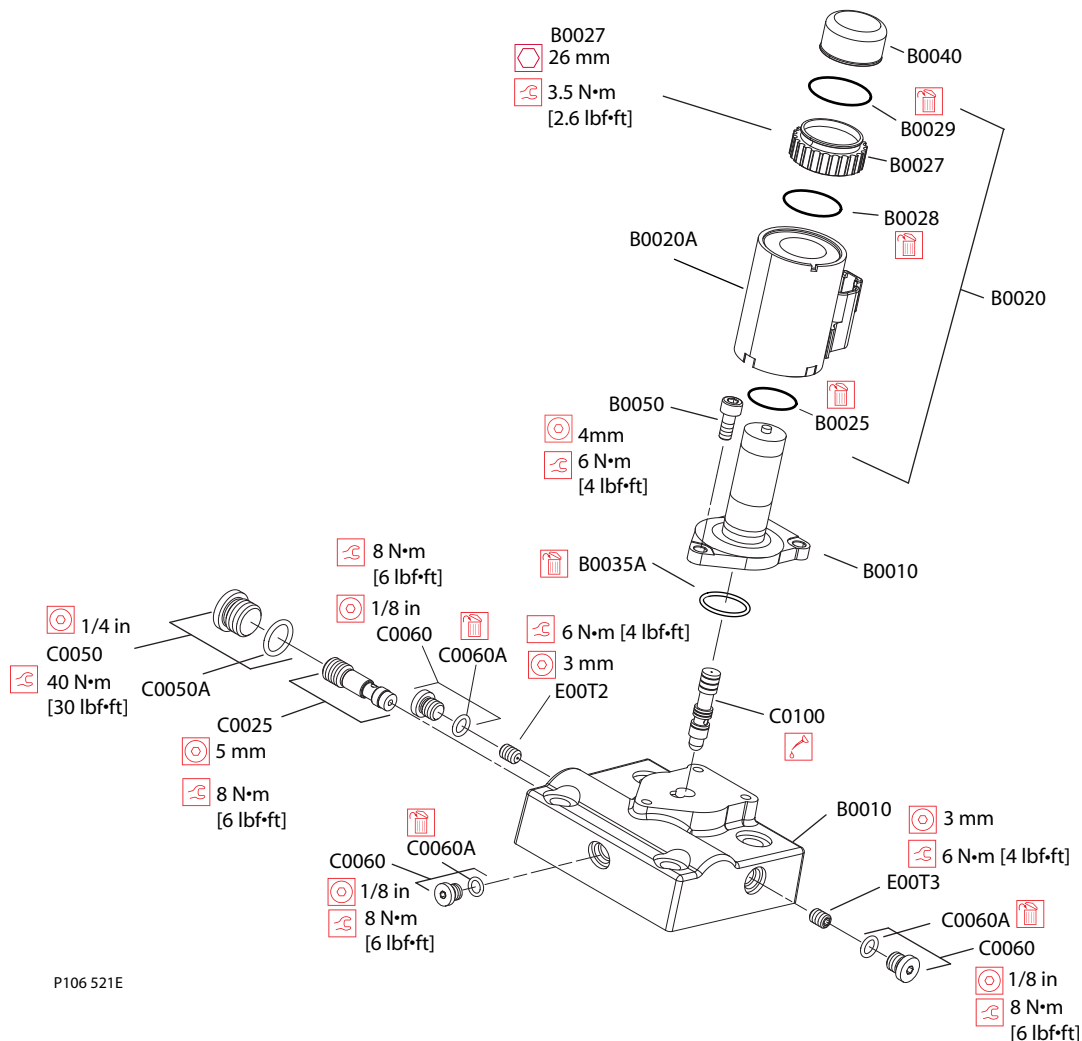
**Assembly**

1. Install orifices (E00T3 and E00T2). Torque to 6 N•m [4 lbf•ft].
2. Lubricate and install new O-rings (C0060A). Using a 1/8 inch internal hex wrench, install and torque plugs (C0060) to 8 N•m [6 lbf•ft].
3. Lubricate and install spool (C0025) into control block. Using a 5 mm internal hex wrench, torque to 14 N•m [11 lbf•ft]
4. Install new O-ring (C0050A). Using a 1/4 inch internal hex wrench, install and torque plug (C0050) to 40 N•m [30 lbf•ft].
5. Lubricate and install spool (C0100).
6. Lubricate and install new O-ring (B035A).
7. Install solenoid (B0010). Using a 4 mm internal hex wrench. Install screws (B0050). Torque to 6 N•m [4 lbf•ft].
8. Lubricate and install new O-ring (B0025) onto solenoid. Install coil (B0020A). Lubricate and install new O-ring (B0028) onto solenoid.
9. Install coil nut (B0027) and torque to 3.5 N•m [2.6 lbf•ft] using a 26mm 12-point socket. Do not overtorque.

Minor repair

10. Install new O-ring (B0029) and plastic cap (B0040) to solenoid.

Proportional control block assembly



P106 521E

Hydraulic proportional control module

Disassembly

1. Use a 4 mm internal hex wrench to remove screws (B0050). Remove actuator (B0010).
2. Remove and discard O-ring (B0035A).
3. Using a 1/4 in internal hex wrench remove plug (C0050) and discard O-ring (C0050A).
4. Use a 5 mm internal hex to remove shuttle valve (C0025).
5. Using a 1/8 in internal hex wrench, remove 3 plugs (C0060) and discard O-rings (C0060A).
6. Using a 3 mm internal hex, remove 2 orifices (E00T3 and E00T2).

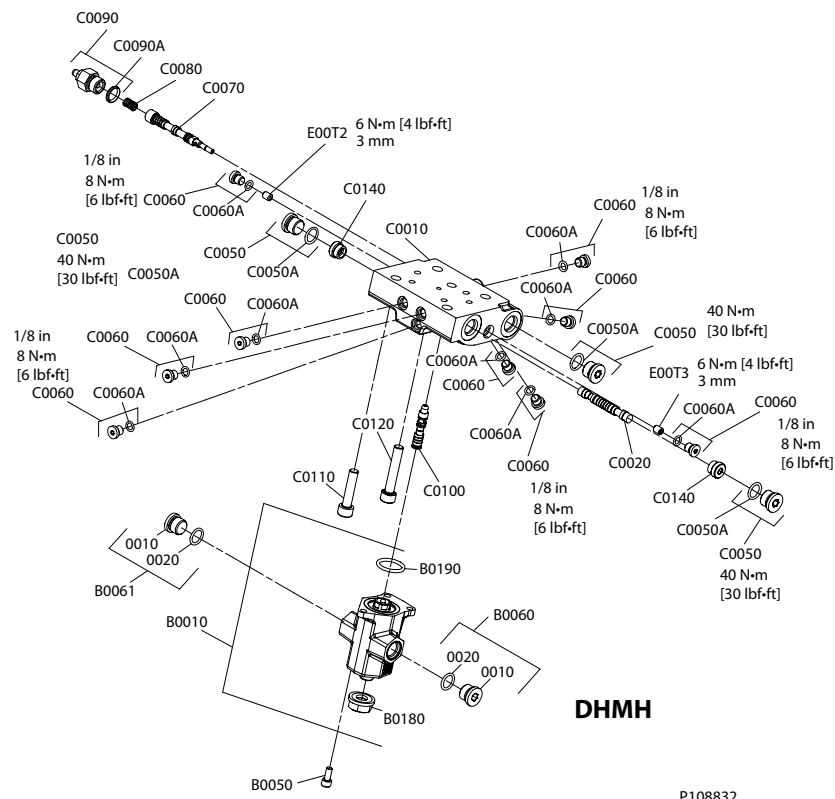
Inspection

Inspect the machined surfaces on the control and the endcap. If you find any nicks or scratches, replace the control or endcap assembly. Check that shuttle ball moves freely in housing (C0025).

Minor repair

**Assembly**

1. Install orifices (E00T3 and E00T2). Torque to 6 N·m [4 lbf·ft].
2. Lubricate and install new O-rings (C0060A). Using a 1/8 inch internal hex wrench, install and torque plugs (C0060) to 8 N·m [6 lbf·ft].
3. Lubricate and install spool (C0025) into control block. Using a 5 mm internal hex wrench, torque to 14 N·m [11 lbf·ft]
4. Install new O-ring (C0050A). Using a 1/4 inch internal hex wrench, install and torque plug (C0050) to 40 N·m [30 lbf·ft].
5. Install actuator (B0010). Using a 4 mm internal hex wrench. Install screws (B0050). Torque to 6 N·m [4 lbf·ft].



6. If replacing the hydraulic actuator, set the threshold pressure to the proper setting. Refer to [Adjusting threshold on test stand](#) on page 39

**Electric two-position control module**

Coil O-rings are not included in the overhaul seal kit. They are included with the purchase of a new coil.

**Disassembly**

1. Use a 26 mm 12-point socket to remove coil nuts (B0026) and O-ring (B0028).
2. Remove coils (B0022) and O-rings (B0024). Discard O-rings.
3. Using a 17 mm open-end wrench on the flats provided, remove solenoid assemblies (B0032).
4. Remove and discard O-rings (B0034).
5. Using a 1/8 inch internal hex wrench, remove four plugs (C0060). Remove and discard O-rings (C0060A).

**Minor repair**

6. Using a 1/4 inch internal hex wrench, remove two plugs (C0050). Remove and discard O-rings (C0050A).
7. Using a 17 mm hex wrench, remove pressure compensator adjusting plug (C0090). Remove and discard O-ring (M223).
8. Remove springs (C0030) and (C0080). Remove spools (C0020) and (C0070).
9. If necessary, use a 3 mm internal hex wrench to remove orifices (E00T2) and (E00T3).

**Inspection**

Clean and inspect the machined surfaces on the control and the endcap. If any nicks or scratches are found, replace the control/endcap assembly.

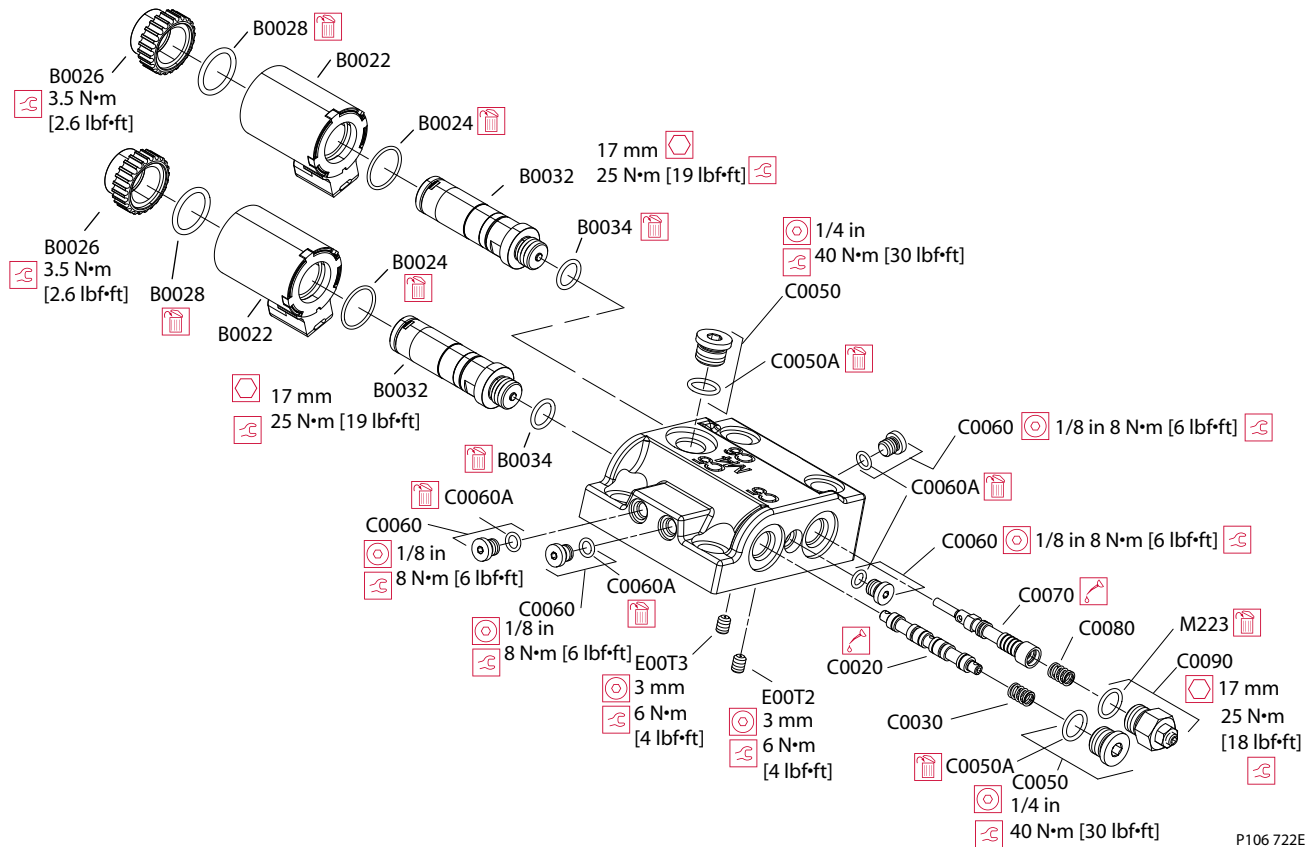
**Assembly**

1. If previously removed, install orifices (E00T3 and E00T2) using a 3mm internal hex wrench. Torque to 6 N•m [4 lbf•ft].
2. Lubricate and install spools (C0020) and (C0070) and springs (C0080) and (C0030).
3. Lubricate and install O-ring (M223). Install pressure compensator adjusting plug (C0090). Torque to 40 N•m [30 lbf•ft].
4. Lubricate and install two O-rings (C0050A). Using a 1/4 inch internal hex wrench, install plugs (C0050). Torque to 25 N•m [19 lbf•ft].
5. Lubricate and install four O-rings (C0060A). Using a 1/8 inch internal hex wrench, install plugs (C0060). Torque to 8 N•m [6 lbf•ft].
6. Lubricate and install O-rings (B0034).
7. Using a 17 mm open-end wrench on the flats provided, install solenoids (B0032). Torque to 25 N•m [19 lbf•ft].
8. Lubricate and install new O-rings (B0024) on solenoids.
9. Install coils (B0022). Lubricate and install new O-rings (B0028).

Minor repair

10. Using a 26 mm 12-point socket, install coil nuts (B0026). Torque to 3.5 N•m [2.6 lbf•ft]. Do not overtorque.

2 position control assembly



P106 722E

Hydraulic two-position control module

Disassembly

1. Using a 1/8 inch internal hex wrench, remove plug (C0160). Remove and discard O-ring (C0160A).
2. Using a 1/8 inch internal hex wrench, remove three plugs (C0060). Remove and discard O-rings (C0060A).
3. Using a 1/4 inch internal hex wrench, remove two plugs (C0050). Remove and discard O-rings (C0050A).
4. Use a 5mm internal hex wrench to remove the shuttle valve (C0025).
5. Using a 3/8 internal hex wrench, remove plug (C0140). Remove and discard O-ring (C0140A).
6. Remove spring (C0080). Remove spool (C0150).
7. If necessary, use a 3 mm internal hex wrench to remove orifices (E00T2) and (E00T3).

Inspection

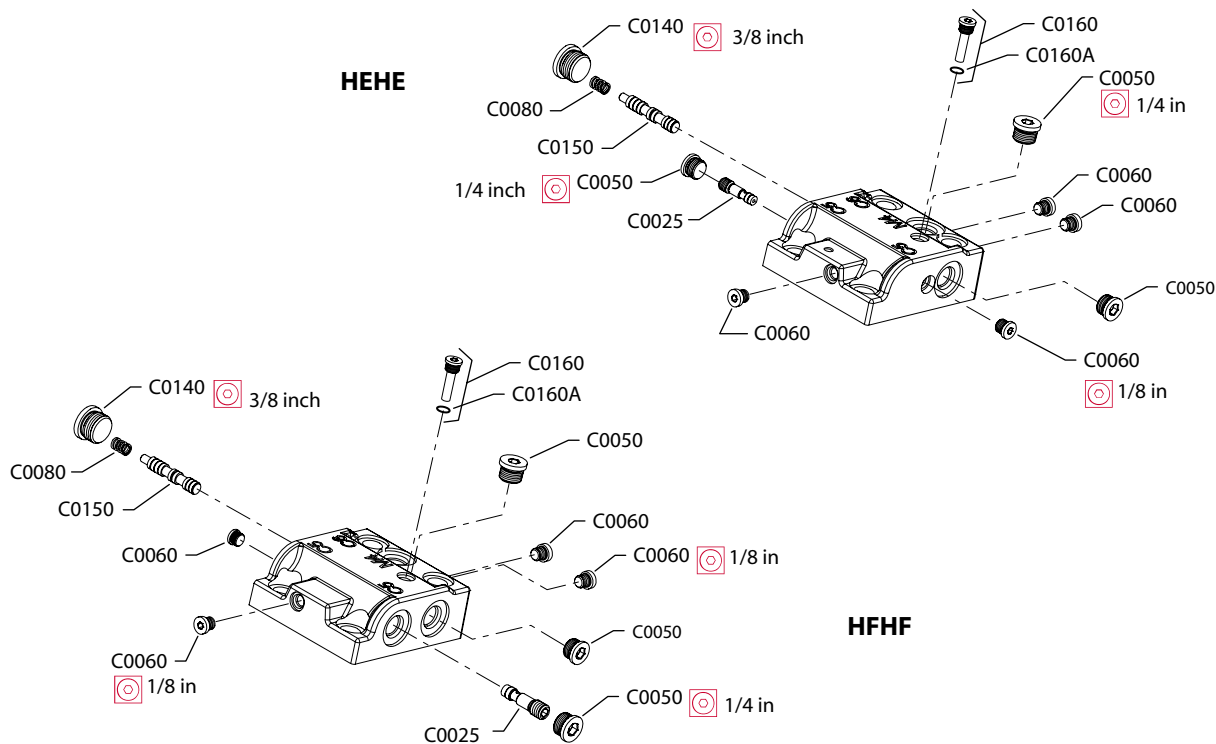
Clean and inspect the machined surfaces on the control and the endcap. If any nicks or scratches are found, replace the control/endcap assembly.

Assembly

1. Lubricate and install spool (C0150) and spring (C0080).

Minor repair

2. Using a 3/8 inch internal hex wrench, install plug (C0140). Torque to 25 N•m [18 lbf•ft].
3. Lubricate and install spool (C0025).
4. Using a 1/4 inch internal hex wrench, install two plugs (C0050). Torque to 40 N•m [30 lbf•ft].
5. Using a 1/8 inch internal hex wrench, install four plugs (C0060). Torque to 8 N•m [6 lbf•ft].
6. Using a 1/8 inch internal hex wrench, install plug (C0160). Torque to 25 N•m [18 lbf•ft].



P108 576E

Hydraulic two-position control module with PCOR

Disassembly

1. Using a 1/8 inch internal hex wrench, remove two plugs (C0060). Remove and discard O-rings (C0060A).
2. Using a 1/4 inch internal hex wrench, remove three plugs (C0050). Remove and discard Orings (C0050A).
3. Use a 5mm internal hex wrench to remove the shuttle valve (C0025).
4. Using a 22 mm hex wrench, remove adapter (B0300). Remove and discard O-ring (QB0300).
5. Using a 17 mm hex wrench, remove pressure compensator adjusting plug (C0090). Remove and discard O-ring (M223).
6. Remove spring (C0080). Remove spool (C0070).
7. If necessary, use a 3 mm internal hex wrench to remove orifices (E00T2) and (E00T3).

Inspection

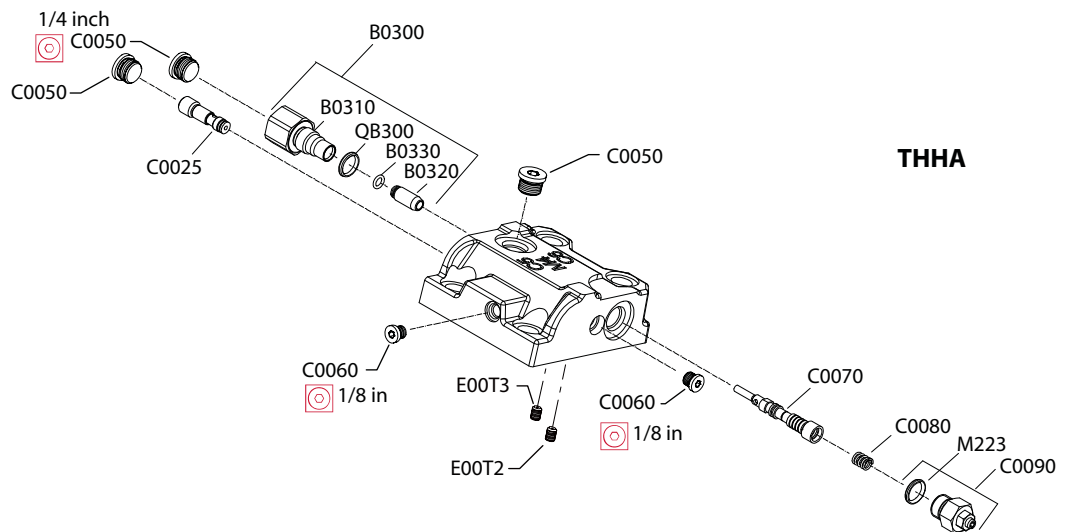
Clean and inspect the machined surfaces on the control and the endcap. If any nicks or scratches are found, replace the control/endcap assembly.

Minor repair

**Assembly**

1. If previously removed, install orifices (E00T3 and E00T2) using a 3mm internal hex wrench. Torque to 6 N·m [4 lbf·ft].
2. Lubricate and install spool and (C0070) and spring (C0080).
3. Lubricate and install O-ring (M223). Install pressure compensator adjusting plug (C0090). Torque to 40 N·m [30 lbf·ft].
4. Lubricate and install O-ring (QB0300). Install adapter (B0300). Torque to 67 N·m [49 lbf·ft].
5. Lubricate and install spool (C0025).
6. Using a 1/4 inch internal hex wrench, install three plugs (C0050). Torque to 40 N·m [30 lbf·ft].
7. Using a 1/8 inch internal hex wrench, install two plugs (C0060). Torque to 8 N·m [6 lbf·ft].

Assemble two position control - THHA



P108913

**Hydraulic two-position control module with PCOR and hydraulic BPD**

**Disassembly**

1. Using a 1/8 inch internal hex wrench, remove three plugs (C0060). Remove and discard O-rings (C0060A).
2. Using a 1/4 inch internal hex wrench, remove four plugs (C0050). Remove and discard O-rings (C0050A).
3. Using a 1/4 inch internal hex, remove plug (C0140). Remove spool (C0020).
4. Use a 5mm internal hex wrench to remove the shuttle valve (C0025).
5. Using a 22 mm hex wrench, remove adapter (B0300). Remove and discard O-ring (QB0300).
6. Using a 17 mm hex wrench, remove pressure compensator adjusting plug (C0090). Remove and discard O-ring (M223).
7. Remove spring (C0080). Remove spool (C0070).
8. If necessary, use a 3 mm internal hex wrench to remove orifices (E00T2) and (E00T3).

**Inspection**

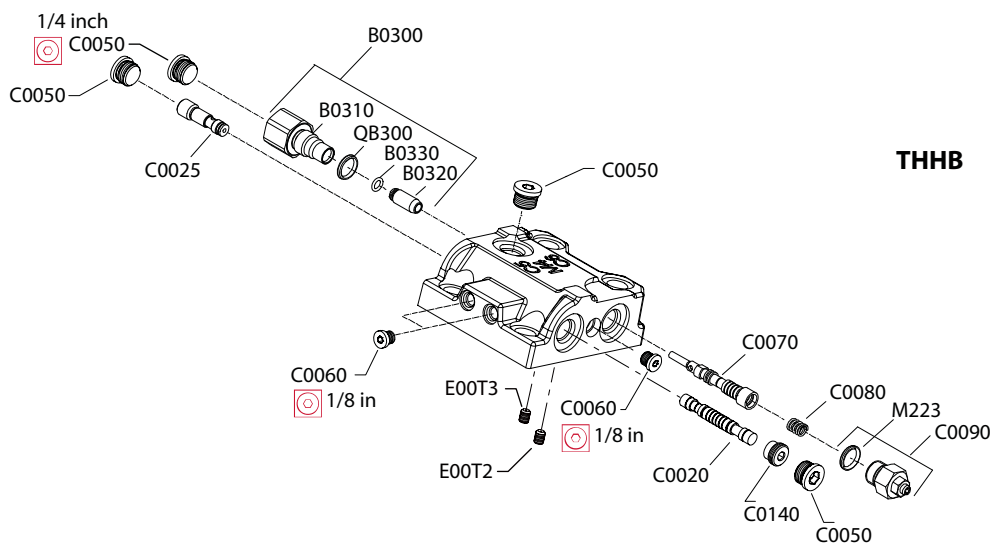
Clean and inspect the machined surfaces on the control and the endcap. If any nicks or scratches are found, replace the control/endcap assembly.

Minor repair

**Assembly**

1. If previously removed, install orifices (E00T3 and E00T2) using a 3mm internal hex wrench. Torque to 6 N•m [4 lbf•ft].
2. Lubricate and install spools and (C0070) and spring (C0080).
3. Lubricate and install O-ring (M223). Install pressure compensator adjusting plug (C0090). Torque to 40 N•m [30 lbf•ft].
4. Lubricate and install O-ring (QB0300). Install adapter (B0300). Torque to 67 N•m [49 lbf•ft].
5. Lubricate and install spool (C0020).
6. Using a 1/4 inch internal hex wrench, install plug (C0140). Torque to 14 N•m [10 lbf•ft].
7. Lubricate and install shuttle (C0025).
8. Using a 1/4 inch internal hex wrench, install four plugs (C0050). Torque to 40 N•m [30 lbf•ft].
9. Using a 1/8 inch internal hex wrench, install three plugs (C0060). Torque to 8 N•m [6 lbf•ft].

*Assemble two position control - THHB*



P108923

Minor repair

**Maximum displacement limiter two-position controls**

It is not necessary to remove the maximum displacement limiter unless it is being replaced.

**Disassembly**

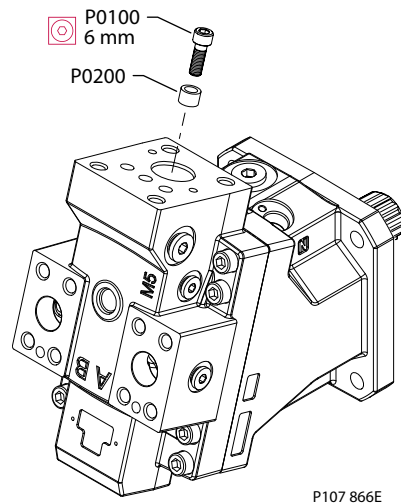
Models with maximum displacement limiter: Remove screw (P0100) using a 6 mm internal hex, and spacer (P0200).

**Assembly**

Install spacer (P0200) and screw (P0100).

Using a 6 mm internal hex, torque screw to 37 N•m [28 lbf•ft].

*Maximum displacement limiter parts*



**Servo piston cover – proportional control**

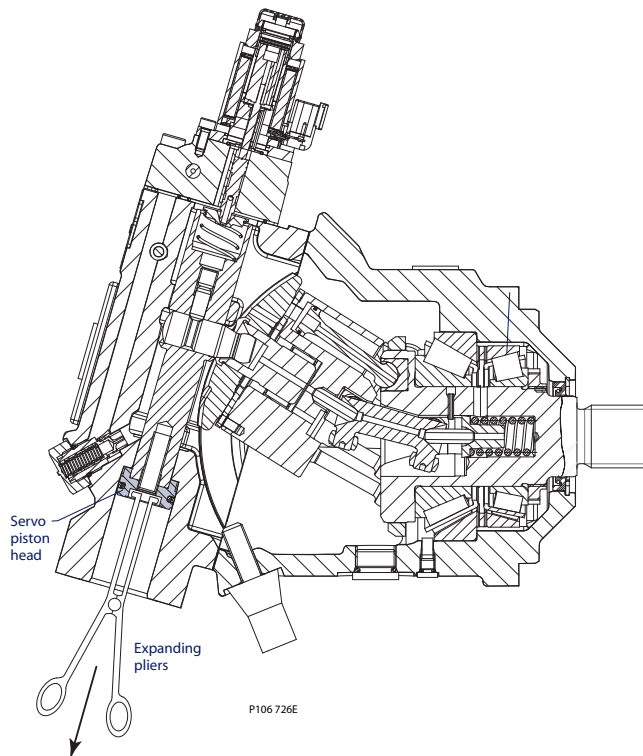
**Removal**

1. Using a 10 mm internal hex wrench, remove four screws (P0020).
2. Remove servo piston cover (P0010).
3. Remove and discard O-ring (P0030).
4. Remove screw (P0050). See table for wrench size.

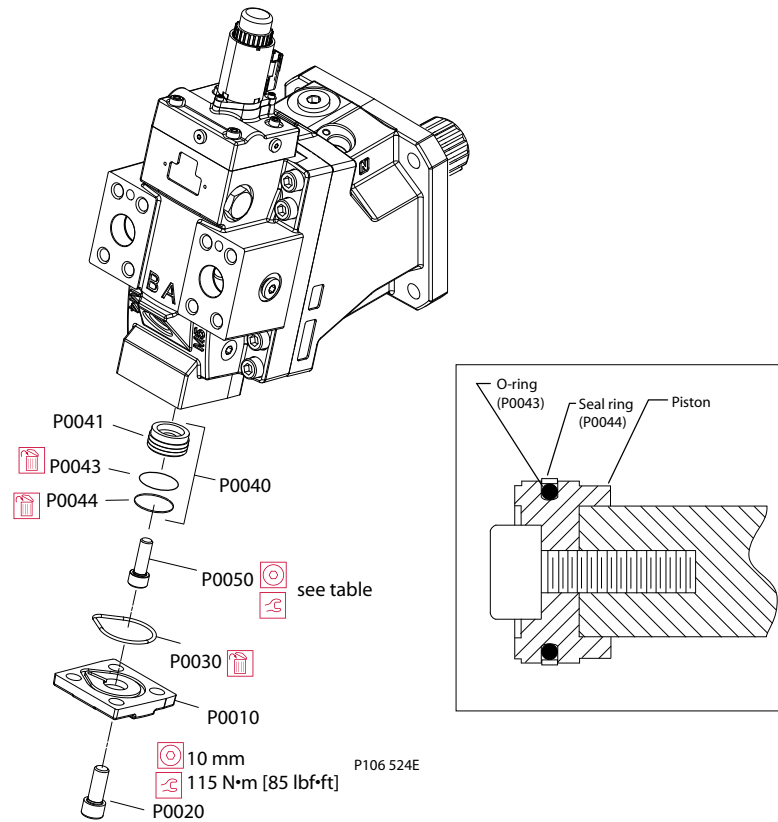
Minor repair

5. Using expanding pliers, remove piston head (P0040). Remove and discard seal ring (P0044) and O-ring (P0043).

*Servo piston cover and bushing*



Minor repair



P0050 wrench size and torque

Model	Wrench size	Torque
060/080	8 mm	66 N·m [49 lbf·ft]
110	10 mm	115 N·m [85 lbf·ft]
160/210/250	12 mm	213 Nm [157 lbf·ft]

**Inspection**

Clean and inspect bushings and machined surfaces for wear or damage. If wear or damage are found, replace component in question.

**Assembly**

1. Lubricate and install new O-ring (P0043) and seal ring (P0044) on piston (P0041).

Allow seals time to relax before installing piston.

2. Install piston and install screw (P0050). Torque screw (P0050) per table.
3. Lubricate and install new O-ring (P0030) and install servo piston cover (P0010).
4. Using a 8 mm or 10 mm internal hex install screws (P0020). Torque to 115 N·m [85 lbf·ft].

**Replace speed sensor**

**Removal**

1. Using a 5 mm internal hex wrench, remove screw (J0020).

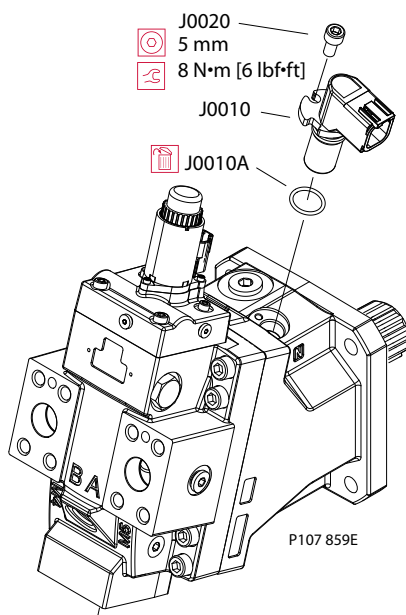
Minor repair

2. Remove speed sensor (J0010).
3. Discard O-ring (J0010A).

**Assembly**

1. Lubricate and install new O-ring (J0010A).
2. Install speed sensor (J0010).
3. Using a 5 mm internal hex wrench, install screw (J0020). Torque to 8 N·m [6 lbf·ft].

*Speed sensor*



Loop flushing spool

**Removal**

1. Remove plugs (K0030) using a 24 mm hex wrench.
2. Remove and discard O-rings (K0030A).
3. Use a magnet to remove springs (K0020) and spool (K0010).

**Inspection**

Clean and inspect spool (K0010). If spool is damaged or worn replace it. Replace springs if they are cracked or bent.

**Reassembly**

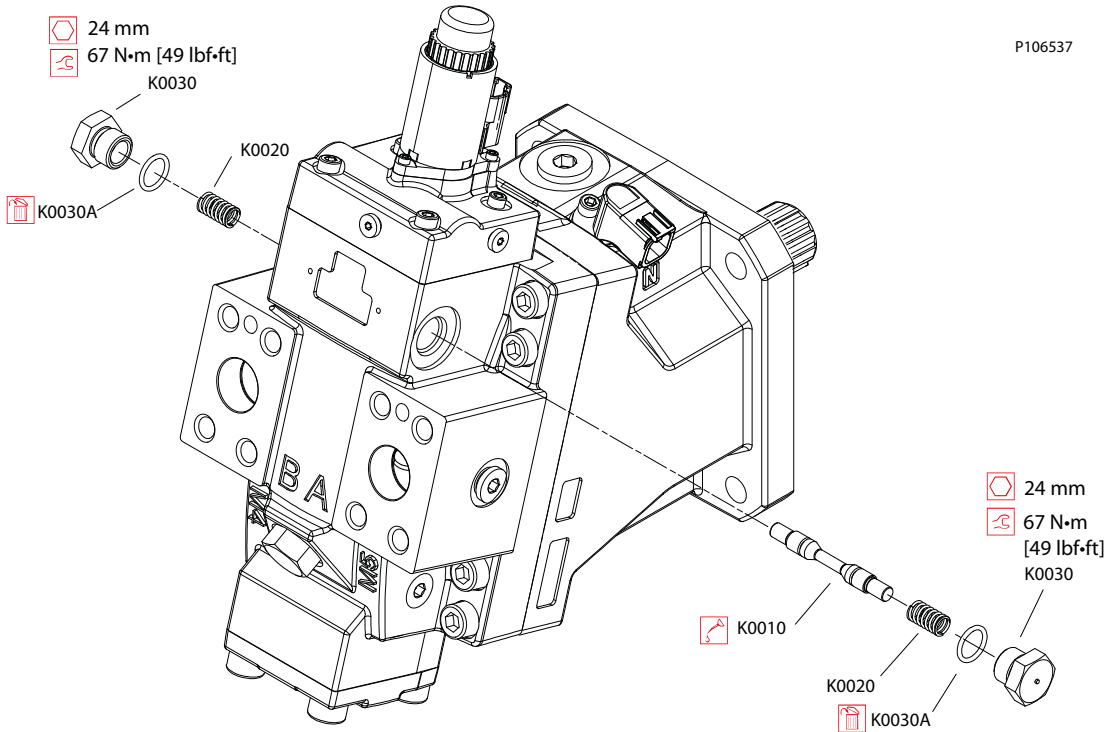
1. Lubricate and install spool (K0010).
2. Lubricate and install springs (K0020).
3. Lubricate and install new O-rings (K0030A).

Minor repair

- Using a 24 mm hex wrench, install plugs (K0030). Torque to 67 N·m [49 lbf·ft]

Loop flushing assembly

P106537



Loop flushing charge relief valve

Removal

- Using a 24 mm hex wrench remove valve (L00\*\*)
- Remove and discard O-ring (L0050).

Do not disassemble valve. If you suspect malfunction, replace valve.

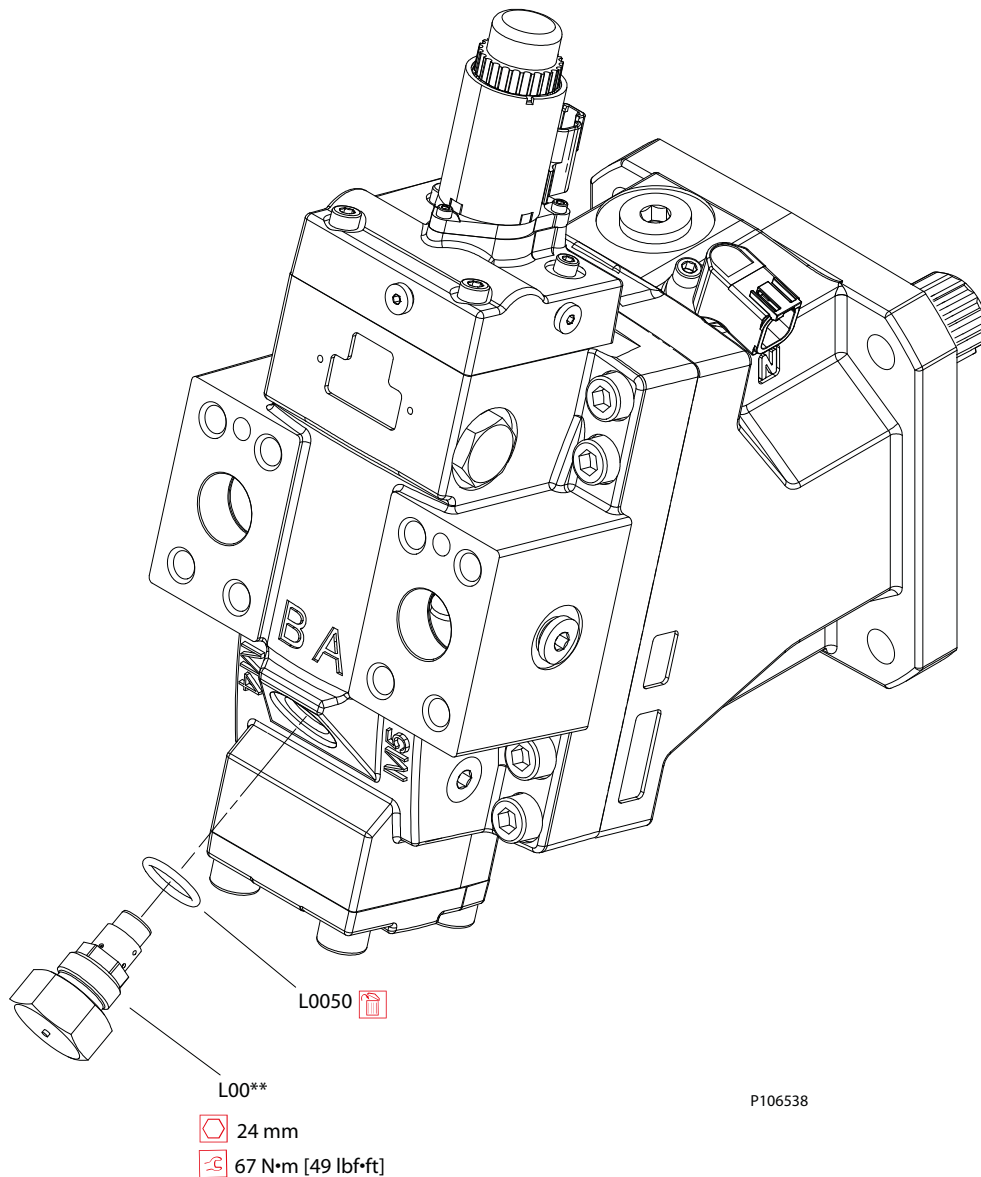
Assembly

- Install new O-ring (L0050).

Minor repair

2. Using a 24 mm hex wrench, install valve (L00\*\*). Torque to 67 N•m [49 lbf•ft].

*Loop flushing charge relief valve replacement*



Minor repair

Minimum Displacement limiter

**Removal**

1. Remove cap (N0120).

Removing the cap destroys the caps locking mechanism. Replace with a new cap.

2. While holding the position of the adjustment screw, remove the seal locknut (N0020) using a 19mm hex wrench. Discard the locknut. After removing the locknut, mark the position of the limiter screw for reassembly.
3. Using a 6 mm internal hex, remove displacement limiter screw (N0010).

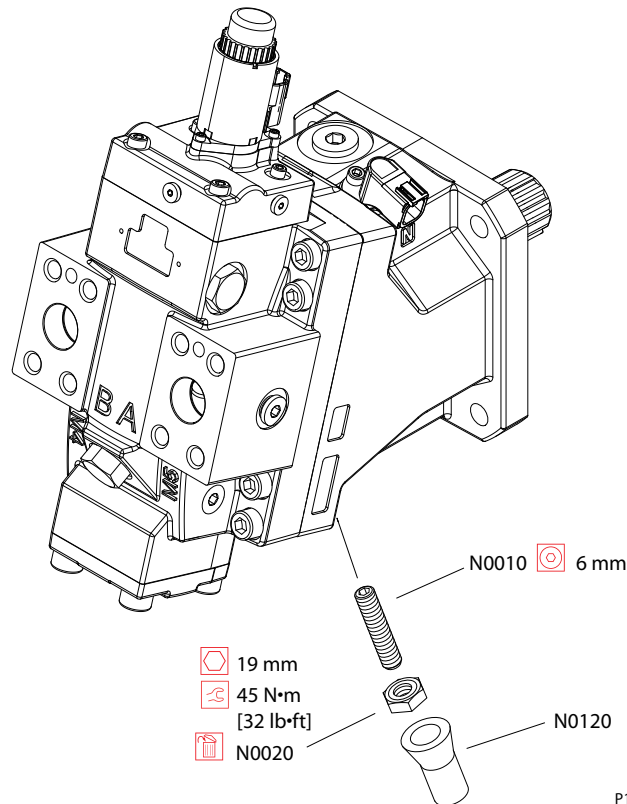
**Inspection**

Inspect set screw for wear or damage. Replace set screw if necessary.

**Assembly**

1. Using a 6 mm internal hex wrench, install adjustment screw (N0010) to original position.
2. Using a 6 mm internal hex wrench, to hold the position of the adjustment screw, install a new seal locknut (N0020) using a 19mm hex wrench. Torque to 45 N·m [32 lb·ft].
3. Install new cap (N0120).

*Displacement limiter assembly*

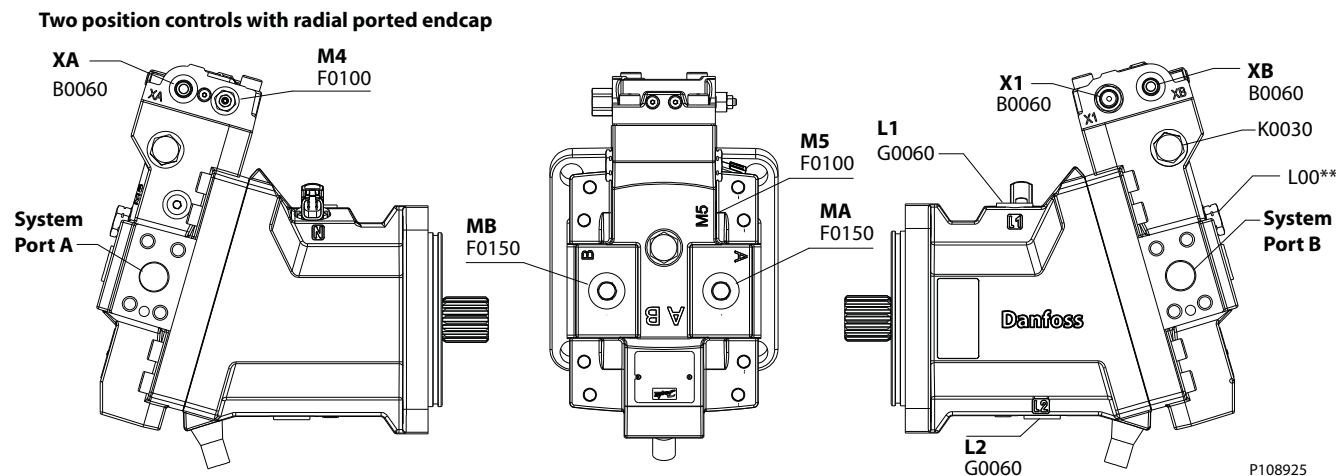
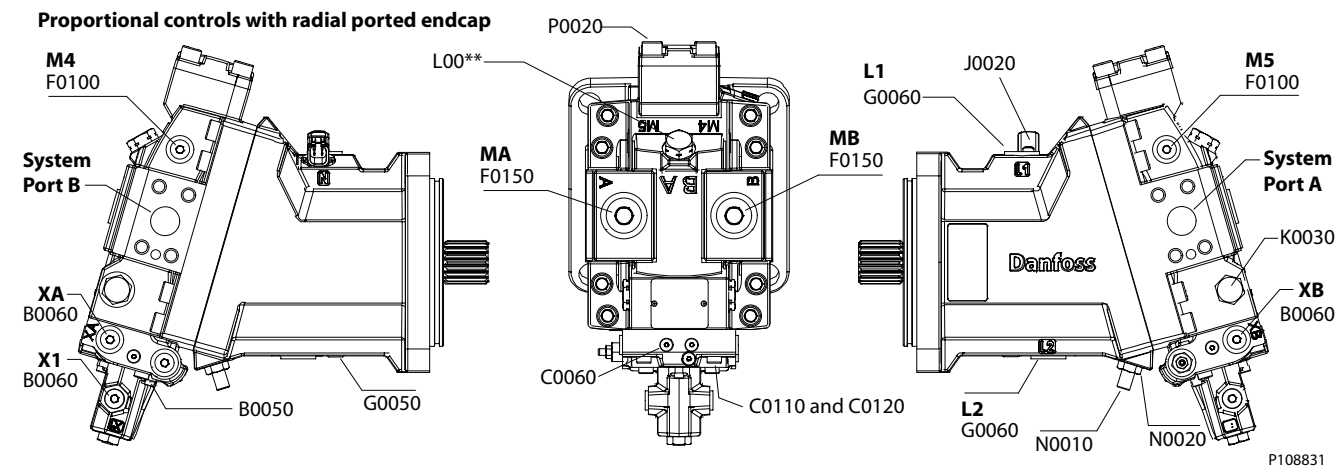


P106 547E

Torque chart

Fasteners and plugs

Port, plug and fastener locations



Fastener size and torque chart

Item	Fastener	Wrench size	Torque
<b>B0050</b>	Solenoid screws	4 mm internal hex	6 N•m [4 lbf•ft]
<b>C0110 (proportional)</b>	Control assembly screws	6 mm internal hex	37 N•m [28 lbf•ft]
<b>C0110 &amp; C0120 (two-position)</b>	Control assembly screws	10 mm internal hex	115 N•m [85 lbf•ft]
<b>J0020</b>	Speed sensor screw	5 mm internal hex	8 N•m [6 lbf•ft]
<b>N0010</b>	Displacement limiter screw	6 mm internal hex	N/A
<b>N0020</b>	Displacement limiter locknut	19 mm	45 N•m [32 lbf•ft]
<b>P0020</b>	Servo piston cover screws	10 mm internal hex	115 N•m [85 lbf•ft]

Torque chart

Plug size and torque chart

Item	O-ring plug	Wrench size	Torque
<b>B0060</b>	9/16 - 18UNF	1/4 internal hex	40 N•m [30 lbf•ft]
<b>C0050</b> (not shown)	9/16-18 UNF	1/4 internal hex	40 N•m [30 lbf•ft]
<b>C0060</b>	5/16 - 24UNF	3/8 internal hex	8 N•m [5 lbf•ft]
<b>F0100</b>	9/16 - 18UNF	1/4 internal hex	40 N•m [30 lbf•ft]
<b>F0150 (060)</b> Radial endcap	1-1/16 - 12 UN	9/16 internal hex	95 N•m [70 lbf•ft]
<b>F0150 (080, 110, 160, 250)</b> Radial endcap	1-1/16 - 12 UN	9/16 internal hex	115 N•m [85 lbf•ft]
<b>G0050</b>	5/16 - 24UNF (SAE and DIN flange)	1/8 internal hex	8 N•m [5 lbf•ft]
<b>G0055</b> (cartridge model only) (not shown)	7/16 - 20UNF (Cartridge)	3/16 internal hex	8 N•m [5 lbf•ft]
<b>G0060 (060, 080)</b>	7/8 - 14UN	3/8 internal hex	70 N•m [52 lbf•lb]
<b>G0060 (110, 160)</b>	1-1/16 - 12UN	9/16 internal hex	70 N•m [52 lbf•lb]
<b>G0060 (250)</b>	1-5/16 - 12UN	5/8 internal hex	70 N•m [52 lbf•lb]
<b>K0030</b>	M18 - 1.5	24 mm hex	67 N•m [49 lbf•ft]
<b>L00**</b>	M18 - 1.5	24 mm hex	67 N•m [49 lbf•ft]
<b>F0160</b> Axial endcap (not shown)	9/16-18 UNF	1/4 internal hex	40 N•m [30 lbf•ft]









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