

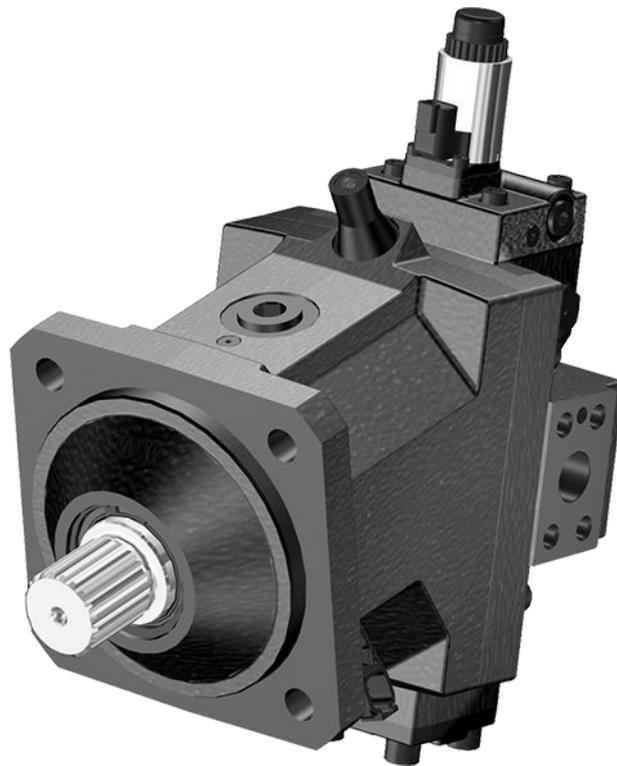
ENGINEERING
TOMORROW

Danfoss

Service Manual

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

H1 Bent Axis Motors



Revision history*Table of revisions*

Date	Changed	Rev
March 2020	Added adjustment details for threshold settings and changed document number from AX00000025	0607
August 2019	Added caution for servo piston removal	0505
August 2018	update adjustment chapter	0504
April 2018	Major layout update, QF080 to QM050 updates	0503
January 2018	update pressure compensator torque values	0502
July 2016	Add G1, G2 controls	0501
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
2008-2015	First edition - and next various changes.	AA-CB

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Introduction

About this manual

This manual includes information for the installation, maintenance, and minor repair procedures for H1 bent axis motors. 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.

Only Danfoss global service partners (GSPs) are authorized to perform major repairs. Danfoss trains Global Service Partners and certifies their facilities on a regular basis. You can locate your nearest service partner at www.danfoss.com > **Contact us** > **Danfoss sales and services** > **Distributor and service partners**

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

When repairing H1 variable displacement closed circuit motors follow these general procedures:

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.

Lubricate moving parts



During assembly, coat all moving parts with a film of clean hydraulic oil. This assures that these parts are lubricated during start-up.

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



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.

Introduction

Unintended machine movement

 **Warning**

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

Flammable cleaning solvents

 **Warning**

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

Fluid under pressure

 **Warning**

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

Personal safety

 **Warning**

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

Hazardous material

 **Warning**

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

Introduction

Symbols used in Danfoss literature

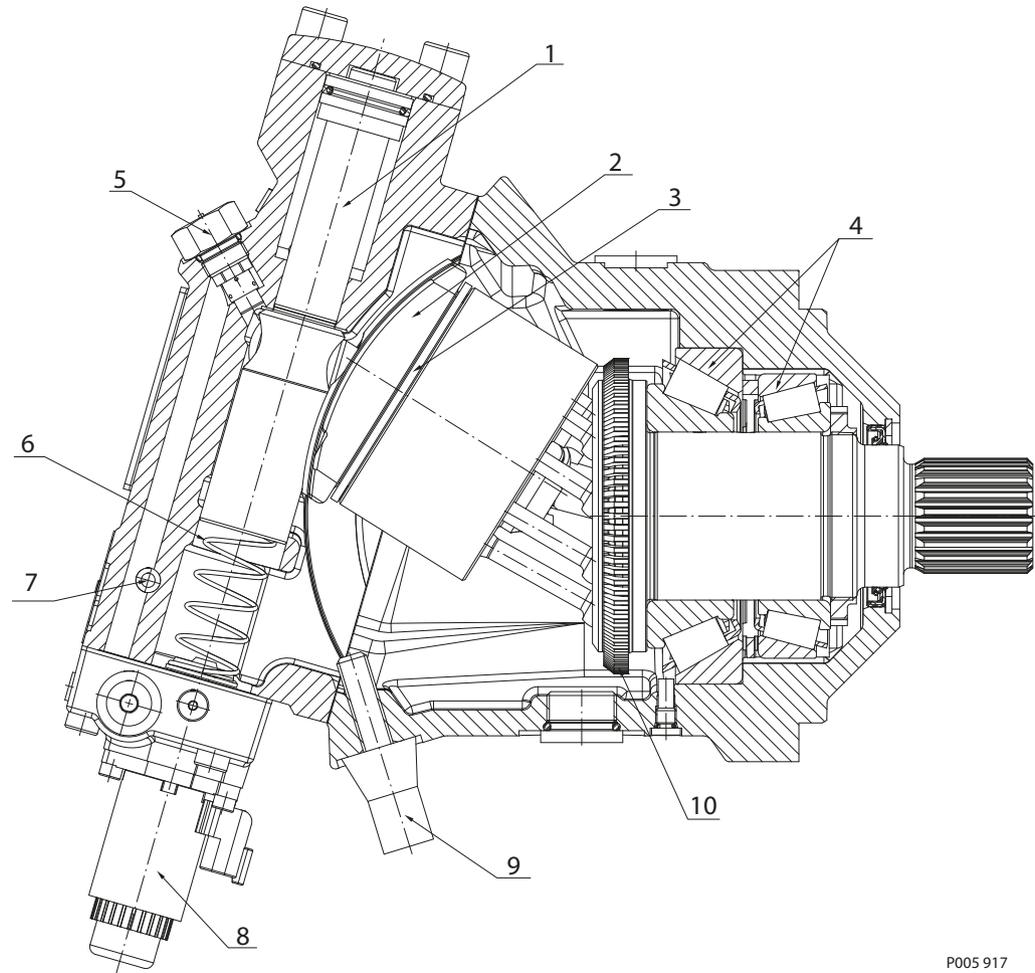
	WARNING may result in injury		Tip, helpful suggestion
	CAUTION may result in damage to product or property		Lubricate with hydraulic fluid
	Reusable part		Apply grease / petroleum jelly
	Non-reusable part, use a new part		Apply locking compound
	Non-removable item		Inspect for wear or damage
	Option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

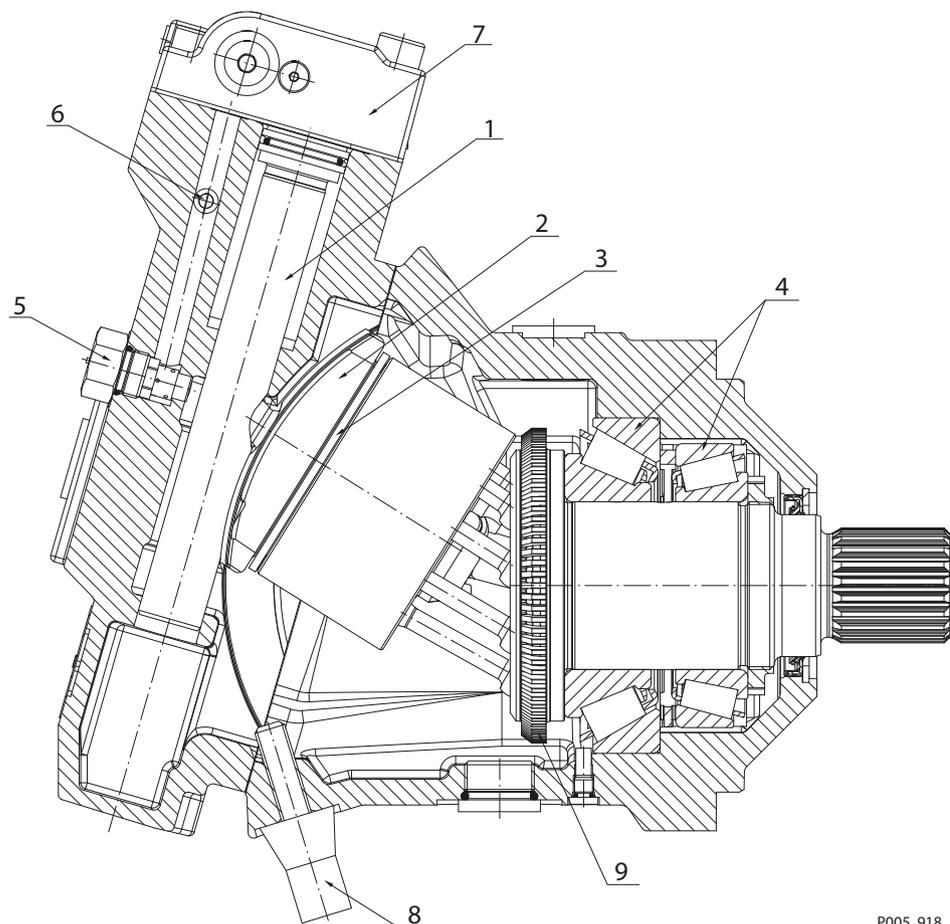


P005 917

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 cm³ and 250 cm³) and DIN 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.

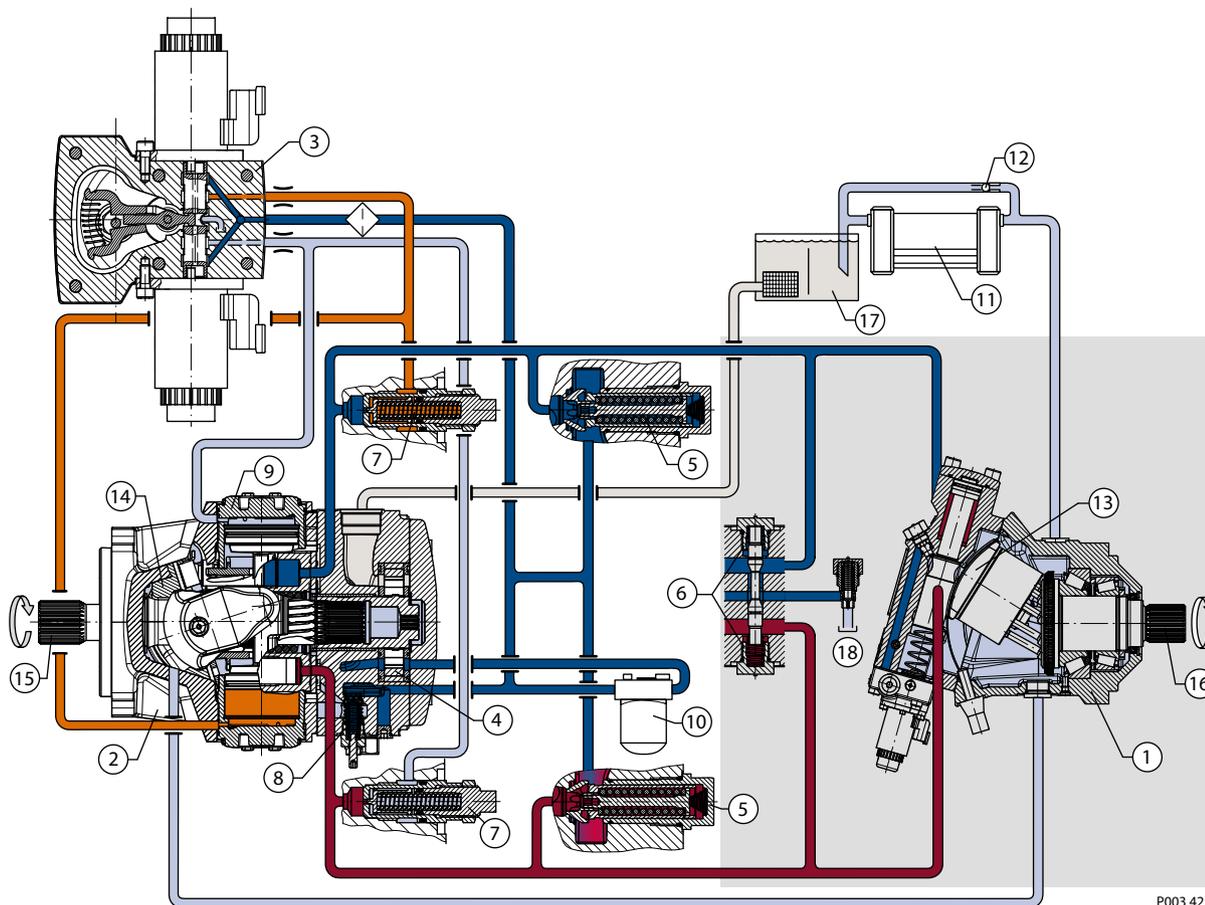
They are capable of sensing the following, all in one package:

- 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[®] microcontrollers for easy "Plug and Perform" installation.

H1 general information

H1 pictorial diagram



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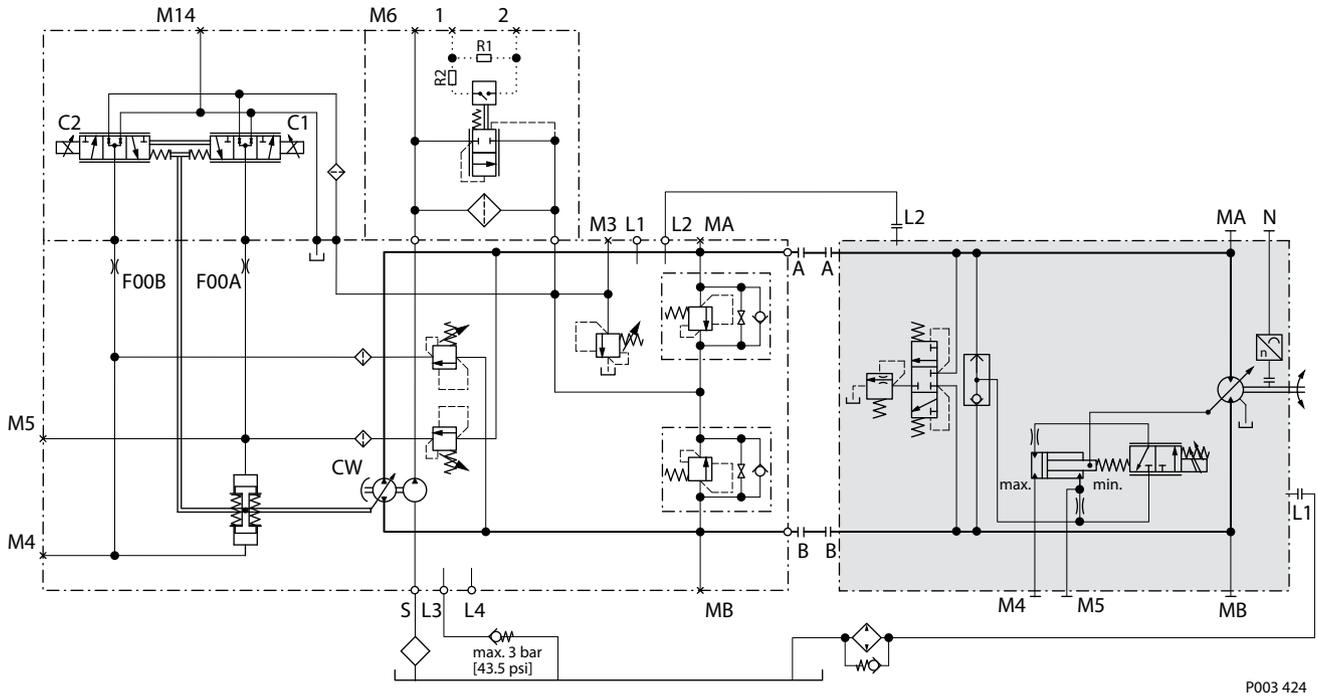
- Working loop A (Low pressure) and charge pressure
- Working loop B (High pressure)
- Servo pressure
- Case drain
- Suction

- | | |
|---|--|
| <ul style="list-style-type: none"> 1. Bent Axis Variable Displacement Motor 2. Axial Piston Variable Displacement Pump 3. Electric Displacement Control (EDC) 4. Charge Pump 5. Charge Check / High Pressure Relief Valve 6. Loop Flushing Valve 7. Pressure Limiter Valve 8. Charge Pressure Relief Valve 9. Servo Cylinder | <ul style="list-style-type: none"> 10. Charge Pressure Filter 11. Heat Exchanger 12. Heat Exchanger Bypass Valve 13. Valve Segment 14. Pump Swashplate 15. Input Shaft 16. Output Shaft 17. Reservoir 18. to Motor Case |
|---|--|

H1 general information

H1 system schematic

System schematic H1 pump and H1 motor with EDC



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

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

Physical properties

Physical properties

Features		Unit	Size					
			060	080	110	160	210	250
Displacement	maximum	cm ³ [in ³]	60 [3.66]	80 [4.88]	110 [6.71]	160 [9.76]	210 [12.81]	250 [15.25]
	minimum		12 [0.73]	16 [0.98]	22 [1.34]	32 [1.95]	42 [2.56]	50 [3.05]
Theoretical flow at max. displ.	at rated speed	l/min [US gal/min]	216 [57]	256 [68]	319 [84]	416 [110]	504 [133]	550 [145]
	at max. speed		270 [71]	328 [87]	407 [108]	528 [139]	630 [166]	700 [185]
Theoretical torque at max. displacement		N·m/bar [lb·in/1000 psi]	0.96 [583]	1.27 [777]	1.75 [1069]	2.55 [1555]	3.34 [2038]	3.98 [2426]
Theor. corner power at rated speed and max. working pressure (Δp = 450 bar [6527 psi])		kW [hp]	266 [357]	321 [430]	396 [531]	513 [689]	609 [817]	684 [917]
Mass moment of inertia of rotating components		kg·m ² [slug·ft ²]	0.0038 [0.0028]	0.0062 [0.0046]	0.0108 [0.0080]	0.0211 [0.0156]	0.0306 [0.0226]	0.0402 [0.0296]
Case volume		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	Size					
	060	080	110	160	210	250
SAE	29.8 kg [65.7 lb]	34.8 kg [76.7 lb]	48.8 kg [107.6 lb]	61.9 kg [136.5 lb]	81.0 kg [179 lb]	87.0 kg [196.2 lb]
DIN	28.3 kg [62.4 lb]	34.4 kg [75.8 lb]	45.0 kg [99.2 lb]	59.3 kg [130.7 lb]	75.0 kg [165 lb]	79.6 kg [175.5 lb]
Cartridge	26.9 kg [59.3 lb]	33.0 kg [72.6 lb]	41.8 kg [92.2 lb]	54.7 kg [120.6 lb]	–	–

Mounting flange

Configuration	Size					
	060	080	110	160	210	250
SAE ISO 3019/1	127-4 (SAE C) 4-bolt		152-4 (SAE-D) 4-bolt		165-4 (SAE E)	
DIN ISO 3019/2, B4	125 HL 4-bolt	140 HL 4-bolt	160 HL 4-bolt	180 HL 4-bolt	200 HL 4-bolt	200 HL 4-bolt
Cartridge	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
Axial and radial ¹⁾	DN19 typ 1	DN25 typ 1	DN25 typ 1	DN32 typ 1	DN32 typ 1	DN32 typ 1
Case drain ports ²⁾	0.875 [$\frac{7}{8}$]-14UN-2B		1.0625 [$1\frac{1}{16}$]-12UN-2B		1.313 [$1\frac{5}{16}$]-12UN-2B]	
Axial gauge ports ²⁾³⁾	0.875 [$\frac{7}{8}$]-14UN-2B	1.0625 [$1\frac{1}{16}$]-12UN-2B				
Radial gauge port ²⁾³⁾	0.5625 [$\frac{9}{16}$]-18UNF-2B					

¹⁾ Split flange Boss per ISO6162, 40 MPa series

²⁾ SAE O-ring boss

³⁾ Countersink may be deeper than specified in the standard.

Operating Parameters

Output Speed

Output Speed	Displacement	Unit	Size					
			060	080	110	160	210	250
Rated	Maximum 32°	min ⁻¹ (rpm)	3600	3200	2900	2600	2350	2200
	Minimum 6°		5900	5300	4800	4250	3850	3650
	Zero 0°		6600	5950	5350	4750	4300	4050
Maximum	Maximum 32°		4500	4100	3700	3300	3000	2800
	Minimum 6°		7250	6600	5950	5250	4800	4500
	Zero 0°		7950	7200	6500	5750	5250	4900

System and Case Pressure, Ambient Temperature

Parameter	All sizes	
System pressure	Maximum working	450 bar [6527 psi]
	Maximum	480 bar [6962 psi]
	Minimum ¹⁾	²⁾
Case pressure	Rated	3 bar [44 psi]
	Maximum	5 bar [73 psi]
	Minimum	0.3 bar [4 psi]
Ambient temperature ³⁾	Maximum	70 °C [158 °F]
	Minimum	-40 °C [-40 °F]

¹⁾ Minimum above case pressure (**open** and **closed** circuit)

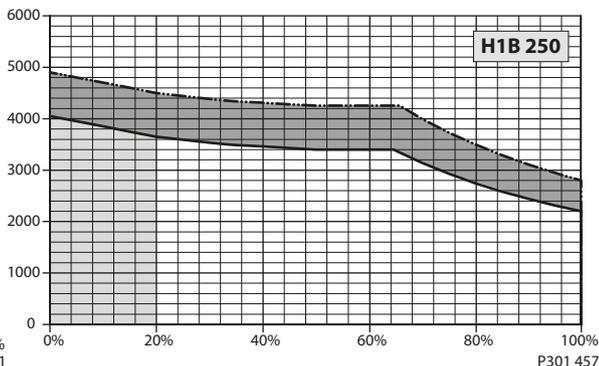
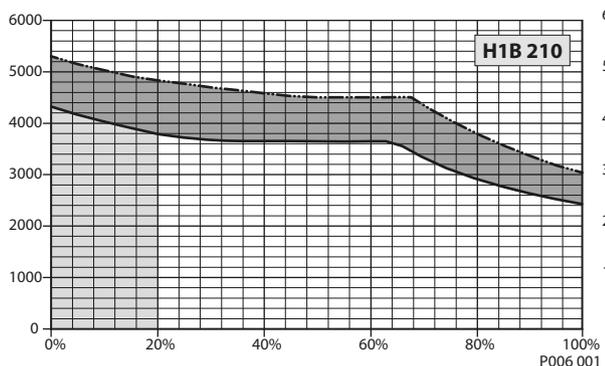
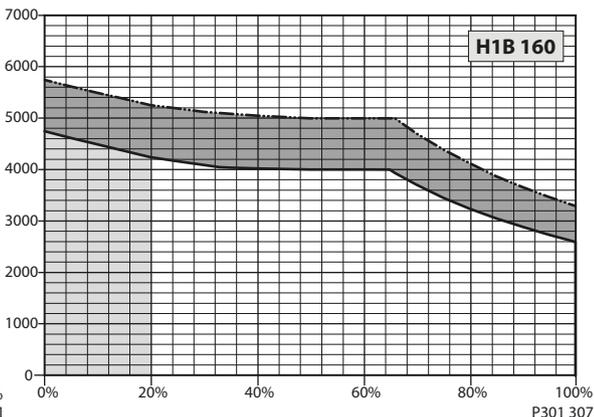
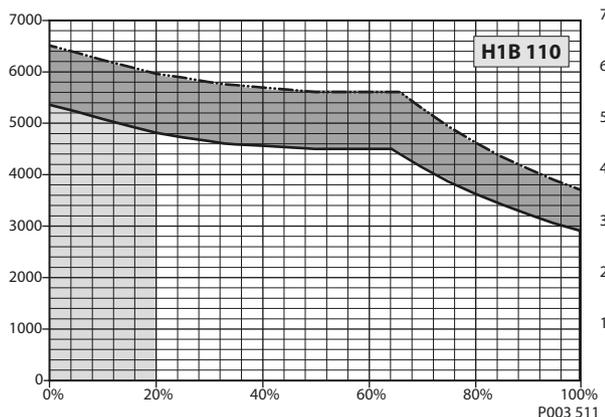
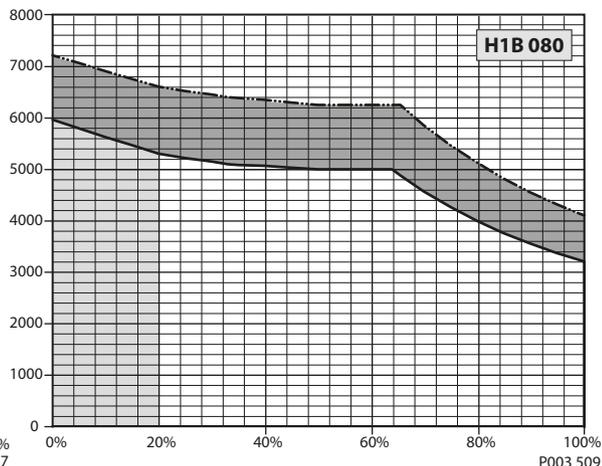
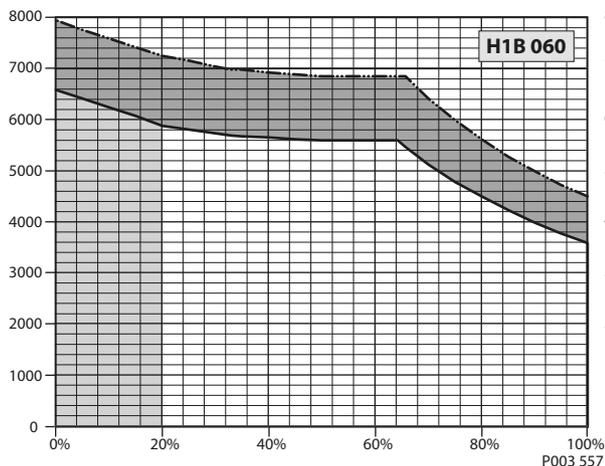
²⁾ See the graphs [Required inlet pressure diagrams \(for cylinder block filling\)](#) on page 16.

³⁾ Air temperature close to the unit.

Technical specifications

H1B speed range diagrams for open and closed circuit

Speed (rpm) versus Displacement (%), Intermittent operation (grey area)



Warning

Zero degree capability results in a high risk of overspeed and drops in efficiency if the motor operates between 0–20% displacement.

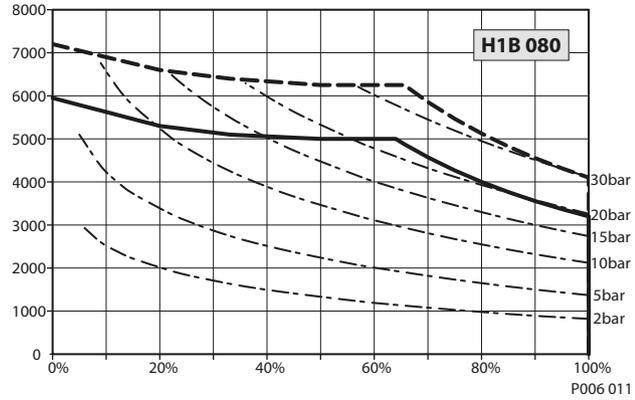
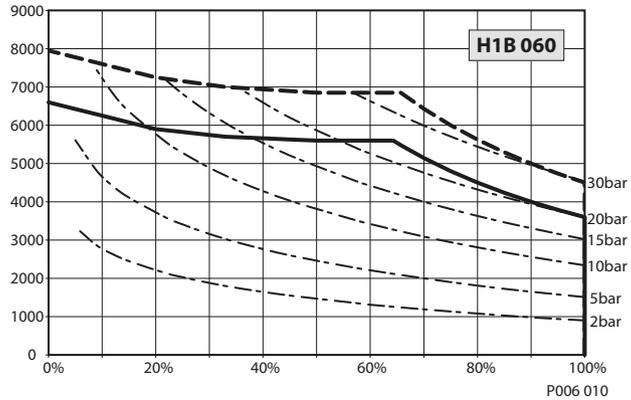
For **open circuit** applications it is not allowed to operate in the intermittent area.

For **closed circuit** applications operating in the intermittent area, please contact your local Danfoss Power Solutions representative.

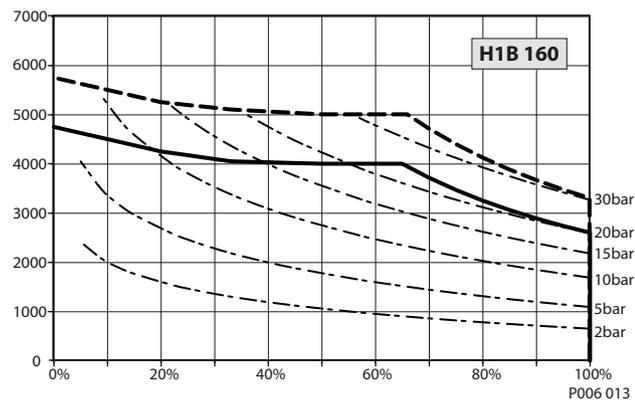
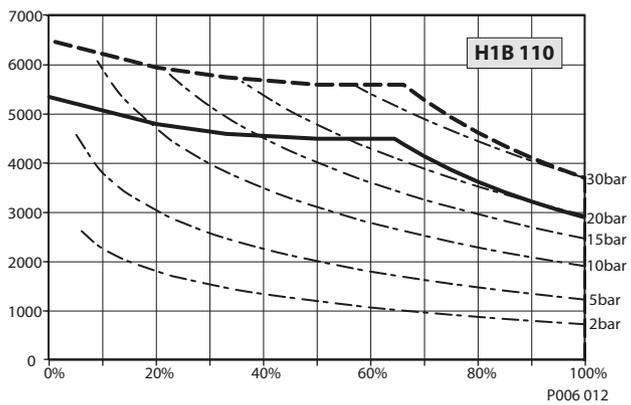
Technical specifications

Required inlet pressure diagrams (for cylinder block filling)

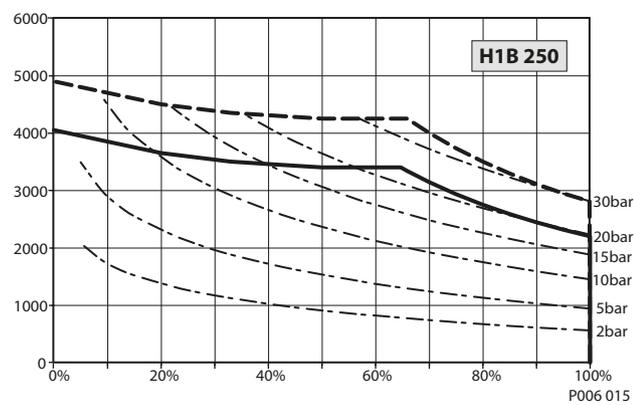
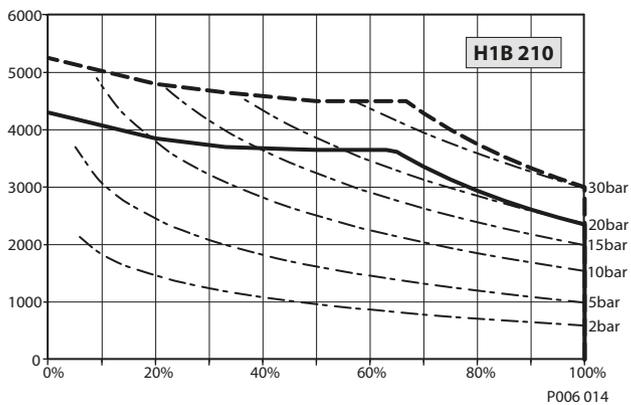
Speed (rpm) and Pressure (bar) versus Displacement (%)



Speed (rpm) and Pressure (bar) versus Displacement (%)



Speed (rpm) and Pressure (bar) versus Displacement (%)



Bold dashed line: Maximum speed

Bold solid line: Rated speed

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.

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

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 [Required inlet pressure diagrams \(for cylinder block filling\)](#) 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 ² /s [SUS]	7 [49]
	Recommended range		12-80 [66-366]
	Maximum intermittent		1600 [7416]
Temperature range ¹⁾²⁾	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 ₁₅₋₂₀ = 75 (β ₁₀ ≥ 10)
	Efficiency (suction / return line filtration)		β ₃₅₋₄₅ = 75 (β ₁₀ ≥ 2)
	Recommended inlet screen mesh size	μm	100 – 125

¹⁾ At the hottest point, normally case drain port.

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

Determination of nominal motor size

Based on SI units

$$Q_e = \frac{V_g \cdot n}{1000 \cdot \eta_v}$$

$$M_e = \frac{V_g \cdot \Delta p \cdot \eta_{mh}}{20 \cdot \pi}$$

$$P_e = \frac{M_e \cdot n}{9550} = \frac{Q_e \cdot \Delta p \cdot \eta_t}{600}$$

$$n = \frac{Q_e \cdot 1000 \cdot \eta_v}{V_g}$$

Where:

Q_e	Input flow (l/min)
M_e	Output torque (N·m)
P_e	Output power (kW)
n	Speed (min ⁻¹)
V_g	Motor displacement per rev. (cm ³ /rev)
P_{high}	High pressure (bar)
P_{low}	Low pressure (bar)
Δp	High pressure minus Low pressure (bar)
η_v	Motor volumetric efficiency
η_{mh}	Mechanical-hydraulic efficiency
η_t	Motor total efficiency (η _v · η _{mh})

Based on US units

$$Q_e = \frac{V_g \cdot n}{231 \cdot \eta_v}$$

$$M_e = \frac{V_g \cdot \Delta p \cdot \eta_{mh}}{2 \cdot \pi}$$

$$P_e = \frac{V_g \cdot n \cdot \Delta p \cdot \eta_t}{396\,000}$$

$$n = \frac{Q_e \cdot 231 \cdot \eta_v}{V_g}$$

Where:

Q_e	Input flow [US gal/min]
M_e	Output torque [lb·in]
P_e	Output power [hp]
n	Speed [rpm]
V_g	Motor displacement per rev. [in ³ /rev]
P_{high}	High pressure [psi]
P_{low}	Low pressure [psi]
Δp	High pressure minus Low pressure [psi]
η_v	Motor volumetric efficiency
η_{mh}	Mechanical-hydraulic efficiency
η_t	Motor total efficiency (η _v · η _{mh})

Operation

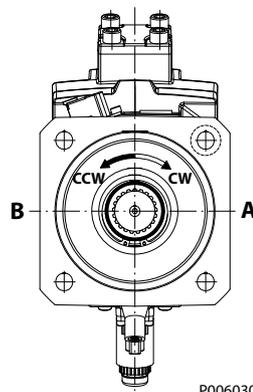
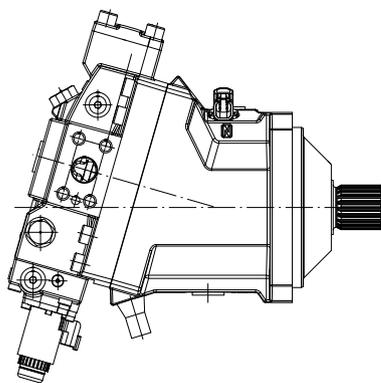
Shaft rotation direction

Shaft rotation direction is determined with a view from the shaft end.

Rotation direction of the motor will be dependent on the control option used as illustrated below.

In the second number or letter of the control code, 1 means 12 V_{DC}, 2 means 24 V_{DC}, and H means hydraulic.

Controls L1, L2, D1, D2, LH, DH



P006030

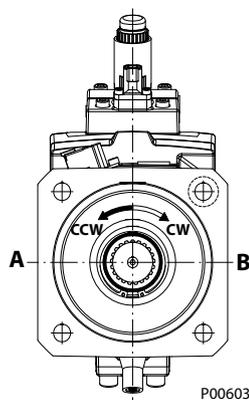
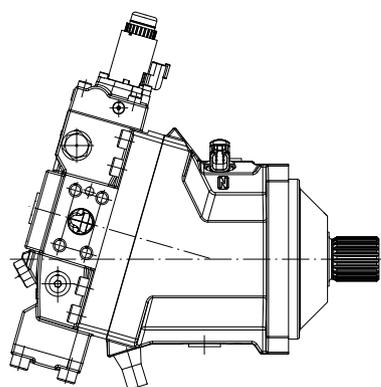
Flow into port A

Flow into port B

Clockwise

Counterclockwise

Controls M1, M2, K1, K2, KH, MH



P006031

Flow into port A

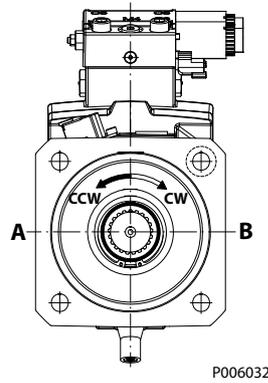
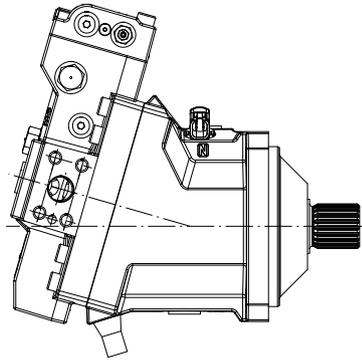
Flow into port B

Counterclockwise

Clockwise

Operation

Controls E1, E2, F1, F2, P1, P2, T1, T2, TA, TH, HE, HF



Flow into port A

Flow into port B

Counterclockwise

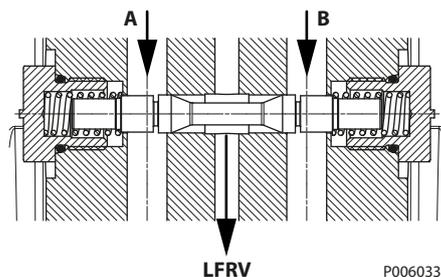
Clockwise

Operation

Loop flushing shuttle spool

An integral loop flushing shuttle spool is used to separate system A and system B pressures.

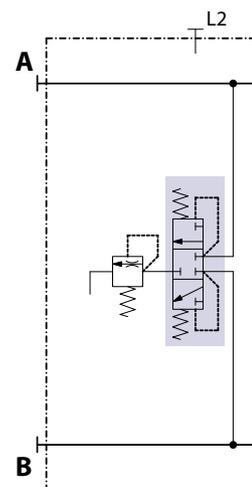
System delta pressure will cause the shuttle spool to shift, allowing the low side system pressure to flow to the loop flushing relief valve.



P006033

Legend:

- A** System loop A
- B** System loop B
- LFRV** to Loop flushing relief valve



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.

Operation

Loop flushing relief valve

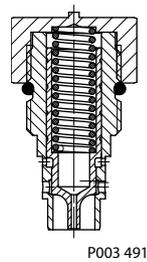
The loop flushing relief valve is incorporated into all H1 motors and uses the loop flushing option in installations that require fluid to be removed from the low pressure side of the system circuit due to cooling requirements.

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].

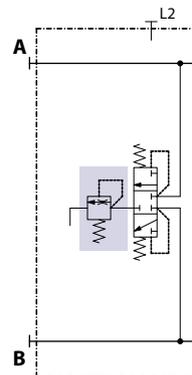
Valves are available with several orifice sizes to meet the flushing flow requirements of all system operating conditions.

Loop flushing relief valve (cross section)



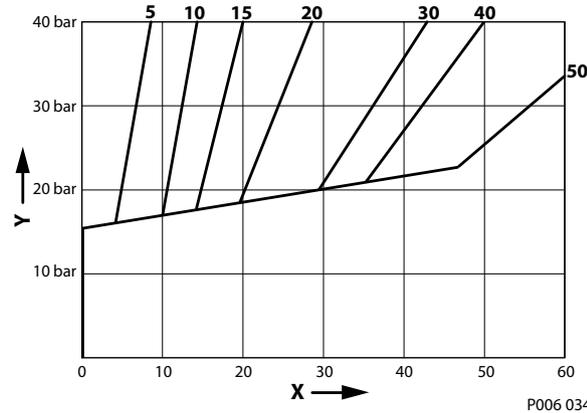
P003 491

Loop flushing relief valve schematic



P003 487

Loop flushing relief valve sizes



P006 034

- X** Loop flushing flow (l/min)
- Y** Low system pressure minus case pressure (bar)

Operation

Speed sensor

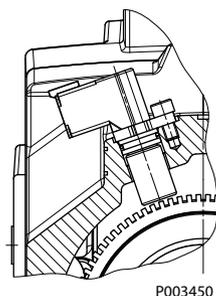
The speed sensor is designed for rugged outdoor, mobile or heavy industrial speed sensing applications. The detection of the speed is contactless and does not need any calibration or adjustments.

For more information, see *Speed and Temperature Sensor, Technical Information, 11046759*.

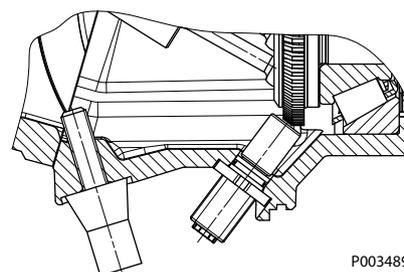
Sensor position

Sensor position in SAE, DIN and Cartridge housing.

SAE and DIN housing



Cartridge housing



Target Ring

Speed (target) rings vary according to the diameter of the cylinder block or shaft on which they are installed. The number of teeth is shown in the table below.

The number of speed (target) ring teeth

H1B size	060	080	110	160	210	250
Teeth	71	78	86	95	104	108

Excessive axial shaft loading during installation of motors with speed sensors and cartridge housings must be avoided. High axial shaft loads during installation of motors can lead to a movement of the shaft and damage the speed sensor.

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.

For 0° motors, the minimum displacement screw can be substituted with a plug that uses less space.

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 10 minutes durations, 2% of duty cycle based load-life, and 310 bar system delta pressure. 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

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**

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

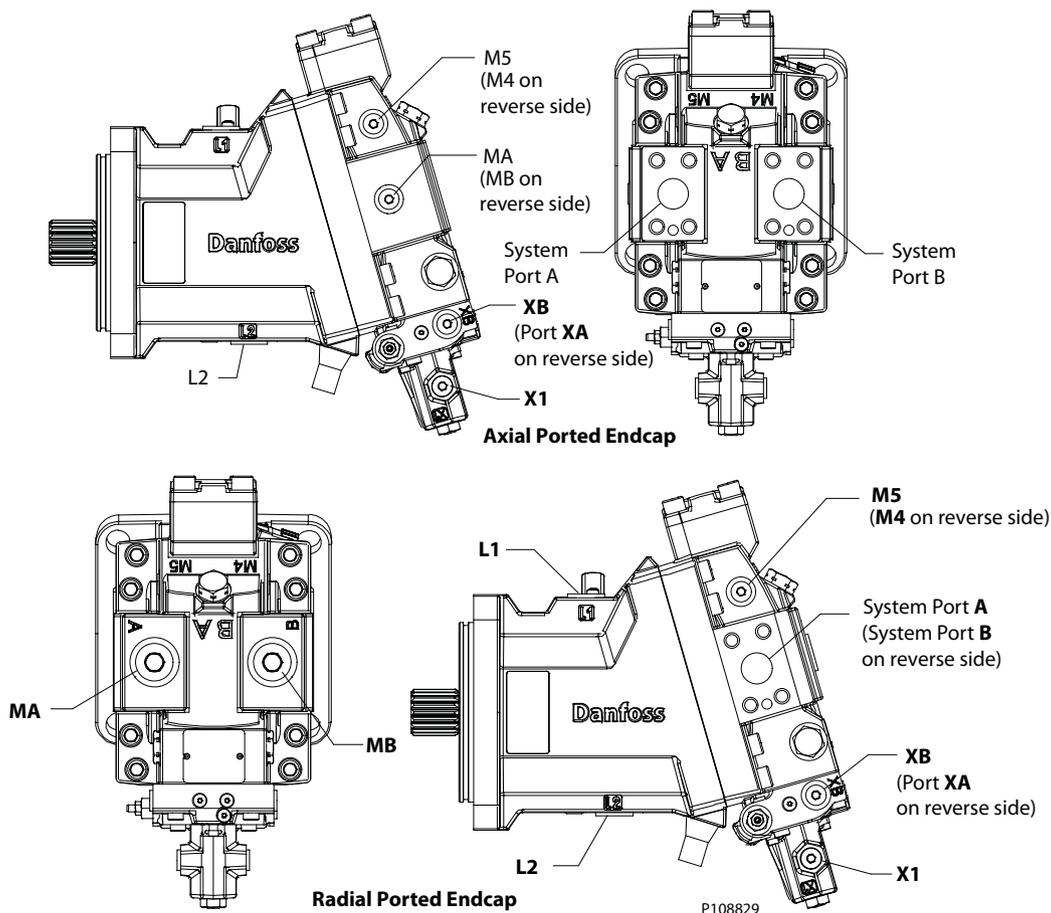
Hydraulic fluid contains hazardous material. Avoid contact with hydraulic fluid. Always dispose of used hydraulic fluid according to state, and federal environmental regulations. Never reuse hydraulic fluid.

Pressure measurements

Ports and Gauge Information

The following drawing with accompanying table show the port locations and gauge sizes needed for installation.

Ports locations (proportional control)



System split flange boss ports, A/B: Code 62 per ISO 6162, Type 1

Port	Size 060	Size 080, 110	Size 160, 210, 250
A, B	3/4 in; Thread: M10 x 1.5 min. 18 mm [0.71 in]	1 in; Thread: M12 x 1.75 min. 23 mm [0.91 in]	1 1/4 in; Thread: M12 x 1.75 min. 23 mm [0.91 in]

Radial/Axial end-cap ports

Port	Size 060	Size 080, 110, 160, 210, 250	System pressure obtained
MA, MB (Radial)	7/8-14 UNF Wrench (int. hex): 3/8 in	1 1/16-12UN Wrench (int. hex): 9/16 in	600 bar [8702 psi]
MA, MB (Axial)	7/8-14 UNF Wrench (int. hex): 3/8 in	9/16-18 UNF Wrench (int. hex): 1/4 in	600 bar [8702 psi]

Pressure measurements

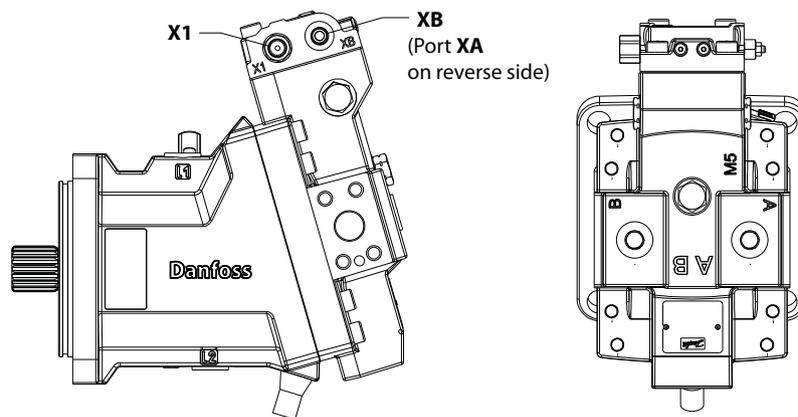
Ports and gauge Information

Port	Size 060/080	Size 110/160	Size 210/250	Pressure obtained
L1, L2	7/8-14 UNF Wrench: 3/8 in	1 1/16-12UN Wrench: 9/16 in	1 5/16-12UN Wrench: 5/8 in	10 bar [145 psi] Case drain
M4, M5	9/16-18 UNF; Wrench (int. hex): 1/4 in			600 bar [8700 psi] ¹⁾
X1, XA, XB	9/16-18 UNF; Wrench (int. hex): 1/4 in			100 bar [1450 psi] ²⁾

¹⁾ Servo pressure rod end.

²⁾ **X1** – Control pressure supply, hydraulic actuator. **XA/XB** – BPD, PCOR inactive at A/B.

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



P108924

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.
14. Reconnect the machine function if disconnected earlier.
15. Start the prime mover, checking to ensure the pump remains in neutral.

Initial startup procedures

- 16.** Check for forward and reverse machine operation, with the prime mover at normal operating speed.

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

Check		Cause	Corrective action
1.	Motor operates at one displacement only.	Control coil failure	Measure resistance at coil pins. Resistance at 20°C [70°F] should be: <ul style="list-style-type: none"> Proportional controls: 14.20 Ω (24V) or 3.66 Ω (12V) Two-position controls: 8.4 Ω (24V) or 34.5 Ω (12V) Replace coil if necessary.
2.	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.
4.	Loop flushing shuttle	Loop flushing shuttle may be sticking in one direction.	Ensure shuttle moves freely in its bore.

Troubleshooting

Check		Cause	Corrective action
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.
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.

Troubleshooting

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**

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

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**

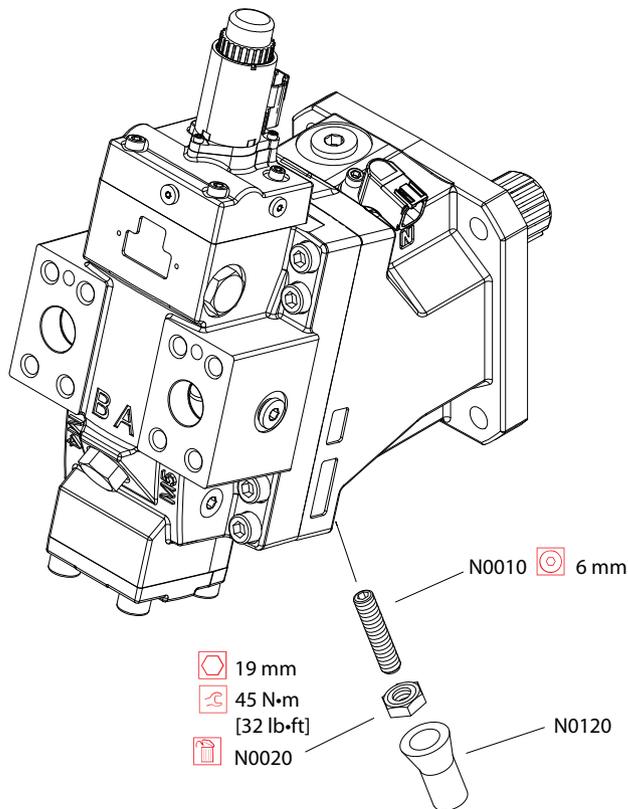
Be careful not to damage solenoids and electrical connections when using straps or chains to remove motor from machine.

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

Adjusting the minimum displacement limiter

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 the table below for displacement change per turn.

Displacement change per turn

Size	060	080	110	160	210	250
Displacement change	2.1 cm ³ [0.13 in ³]	2.6 cm ³ [0.16 in ³]	3.2 cm ³ [0.20 in ³]	4.1cm ³ [0.25 in ³]	5.1 cm ³ [0.31 in ³]	5.5 cm ³ [0.34 in ³]

5. When properly adjusted, hold adjusting screw in place and torque seal lock-nut to 45 N·m [32 lbf·ft].
6. With motor on machine or test stand, verify correct motor function. Refer to [Ports and Gauge Information](#) on page 27 for location of gauge ports and suggested gauge sizes.
7. Install new cap (N0120).

Adjustments

Optional threshold adjustment – Electric proportional controls

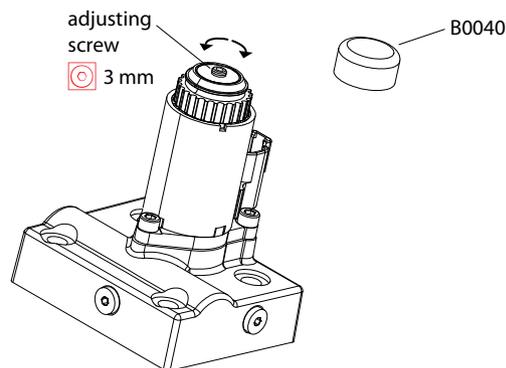
Adjusting threshold on test stand

1. Connect flow meter to A or B system port. Refer to [Ports and Gauge Information](#) on page 27 for port locations.
2. Connect solenoid to PWM signal generator at 150 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



4. Adjust PWM signal to current calculated from the *H1B 060/080/110/160/210/250 Technical Information* (BC152886483576) document in the corresponding control section. Note the 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.

One full turn of the adjusting screw changes the threshold by approximately 60 mA for 12V controls and 30mA for 24V controls. CW turn decreases the setting and CCW turn increases the setting. 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.
6. When threshold is adjusted correctly, stop prime mover, install cap. Run vehicle and test for proper motor operation.
7. Remove from test stand.

Adjustments

Optional threshold adjustment – Hydraulic proportional controls

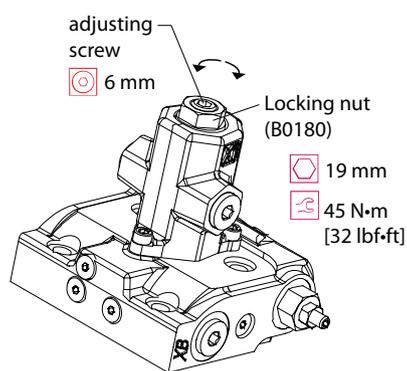
Adjusting threshold on test stand

1. Connect flow meter to A or B system port. Refer to [Ports and Gauge Information](#) on page 27 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.
 One full turn of the adjusting screw changes the threshold by approximately 2.3 bar. CW turn increases the setting and CCW turn decreases the setting. Test your adjustment by lowering the control pressure, then increasing the control 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

PCOR adjustment for all controls except P1/P2 controls is described below. PCOR adjustment for P1/P2 controls 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.

No adjustment is available for the Brake Pressure Defeat (BPD) option. Coil is either energized or de-energized, if coil is used.

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.

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.

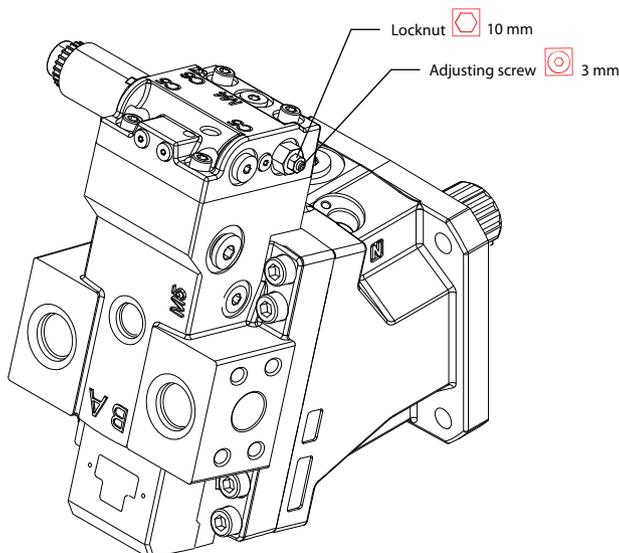
Adjustments

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

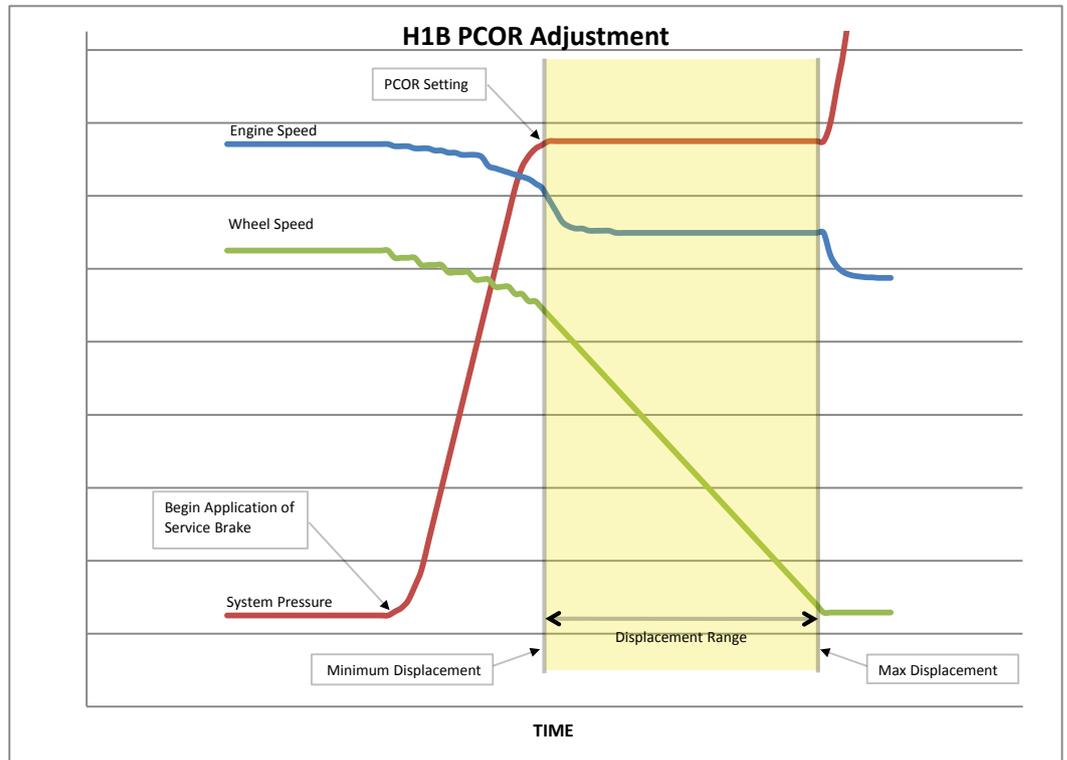
1. If adjustment is required, use a 3mm internal hex to hold the PCOR adjusting screw in place and use a 10mm wrench to loosen the PCOR lock nut. One full turn of the adjusting screw changes the PCOR setting by approximately 90 Bar.
 - a) Turn adjusting screw clockwise to increase the PCOR setting.
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



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

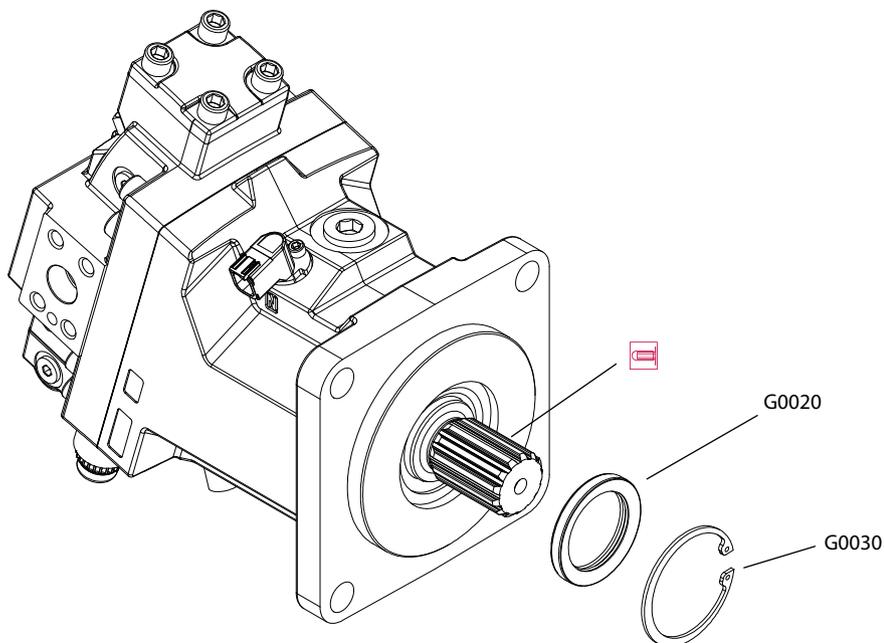
Inspect retaining ring for wear or damage. Replace if necessary. Inspect shaft for wear or groove at seal area.

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.

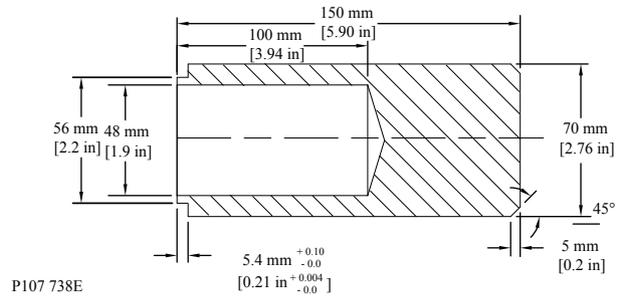
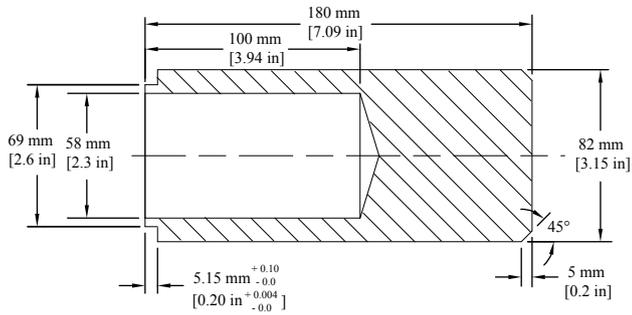
If not using seal installation tool: Do not press seal beyond snap-ring groove. Stop pressing just when you have room to install the retaining ring into the bore. Pressing the seal and snap-ring together ensures proper installation depth. Using the seal installation tool prevents pressing the seal too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

Shaft seal



Minor repair

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



Minor repair

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).

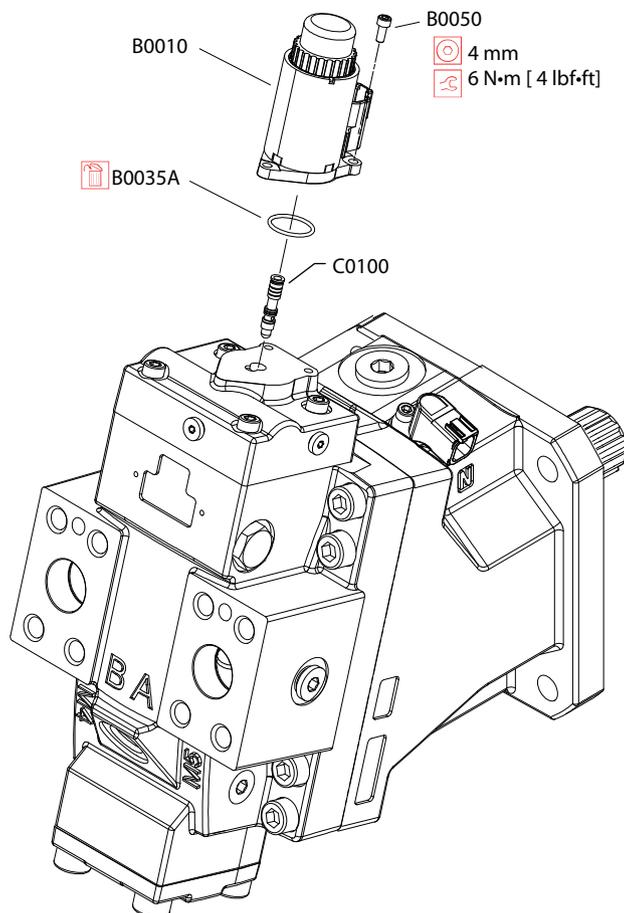
Inspection

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

Replacing solenoid



Minor repair

Hydraulic proportional actuator replacement

Removal

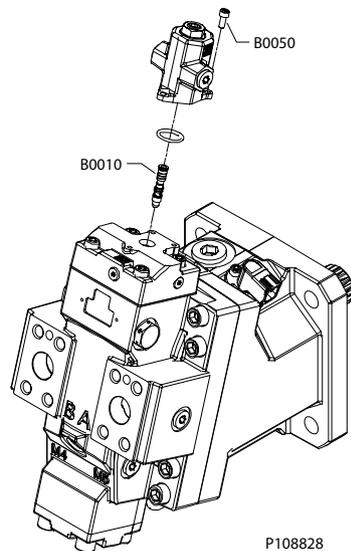
1. Remove three cap screws (B0050) using a 4 mm internal hex wrench.
2. Remove the actuator (B0010).

Inspection

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

Assembly

Replacing actuator



1. Install cap screws (B0050) using a 4 mm internal hex wrench and torque screws to 6 N·m [4 lbf·ft].
2. Test the motor for proper operation.

Minor repair

Control module replacement

Removal

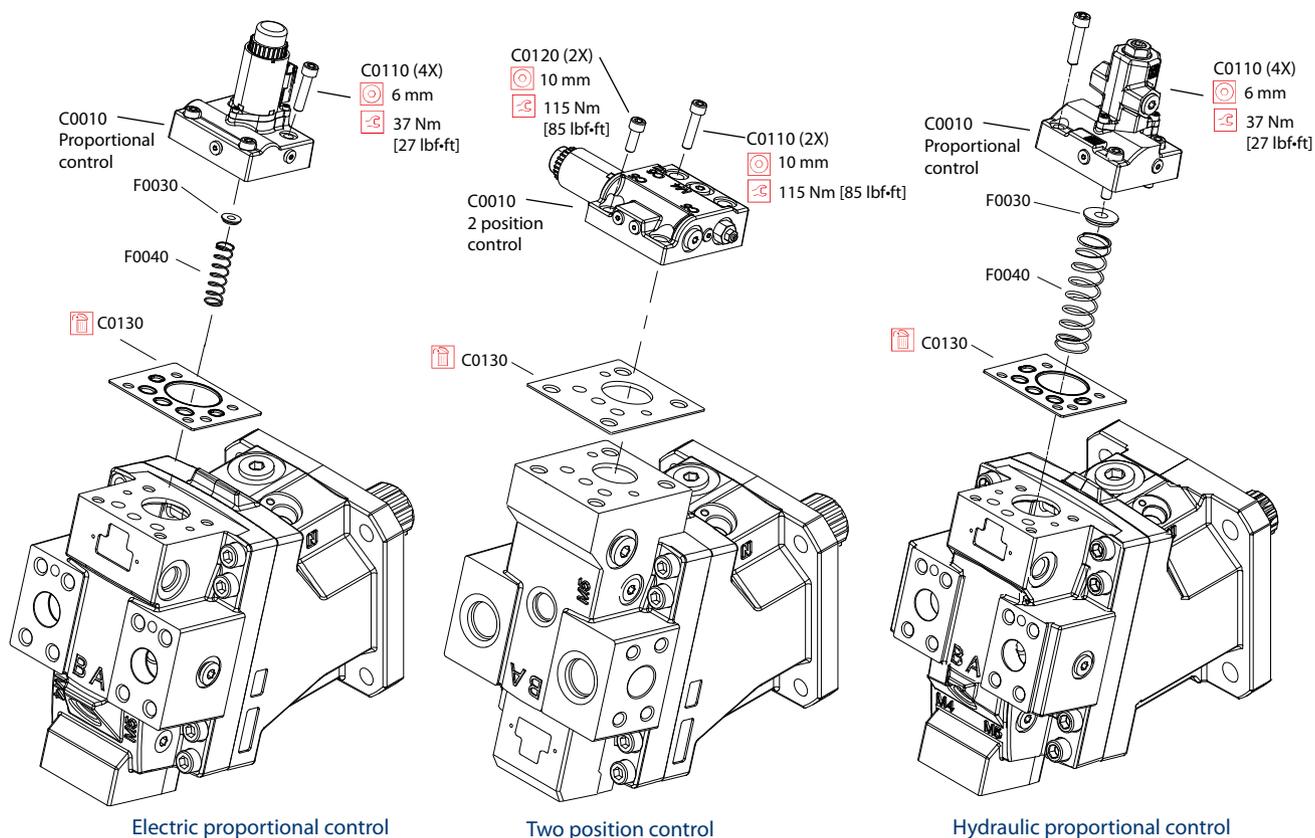
1. Remove four cap screws (C0110 and/or C0120). Refer to table for wrench sizes.
2. Remove control (C0010) from motor. Remove and discard gasket (C0130).
3. Proportional control only - using a magnet, remove spring seat (F0030) and spring (F0040).

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

Control module removal/installation



Minor repair

1. Lubricate and install spring (F0040) and spring seat (F0030) into servo.
2. Install a new gasket (C0130).
3. Position control on motor.
4. Install four cap screws (C0110 and/or C0120).

C0110 and C0120 Wrench Size

Screw	Control	Torque	Internal Hex Wrench
C0110	Electric / Hydraulic proportional	37 N·m [27 lbf·ft]	6 mm
C0110, C0120	Two-position	115 N·m [85 lbf·ft]	10 mm

Minor repair**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).
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).

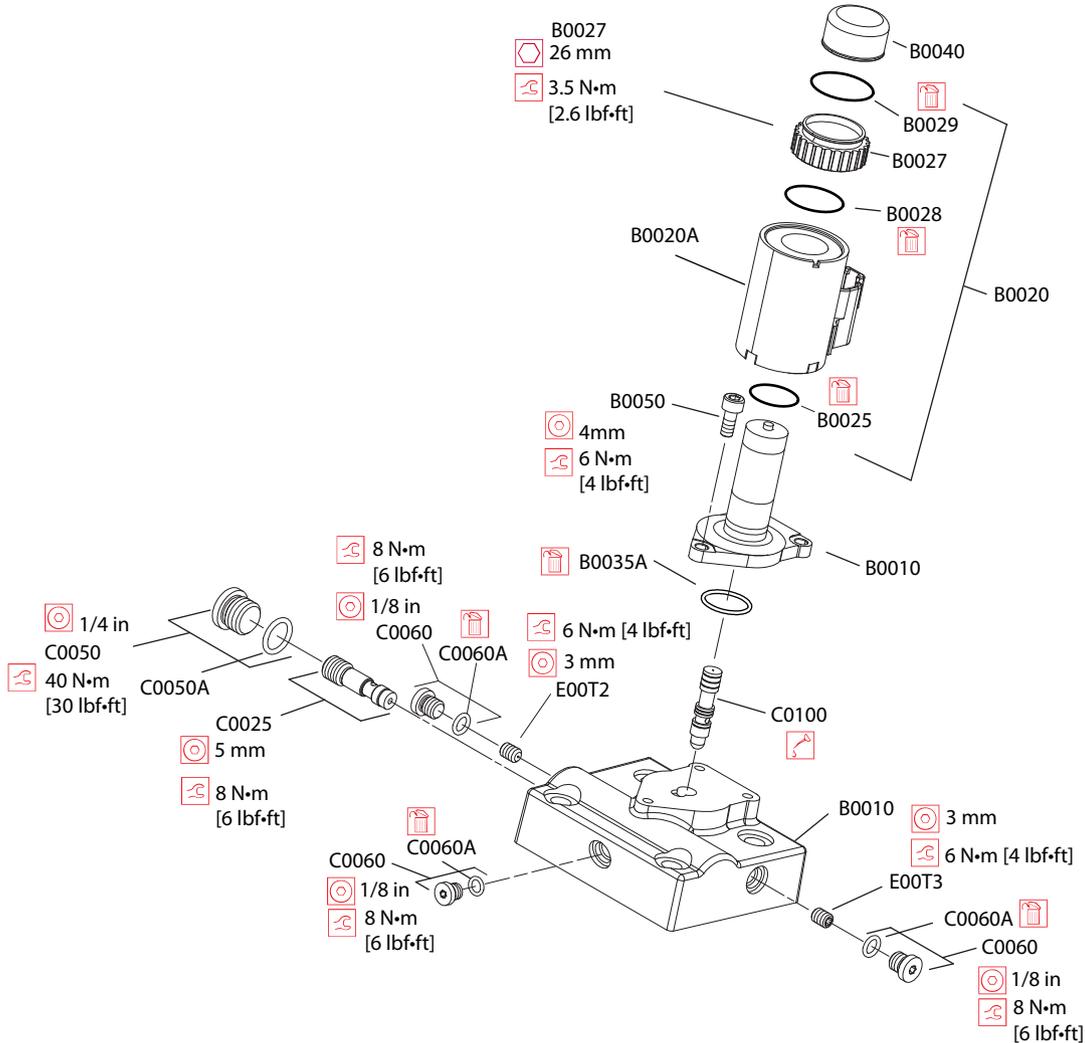
Inspection

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).

Minor repair

Assembly

Proportional control block assembly



1. Install orifices (E00T3 and E00T2) with torque to 6 N·m [4 lbf·ft].
2. Lubricate and install new O-rings (C0060A).
3. Install and torque plugs (C0060) to 8 N·m [6 lbf·ft] using a 1/8 inch internal hex wrench.
4. Lubricate and install spool (C0025) into control block using a 5 mm internal hex wrench, torque to 14 N·m [11 lbf·ft]
5. Install new O-ring (C0050A).
6. Install and torque plug (C0050) to 40 N·m [30 lbf·ft] using a 1/4 inch internal hex wrench.
7. Lubricate and install spool (C0100).
8. Lubricate and install new O-ring (B0035A).
9. Install solenoid (B0010) using a 4 mm internal hex wrench.
10. Install screws (B0050) with torque to 6 N·m [4 lbf·ft].
11. Lubricate and install new O-ring (B0025) onto solenoid.
12. Install coil (B0020A).

Minor repair

13. Lubricate and install new O-ring (B0028) onto solenoid.
14. Install coil nut (B0027) and torque to 3.5 N·m [2.6 lbf·ft] using a 26 mm 12-point socket.

[Do not over torque.](#)

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

Minor repair

Hydraulic proportional control module

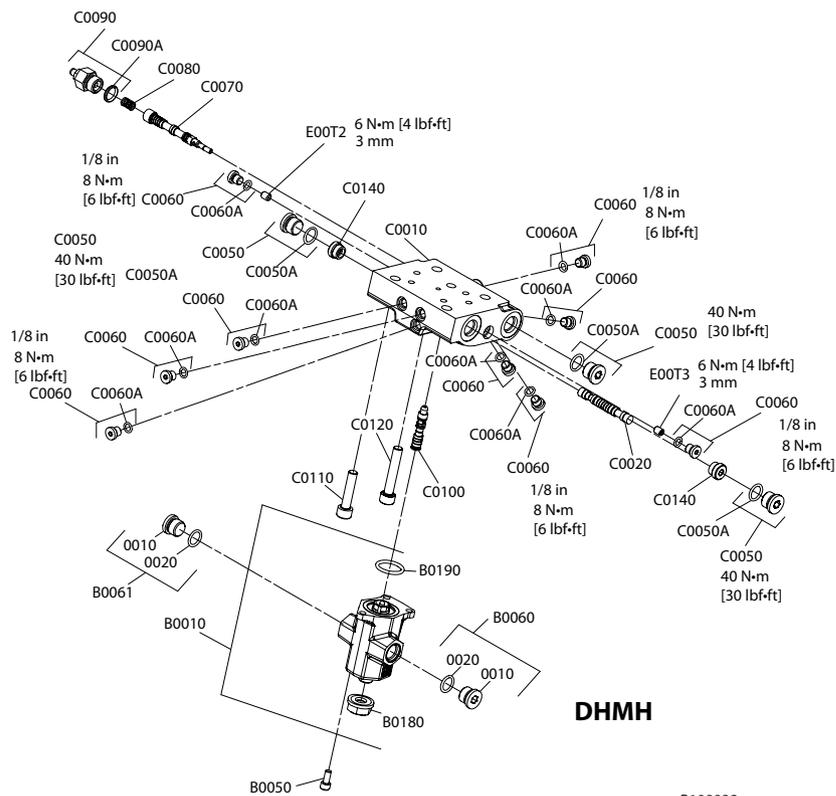
Disassembly

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).

Assembly



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

Minor repair

6. Install and torque plug (C0050) to 40 N•m [30 lbf•ft] using a 1/4 inch internal hex wrench.
7. Install actuator (B0010) using a 4 mm internal hex wrench.
8. Install screws (B0050) with torque to 6 N•m [4 lbf•ft].

If replacing the hydraulic actuator, set the threshold pressure to the proper setting. Refer to [Adjusting threshold on test stand](#) on page 37

Minor repair**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).
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.

Minor repair

1. If previously removed, install orifices (E00T3 and E00T2) using a 3 mm 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 25 N•m [18 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. Install solenoids (B0032) using a 17 mm open-end wrench on the flats provided. Torque to 25 N•m [19 lbf•ft] .
8. Lubricate and install new O-rings (B0024) on solenoids.
9. Install coils (B0022).
10. Lubricate and install new O-rings (B0028).
11. Install coil nuts (B0026) using a 26 mm 12-point socket. Torque to 3.5 N•m [2.6 lbf•ft].

Do not over torque.

Minor repair

Hydraulic two-position control module

Disassembly

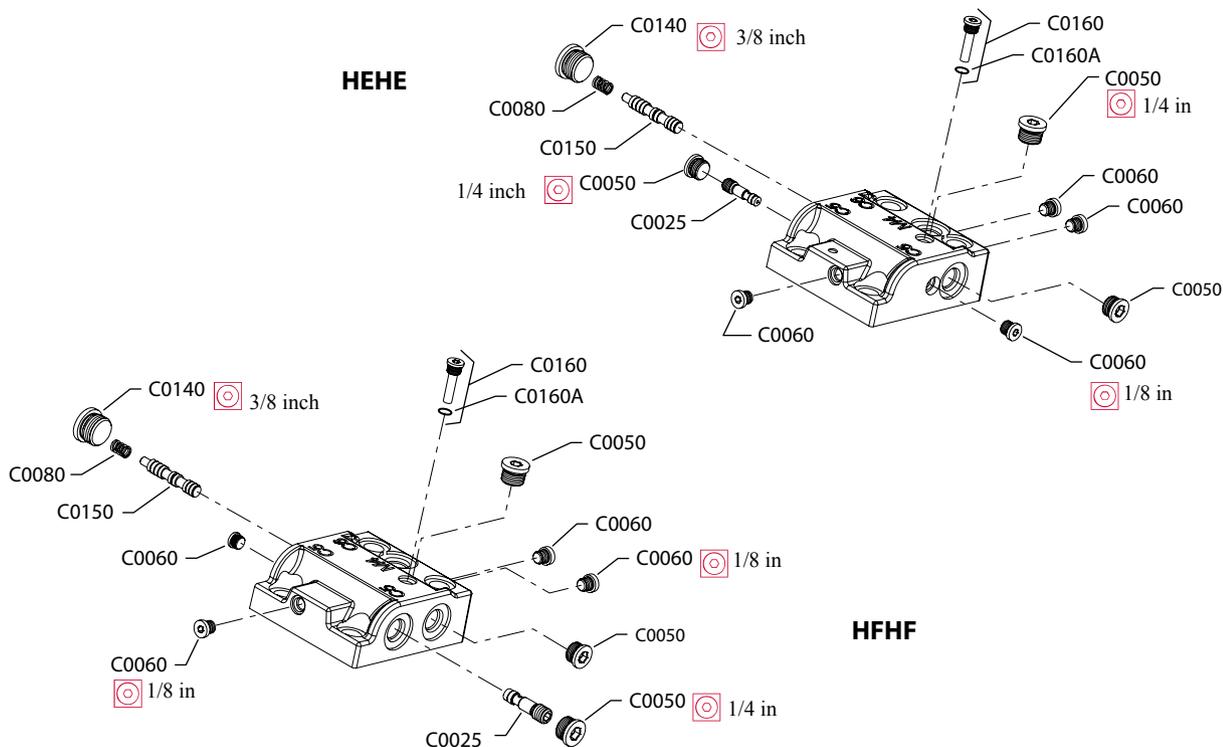
1. Using a 1/8 inch internal hex wrench, remove plug (C0160). Remove and discard O-ring (C0160A).
2. Using a 1/8 inch internal hex wrench, remove three plugs (C0060). Remove and discard O-rings (C0060A).
3. Using a 1/4 inch internal hex wrench, remove two plugs (C0050). Remove and discard O-rings (C0050A).
4. Use a 5mm internal hex wrench to remove the shuttle valve (C0025).
5. Using a 3/8 inch 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

Hydraulic two-position control assembly (HEHE, HFHF)



P108 576E

1. Lubricate and install spool (C0150) and spring (C0080).
2. Using a 3/8 inch internal hex wrench, install plug (C0140). Torque to 25 N•m [18 lbf•ft].
3. Lubricate and install shuttle valve (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].

Minor repair

Hydraulic two-position control module with PCOR

Disassembly

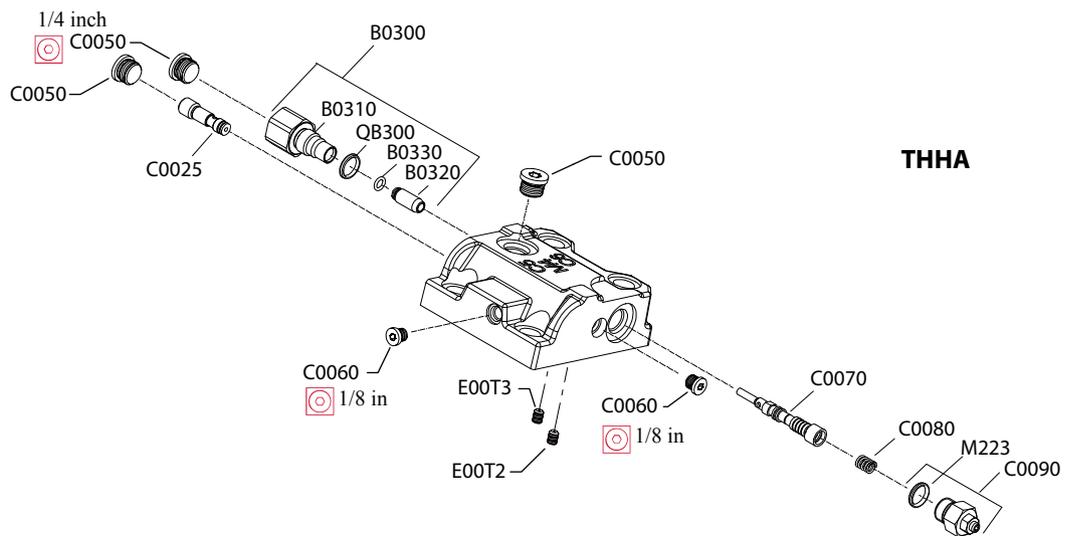
1. Using a 1/8 inch internal hex wrench, remove two plugs (C0060). Remove and discard O-rings (C0060A).
2. Using a 1/4 inch internal hex wrench, remove three plugs (C0050). Remove and discard Orings (C0050A).
3. Use a 5mm internal hex wrench to remove the shuttle valve (C0025).
4. Using a 22 mm hex wrench, 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.

Assembly

Two-position control assembly (THHA)



P108913

1. If previously removed, install orifices (E00T3 and E00T2) using a 3 mm internal hex wrench with 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).
4. Install pressure compensator adjusting plug (C0090) with torque to 25 N•m [15 lbf•ft].
5. Lubricate and install O-ring (QB0300).
6. Install adapter (B0300) with torque to 67 N•m [49 lbf•ft].
7. Lubricate and install spool (C0025).
8. Install three plugs (C0050) using a 1/4 inch internal hex wrench, with torque to 40 N•m [30 lbf•ft].
9. Install two plugs (C0060) using a 1/8 inch internal hex wrench, with torque to 8 N•m [6 lbf•ft].

Minor repair

Hydraulic two-position control module with PCOR and hydraulic BPD

Disassembly

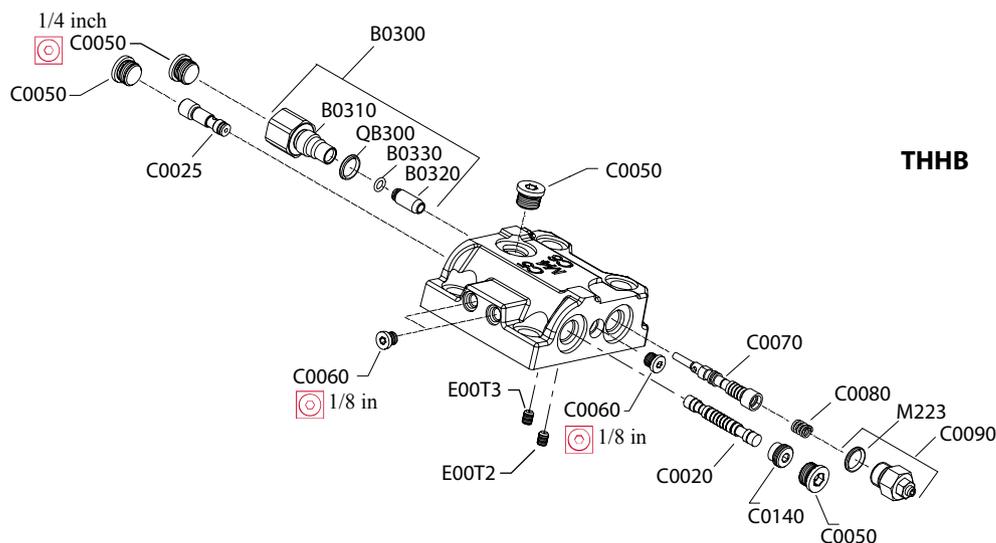
1. Using a 1/8 inch internal hex wrench, remove three plugs (C0060). Remove and discard O-rings (C0060A).
2. Using a 1/4 inch internal hex wrench, remove four plugs (C0050). Remove and discard O-rings (C0050A).
3. Using a 1/4 inch internal hex, remove plug (C0140). Remove spool (C0020).
4. Use a 5mm 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.

Assembly

Two-position control assembly (THHB)



P108923

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).
4. Install pressure compensator adjusting plug (C0090). Torque to 25 N•m [18 lbf•ft].
5. Lubricate and install O-ring (QB0300).
6. Install adapter (B0300). Torque to 67 N•m [49 lbf•ft].
7. Lubricate and install spool (C0020).
8. Using a 1/4 inch internal hex wrench, install plug (C0140). Torque to 14 N•m [10 lbf•ft].

Minor repair

9. Lubricate and install shuttle (C0025).
10. Using a 1/4 inch internal hex wrench, install four plugs (C0050). Torque to 40 N·m [30 lbf·ft].
11. Using a 1/8 inch internal hex wrench, install three plugs (C0060). Torque to 8 N·m [6 lbf·ft].

Minor repair

Maximum displacement limiter two-position controls

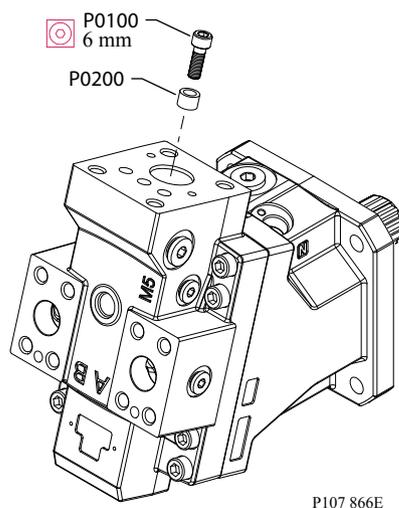
It is not necessary to remove the maximum displacement limiter unless it is being replaced.

Disassembly

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

Assembly

Maximum displacement limiter assembly

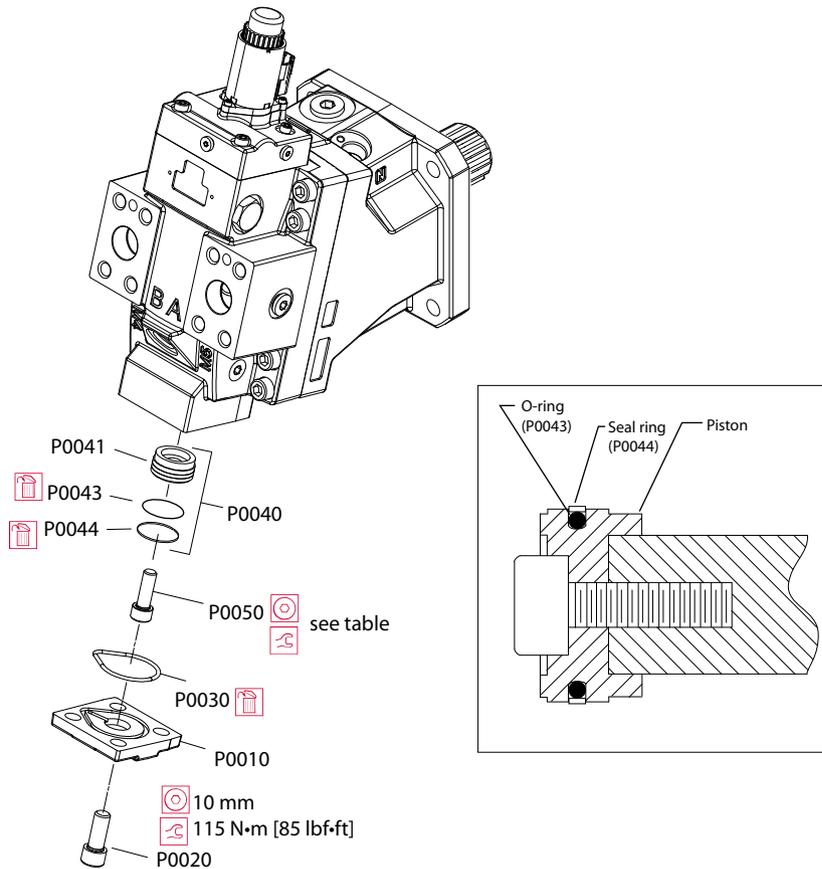


1. Install spacer (P0200) and screw (P0100) using a 6 mm internal hex.
2. Torque screw to 37 N•m [28 lbf•ft].

Minor repair

Servo piston cover – proportional control

Removal



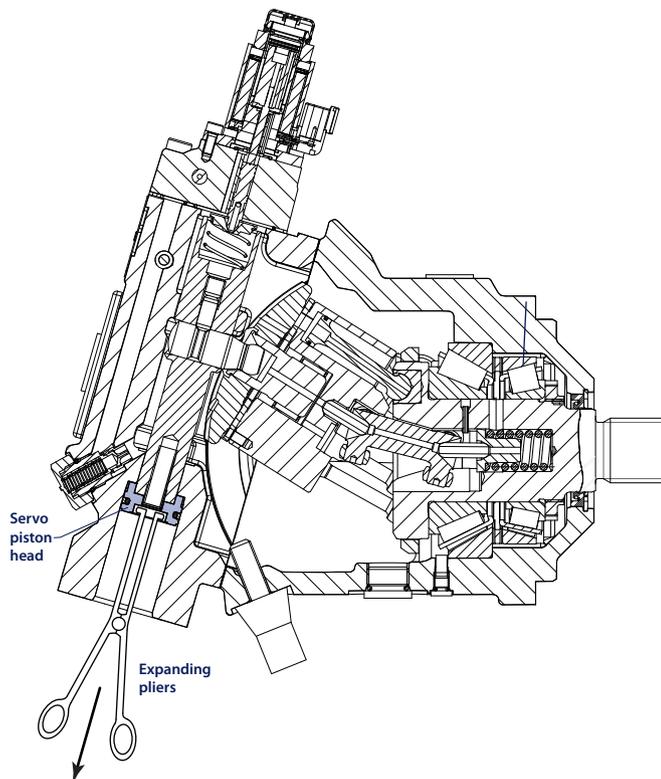
1. Remove four screws (P0020) using a 10 mm internal hex wrench.
2. Remove servo piston cover (P0010).
3. Remove and discard O-ring (P0030).
4. Remove screw (P0050).

Caution

For the safe removal of end cap and servo piston, please refer to the H1B Bent Axis Variable Motor Repair Instructions available to Authorized Service Centers.

Minor repair

- Using expanding pliers, remove piston head (P0040).



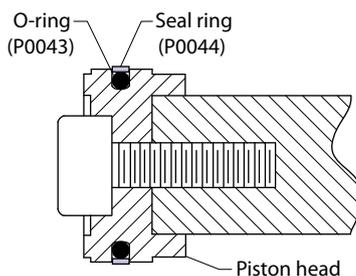
- Remove and discard seal ring (P0044) and O-ring (P0043).

Inspection

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

Assembly

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



Allow seals time to relax before installing piston.

- Install piston and install screw (P0050).

See the table for wrench size below:

Wrench size (internal hex)

Size	060/080	110	160/210/250
Wrench size	8 mm	10 mm	12 mm

Minor repair*Torque for P0050*

Size	060/080	110	160/210/250
Torque	66 N·m [49 lbf·ft]	115 N·m [85 lbf·ft]	213 N·m [157 lbf·ft]

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].

[Refer to the H1B Bent Axis Variable Motor Repair Instructions \(available to Authorized Service Centers\) if further motor disassembly is needed.](#)

Minor repair

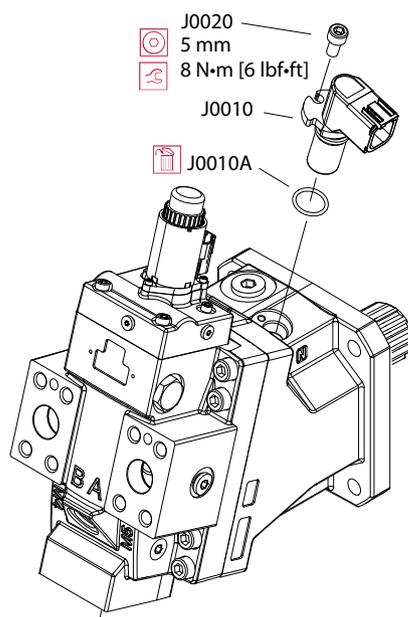
Replace speed sensor

Removal

1. Using a 5 mm internal hex wrench, remove screw (J0020).
2. Remove speed sensor (J0010).
3. Discard O-ring (J0010A).

Assembly

Speed sensor assembly



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

Minor repair

Loop flushing spool

Removal

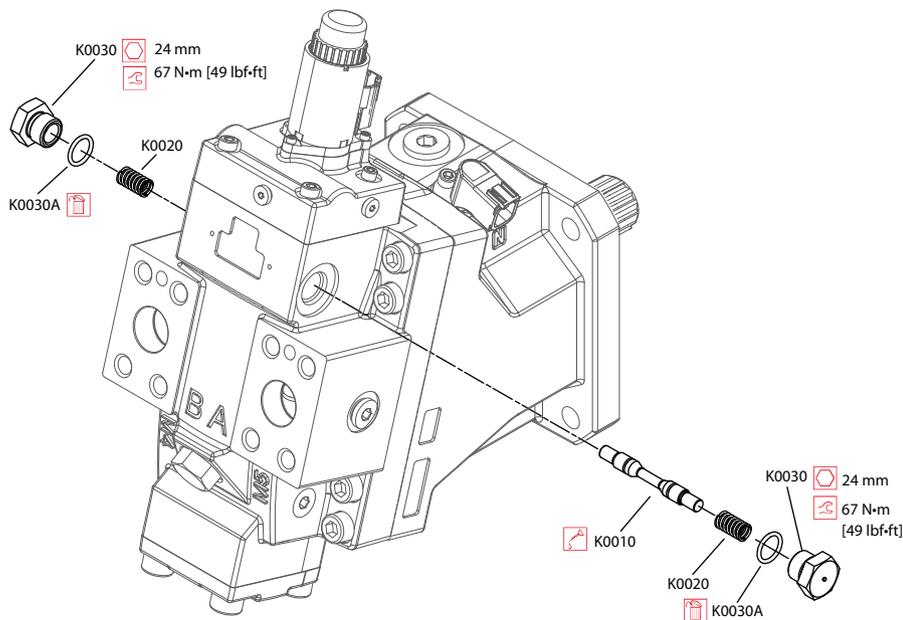
1. Remove plugs (K0030) using a 24 mm hex wrench.
2. Remove and discard O-rings (K0030A).
3. Use a magnet to remove springs (K0020) and spool (K0010).

Inspection

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

Reassembly

Loop flushing reassembly



1. Lubricate and install spool (K0010).
2. Lubricate and install springs (K0020).
3. Lubricate and install new O-rings (K0030A).
4. Install plugs (K0030) using a 24 mm hex wrench with torque to 67 N·m [49 lbf·ft].

Minor repair

Loop flushing charge relief valve

Removal

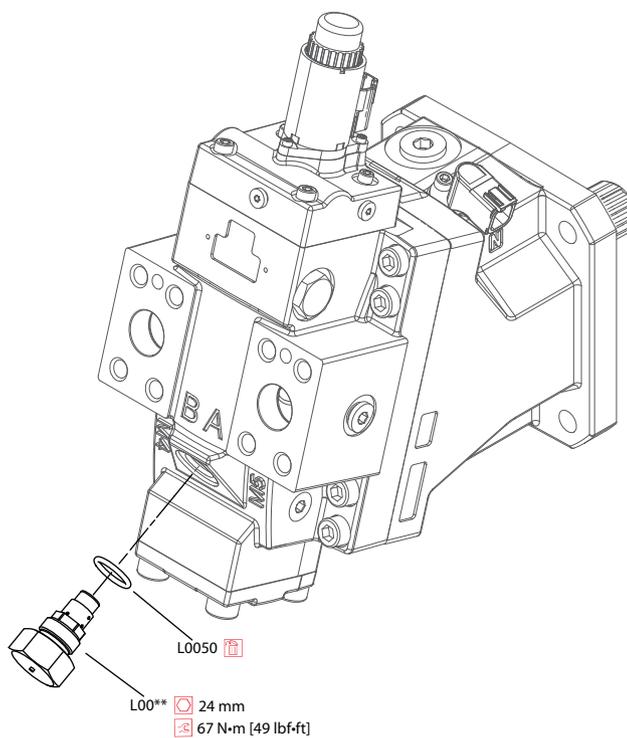
1. Using a 24 mm hex wrench remove valve (L00**)
2. Remove and discard O-ring (L0050).

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

Assembly

1. Install new O-ring (L0050).
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).

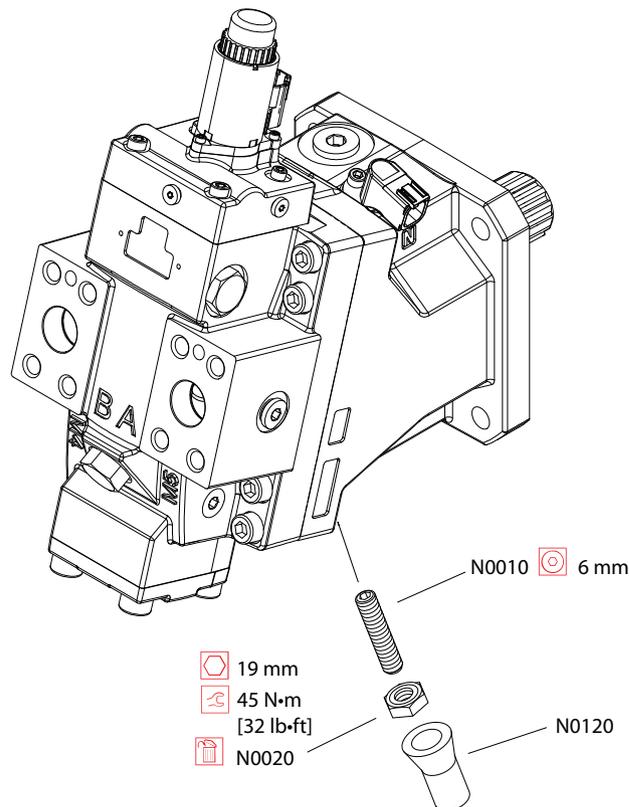
Inspection

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 lbf·ft].
3. Install new cap (N0120).

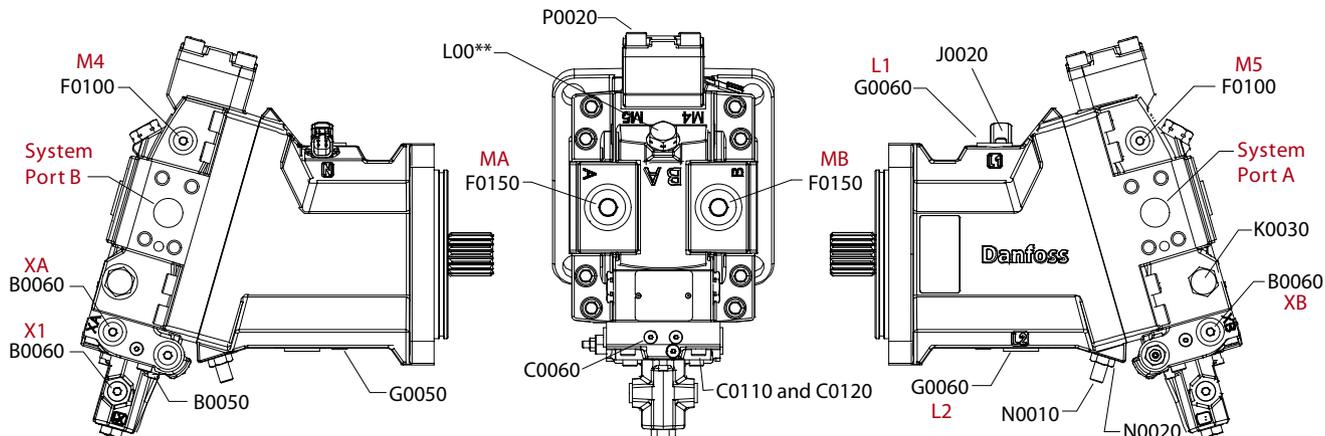
Displacement limiter assembly



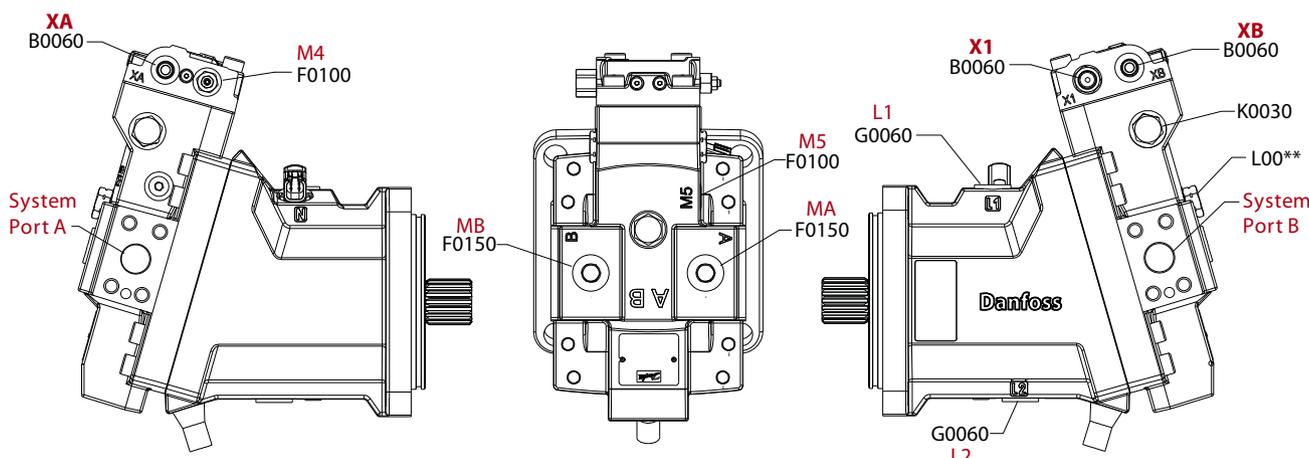
Torque chart

Fasteners, plugs with torque chart

Proportional controls port, plug and fasteners (with radial ported endcap)



Two-position controls port, plug and fasteners (with radial ported endcap)



Fastener size and torque chart

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

Plug size and torque chart

Item	O-ring plug	Wrench size	Torque
B0060	9/16 - 18UNF	1/4 internal hex	40 N·m [30 lbf·ft]
C0050	9/16-18 UNF (not shown)	1/4 internal hex	40 N·m [30 lbf·ft]
C0060	5/16 - 24UNF	3/8 internal hex	8 N·m [5 lbf·ft]

Torque chart

Plug size and torque chart (continued)

Item	O-ring plug	Wrench size	Torque
F0100	9/16 - 18UNF	1/4 internal hex	40 N•m [30 lbf•ft]
F0150 (060)	1-1/16 - 12 UN (Radial endcap)	9/16 internal hex	95 N•m [70 lbf•ft]
F0150 (080, 110, 160, 210, 250)			115 N•m [85 lbf•ft]
G0050	5/16 - 24UNF (SAE and DIN flange)	1/8 internal hex	8 N•m [5 lbf•ft]
G0055	7/16 - 20UNF (Cartridge only/not shown)	3/16 internal hex	8 N•m [5 lbf•ft]
G0060 (060, 080)	7/8 - 14UN	3/8 internal hex	70 N•m [52 lbf•lb]
G0060 (110, 160)	1-1/16 - 12UN	9/16 internal hex	70 N•m [52 lbf•lb]
G0060 (210, 250)	1-5/16 - 12UN	5/8 internal hex	70 N•m [52 lbf•lb]
K0030	M18 - 1.5	24 mm hex	67 N•m [49 lbf•ft]
L00**	M18 - 1.5	24 mm hex	67 N•m [49 lbf•ft]
F0160	9/16-18 UNF (Axial endcap, not shown)	1/4 internal hex	40 N•m [30 lbf•ft]

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