

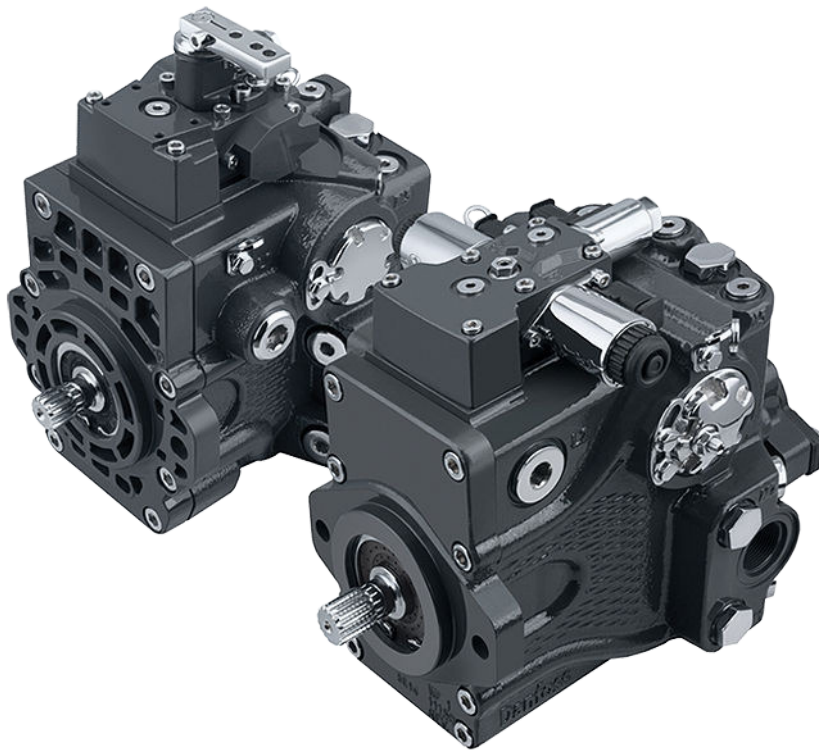
ENGINEERING
TOMORROW



Technical Information

MP1 Axial Piston Pumps

Size 28/32, 38/45



Revision history*Table of revisions*

Date	Changed	Rev
June 2024	Corrected dimensions for 28/32 in Auxiliary mounting drawing section	0603
March 2024	Typo	0602
February 2024	Corrected 15 teeth shaft spline class	0601
January 2024	Added MDC response time	0509
October 2023	Minor correction onto NFPE control	0508
October 2023	Typo	0507
October 2023	Minor correction onto some drawings in Controls section.	0506
July 2022	Added missing loop flushing valve sectional drawing and performance graph	0505
May 2022	Minor update onto 28/32 dimensions with speed sensor	0504
February 2022	Added option A3 endcap option to 38/45cc	0503
January 2022	Corrected the number of charge pressure in operating parameters	0502
December 2021	Added HDC control options	0501
April 2021	Corrected interface with ECU (EDC) graphic	0407
2017 - 2020	Various changes	0102 - 0406
August 2016	First Edition	0101

Contents

General description

Overview.....	6
Features.....	6
System diagram.....	7
Schematic.....	8

Technical specifications

Design specifications.....	9
Technical data.....	9
Operating parameters.....	10
Fluid specifications.....	10

Operation

High Pressure Relief Valve (HPRV) and charge check.....	11
Bypass function.....	11
Charge Pressure Relief Valve (CPRV).....	12
Loop flushing valve.....	13
Electrical displacement control (EDC).....	14
EDC principle.....	14
EDC operation.....	14
Control signal requirements, EDC MP1.....	15
EDC solenoid data.....	15
Control response.....	16
EDC response time.....	16
Manual override (MOR).....	16
Hydraulic displacement control (HDC).....	18
HDC principle.....	18
HDC operation.....	18
Hydraulic signal pressure range.....	19
Pump output flow direction vs. control pressure.....	19
Control response.....	19
Response time, HDC.....	20
Swashplate angle sensor for EDC controls.....	21
Swash plate angle sensor parameters (EDC).....	21
Swash plate angle sensor connector.....	22
Interface with ECU (EDC).....	22
Manual displacement control (MDC).....	22
MDC principle.....	22
MDC operation.....	24
MDC shaft rotation.....	24
Control response.....	25
MDC response time.....	25
Neutral start switch (NSS).....	25
Case gauge port M14.....	26
Lever.....	27
Forward-neutral-reverse electric control (FNR).....	27
FNR principle.....	27
Control response.....	29
Response time, FNR.....	30
Non feedback proportional electric control (NFPE).....	30
Control signal requirements.....	31
Control response.....	32
Response time.....	32
Non-feedback, proportional hydraulic control (NFPH).....	32
Control response.....	33
Response time.....	34
Automotive control (AC).....	34
Control-cut-off valve (CCO valve).....	37
CCO solenoid data.....	38
Brake gauge port with MDC.....	39

Contents

Displacement limiter.....	39
Displacement change (approximate).....	39
Speed sensor.....	40
Temperature Range.....	40
Output pulses.....	40
Mating connectors.....	40
Speed sensor 4.5 – 8 V.....	40
Temperature Signal.....	41

Operating parameters

Input speed.....	42
System Pressure.....	42
Charge pressure.....	43
Charge pump inlet pressure.....	43
Case pressure.....	43
Temperature.....	43
Viscosity.....	44

System design parameters

Filtration system	45
Filtration.....	45
Suction filtration.....	45
Charge pressure filtration.....	46
Independent braking system.....	47
Fluid selection.....	47
Reservoir.....	47
Case drain.....	47
Charge pump.....	47
Charge pump sizing/selection.....	48
Charge pump output flow.....	49
Bearing life and external shaft loading.....	49
Hydraulic unit life.....	51
Mounting flange loads.....	51
Shaft torques.....	53
Shaft selection.....	53
Shaft torque and splines lubrication.....	53
Shaft torque for tapered shafts.....	53
Shaft availability and torque ratings.....	54
Understanding and minimizing system noise.....	54
Sizing equations.....	56

Model code

Model code (A - B - C).....	57
Model code (D).....	58
Model code (F).....	59
Model code (H - J - T).....	60
Model code (K).....	61
Model code (E - M - N - Z - L).....	62
Model code (V - G - W).....	63
Model code (X - Y).....	65

Installation drawings

28/32 ports.....	66
38/45 ports.....	67
28/32 dimensions.....	68
28/32 dimensions with speed sensor.....	70
38/45 dimensions.....	71
38/45 dimensions with speed sensor.....	74
Input shafts: option G4, F6 (SAE B, 13 teeth).....	75
Input shafts: option G1, F1 (SAE B, 14 teeth).....	76
Input shafts: option G5, F5 (SAE B, 15 teeth).....	77

Contents

Input shafts: option A7, A9 (SAE B, straight key shaft).....78
 Input shafts: option G6, G7 (SAE B, 19 teeth)..... 79
 Input shafts: option A6, A8 (SAE B, straight key shaft).....80
 Input shafts: option F2, F3 (SAE B, taper key shaft)81
 Tapered shaft customer acknowledgement.....81
 Auxiliary mounting: option A16, B16, C16, D16, E16, F16 (SAE A, 9 teeth)..... 82
 Auxiliary mounting: option A19, B19, C19, D19, E19, F19 (SAE A, 11 teeth).....83
 Auxiliary mounting: option A22, B22, C22, D22, E22, F22 (SAE B, 13 teeth)..... 84
 Auxiliary mounting: option A25, B25, C25, D25, E25, F25 (SAE B-B 15 teeth) 85

Controls

Electric displacement control (EDC).....86
 Electric displacement control with CCO (EDC+CCO)..... 87
 EDC with ASNSR.....88
 Hydraulic displacement control (HDC)..... 89
 Manual displacement control (MDC).....90
 MDC with NSS option M2.....91
 MDC with CCO options M3, M4.....92
 MDC with NSS and CCO options M5, M6.....93
 Forward-neutral-reverse (FNR).....94
 Non-feedback proportional electric (NFPE)..... 95
 Non-feedback proportional hydraulic (NFPH).....96
 Automotive control (AC).....97
 AC connectors dimensions.....98

Filtration

Suction filtration: option S.....99
 Remote full flow charge pressure filtration: option R..... 100
 External full flow charge pressure filtration: option E..... 101

General description

MP1 overview

The MP1 pump is a variable displacement axial piston pump intended for closed circuit medium power applications. The swashplate motion is controlled via compact hydraulic servo control system. A variety of controls are available. These include mechanic or electric actuated feedback controls, electric or hydraulic actuated non-feedback type controls, and a three-position electric control.. These controls feature low hysteresis and responsive performance.

MP1 features

Designed for quality and reliability

- Uniform design concept across frame sizes
- Single piece housing to minimize leaks
- Technologically advanced kit and servo system
- Predictable, low friction swashplate bearing for precise machine control

Machine integration benefits

- Industry leading pump length
- Clean side for easier machine integration
- Metric and Inch O-ring boss and Split flange (38/45 only) system port interfaces
- Standard connection interfaces

Greater total efficiency

- Increased pump efficiency
- Lower control pressure for less power consumption

Control options

- Electrical displacement control (EDC)
- Manual displacement control (MDC)
- Hydraulic displacement control (HDC)
- Automotive control (AC-1, AC-2)
- Forward-neutral-reverse (FNR)
- Non-feedback proportional electric (NFPE)
- Non-feedback proportional hydraulic (NFPH)
- Common control across entire family

Expanded functionality

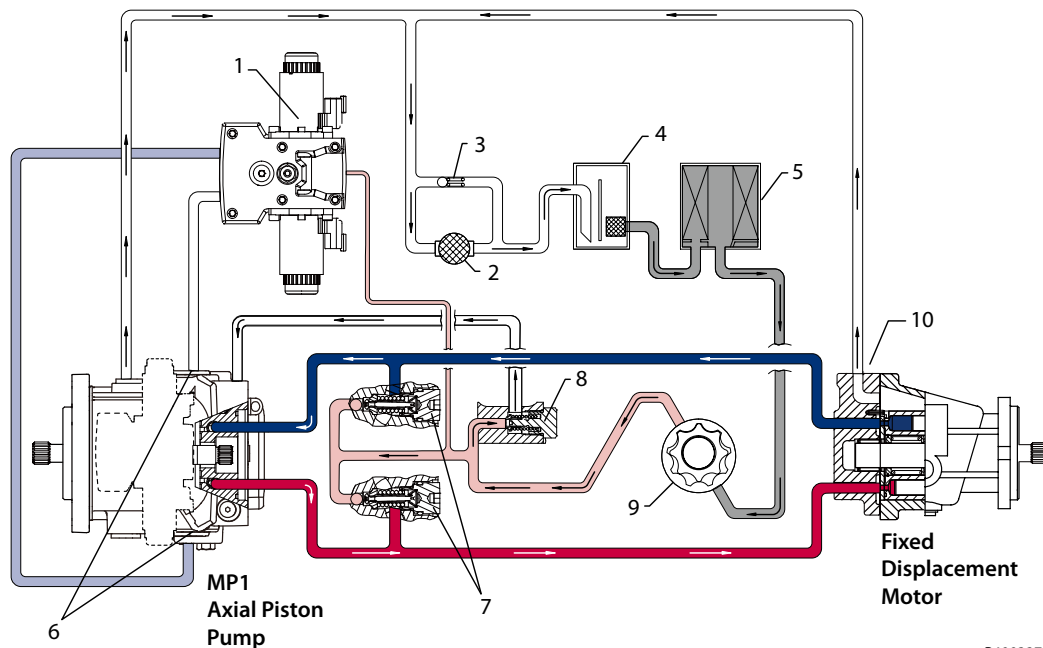
- PLUS+1® Compliant control and options
- Easy integration with Telematics
- Integrated Flushing valve available

Modularity

- Common control, charge pump and auxiliary pad options
- Easy and quick conversion to the right configuration

General description

MP1 system diagram



P400327

- | | | |
|--|------------------------|--------------------------|
| Servo Pressure | System High Pressure | System Low Pressure |
| Charge Pressure | Case Flow | Suction Flow |
| 1. Control | 2. Heat Exchanger | 3. Heat Exchanger Bypass |
| 4. Reservoir | 5. Filter | 6. Servo Piston |
| 7. Check Valves with High Pressure Relief Valves | 8. Charge Relief Valve | 9. Charge Pump |
| 10. Case Drain | | |

MP1 28/32

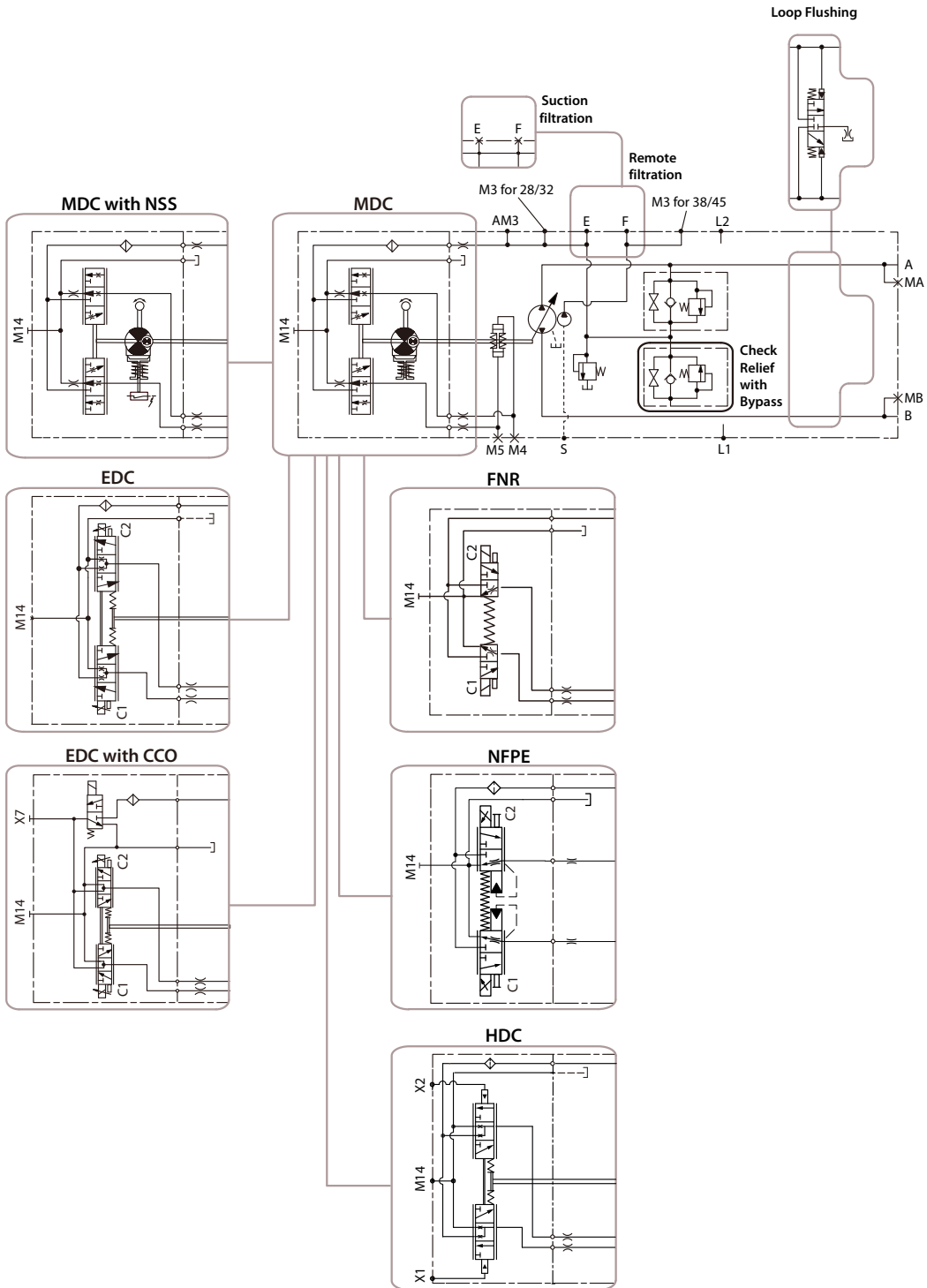


MP1 38/45



General description

MP1 schematic



Technical specifications

MP1 design specifications

Features	MP1
Design	Axial piston pump with variable displacement using compact servo piston control.
Direction of input rotation	Clockwise or counterclockwise
Recommended installation position	Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, HDC, FNR, NFPE, NFPH, AC-1, AC-2 and MDC control. Vertical input shaft installation is acceptable. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for non-conformance to these guidelines.
Filtration configuration	Suction or charge pressure filtration

MP1 technical data

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

Technical specifications
MP1 operating parameters

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

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

MP1 fluid specifications

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

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

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

³ At the hottest point, normally case drain port.

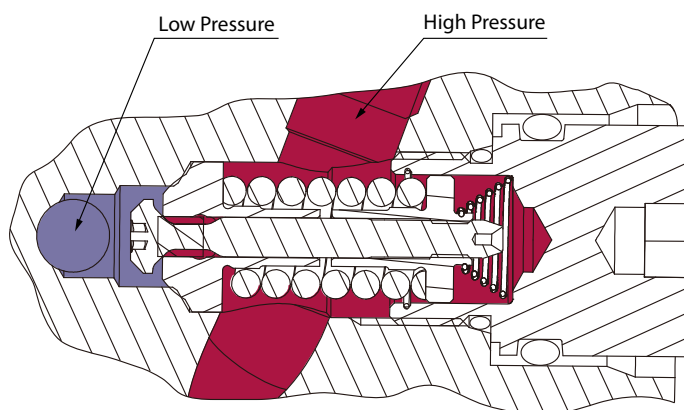
Operation

MP1 high pressure relief valve (HPRV) and charge check

All MP1 pumps are equipped with a combination high pressure relief and charge check valve. The high-pressure relief function is a dissipative (with heat generation) pressure control valve for the purpose of limiting excessive system pressures. The charge check function acts to replenish the low-pressure side of the working loop with charge oil. Each side of the transmission loop has a dedicated HPRV valve that is non-adjustable with a factory set pressure. When system pressure exceeds the factory setting of the valve, oil is passed from the high pressure system loop, into the charge gallery, and into the low pressure system loop via the charge check.

The pump order code allows for different pressure settings to be used at each system port. The system pressure order code for pumps with only HPRV is a reflection of the HPRV setting.

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



P400353

Bypass function

The bypass function allows a machine or load to be moved without rotating the pump shaft or prime mover. The single pump HPRV valve also provides a loop bypass function when each of the two HPRV hex plugs are mechanically backed out three full turns.

Engaging the bypass function mechanically connects both A & B sides of the working loop to the common charge gallery.

Possible damage to hydromotor(s).

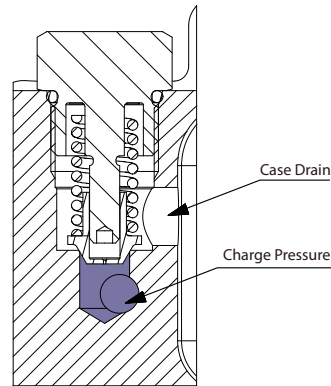
Excessive speeds and extended load/vehicle movement must be avoided. The load or vehicle should be moved not more than 20% of maximum speed and for a duration not exceeding 3 minutes. When the bypass function is no longer needed, care should be taken to re-seat the HPRV hex plugs to the normal operating position.

Operation

MP1 charge pressure relief valve (CPRV) function

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

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



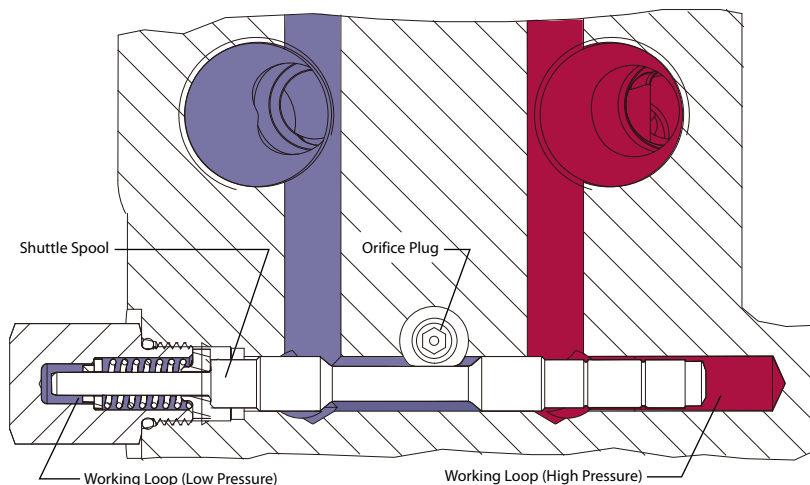
P400341

Operation

Loop flushing valve

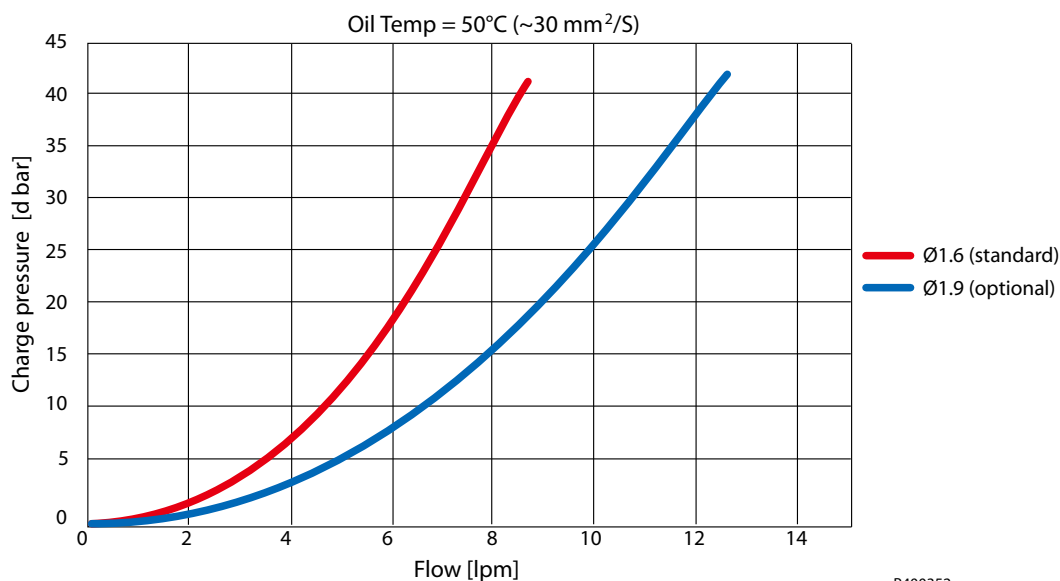
MP1 pumps are available with an optional integral loop flushing. A loop flushing valve will remove heat and contaminants from the main loop at a rate faster than otherwise possible.

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



P400342

Loop flushing performance



P400352

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

Operation

Electrical displacement control (EDC)

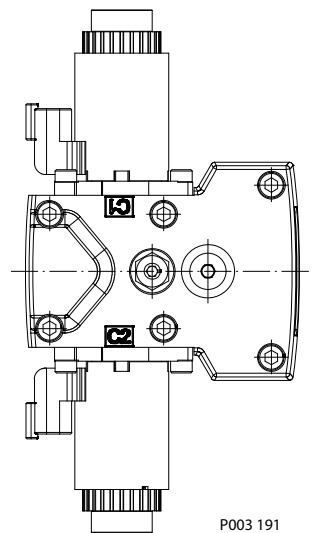
EDC principle

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

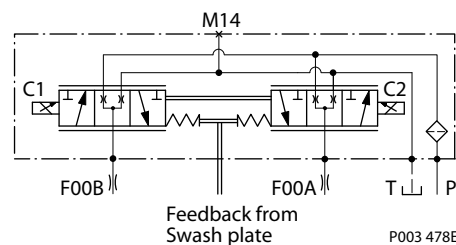
The Electrical Displacement Control (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure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

A 170 μm screen is located in the supply line immediately before the control porting spool.

EDC control



EDC schematic



EDC operation

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

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

Operation

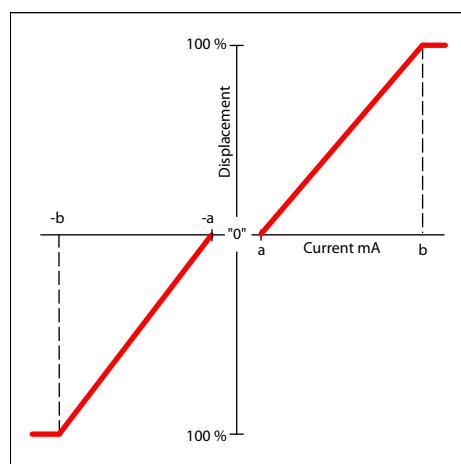
The EDC incorporates a positive neutral deadband as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold current is reached, the swashplate is positioned directly proportional to the control current. To minimize the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

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

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

Control signal requirements, EDC MP1

Pump displacement vs. control current



EDC control current

Voltage		12 V _{DC}	24 V _{DC}
Minimum current to stroke pump	a*	640 mA	330 mA
	b	1640 mA	820 mA
Pin connections		any order	

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

EDC solenoid data

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Operation

Pump output flow direction vs. control signal

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

* For coil location see Installation drawings.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

$\Delta p = 250 \text{ bar [3626 psi]}$

Charge pressure = 20 bar [290 psi]

Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]

Speed = 1800 min⁻¹ (rpm)

MP1 EDC response time

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

Manual override (MOR)

Initial actuation of the o-ring seal MOR plunger will require a force of 45 N. Additional actuations typically require less force to engage the MOR plunger. Proportional control of the pump via the MOR is not intended. The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke.

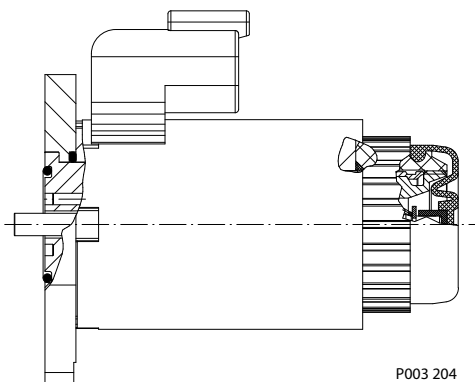
Unintended MOR operation can cause the pump to go into stroke.

The vehicle or device must always be in a safe condition (example: vehicle lifted off the ground) when using the MOR function. The MOR should be engaged anticipating a full stroke response from the pump.

Refer to control flow table for the relationship of solenoid to direction of flow.

Operation

MOR and schematic



Operation

Hydraulic displacement control (HDC)

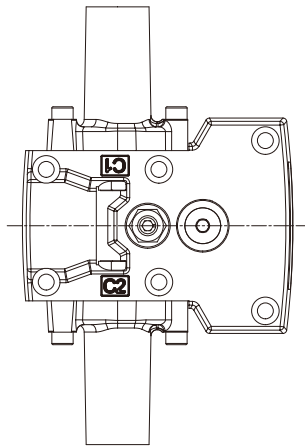
HDC principle

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

The HDC control uses a hydraulic input signal to operate a porting spool, which ports hydraulic pressure to either side of a double acting servo piston. The hydraulic signal applies a force input to the spool which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction. Under some circumstances, such as contamination, the porting spool could stick and cause the pump to stay at some displacement.

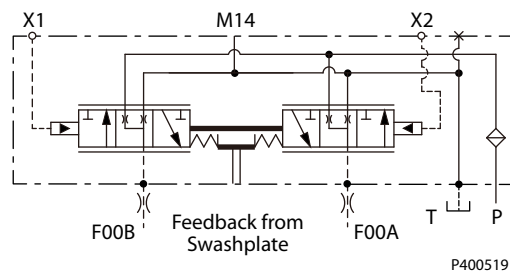
A serviceable 175 µm screen is located in the supply line immediately before the control porting spool.

HDC control



P400520

HDC schematic



P400519

HDC operation

HDC's are hydraulically driven control which ports hydraulic pressure to either side of a porting spool, which pressurizes one end of the servo piston, while draining the other end to case. Pressure differential across the servo piston moves the swashplate.

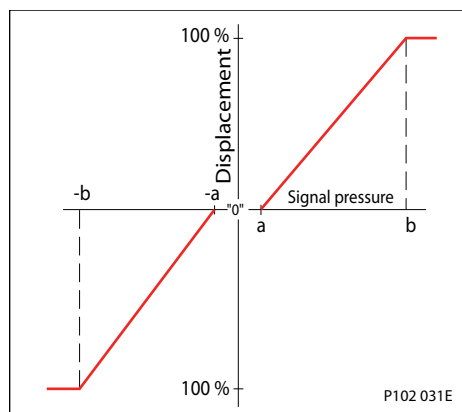
A swashplate feedback link, opposing control linkage, and a linear spring provide swashplate position force feedback to the hydraulic pressure. As hydraulic pressures in the operating loop change with load, the control assembly and servo/swashplate system work constantly to maintain the commanded position of the swashplate.

Operation

The HDC incorporates a positive neutral dead band as a result of the control spool porting, preloads from the servo piston assembly, and the linear control spring. Once the neutral threshold point is reached, the swashplate is positioned directly proportional to the control pressure.

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

Pump displacement vs signal pressure



Hydraulic signal pressure range

Option	Type	a*	b*	Max. pressure
T1	Standard	4.2 bar	16.2 bar	30 bar
T2	Option	3 bar	11.6 bar	30 bar

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

Pump output flow direction vs. control pressure

Shaft rotation HDC	Clockwise (CW) seen from shaft		Counter Clockwise (CCW) seen from shaft	
	X1	X2	X1	X2
Port energized	X1	X2	X1	X2
Port A	Out (high)	In (low)	In (low)	Out (high)
Port B	In (low)	Out (high)	Out (high)	In (low)
Servo port high pressure	M4	M5	M4	M5

For appropriate performance of HDC characteristic, keep the drain pressure of pilot valve to be equal or slightly higher than pump case pressure.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

$$\Delta p = 250 \text{ bar [3626 psi]}$$

$$\text{Charge pressure} = 20 \text{ bar [290 psi]}$$

$$\text{Viscosity and temperature} = 30 \text{ mm}^2/\text{s [141 SUS]} \text{ and } 50 \text{ }^\circ\text{C [122 }^\circ\text{F]}$$

$$\text{Speed} = 1800 \text{ min}^{-1} \text{ (rpm)}$$

Operation**Response time, HDC**

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

Operation

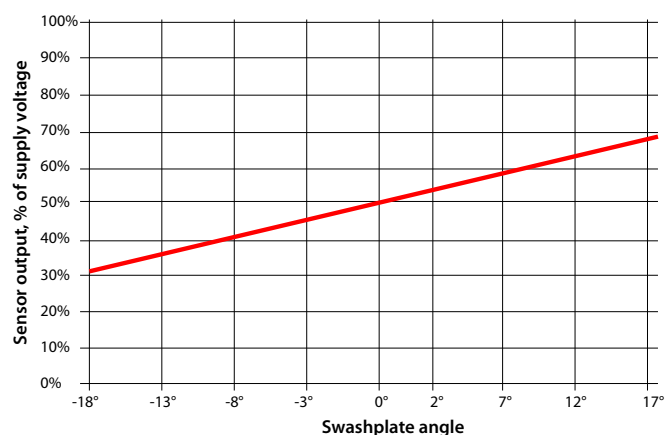
Swashplate angle sensor for EDC controls

The angle sensor detects the swash plate position with an accuracy dependent upon the calibration effort done for the application and direction of rotation from the neutral position. At minimum the sensor can be used for forward, neutral and reverse (FNR) detection.

The sensor works on the hall-effect technology. The implemented technology is based on a measurement of the magnetic field direction in parallel to the chip surface. This field direction is converted to a voltage signal at the output.

Enhanced calibration of the non-linear behavior leads to more exact calculation of the pump swashplate angle. The 4-pin DEUTSCH connector is part of the sensor housing. The swashplate angle sensor is available for all EDC controls for 12 V and 24 V.

Swashplate angle vs. output of supply voltage



Warning

Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Contact your Danfoss representative in case the angle sensor will be used for safety functions.

Swash plate angle sensor parameters (EDC)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.5 V _{DC}	5 V _{DC}	5.5 V _{DC}
Supply protection	–	–	18 V _{DC}
Pump neutral output (% of supply voltage)	–	50%	–
Working range (swash plate angle)	–18°	–	18°
Required supply current	–	–	30 mA
Output current signal	–	9 mA	11 mA
Working temperature	–40 °C	80 °C	115 °C

Electrical Protection	Standard	Class
IP Rating	IEC 60 529	IP 67
	DIN 40 050, part 9	IP 69K with mating connector
EMC Immunity	ISO 11452-2	100 V/m

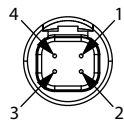
Operation

Calibration of the sensor output within the software is mandatory. Vehicle neutral thresholds in the software ($\pm 0.5^\circ$) are vehicle dependent and must consider different conditions, example: system temperature, system pressure and/or shaft speed.

For safety function: If the sensor fails (invalid signal $< 10\%$ or $> 90\%$ of supply voltage), it must be sure that the ECU will go into a diagnostic mode and shift into limited mode in order for the driver to take the full control or the mechanical breaks should be activated. Strong magnetic fields in the proximity of the sensor can influence the sensor signal and must be avoided.

Swash plate angle sensor connector

Connector DEUTSCH, 4-pin



Pin assignment:

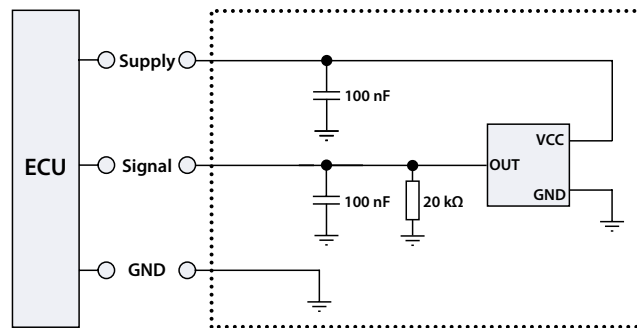
1. Ground (GND)
2. Not connected
3. Output signal 1 (SIG 1)
4. Supply (V+)

Connector order numbers

Description	Quantity	Order number
Mating connector DEUTSCH DTM06-4S-E004	1	11105824
Wedge lock WM-4S	1	not available
Socket contact 0462-201-2031	3	
Mating connector kit	1	11212713

Interface with ECU (EDC)

Interface with ECU diagram



Manual displacement control (MDC)

MDC principle

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

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

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

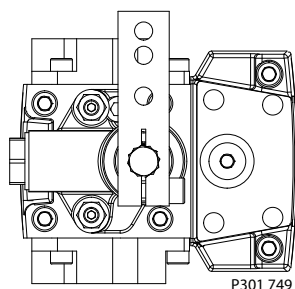
Operation

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

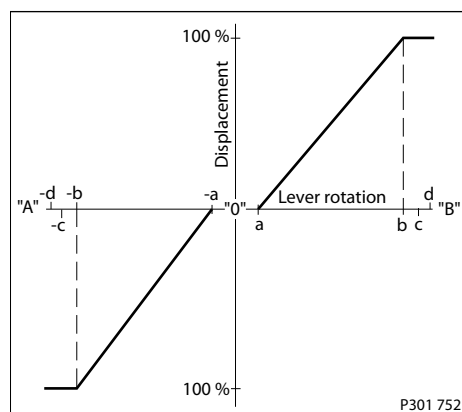
A 170 µm screen is located in the supply line immediately before the control porting spool.

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

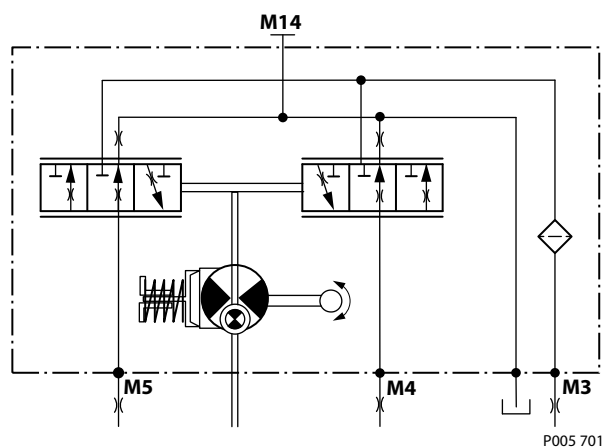
Manual Displacement Control



Pump displacement vs. control lever rotation



MDC schematic diagram



Where:

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

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

Operation

Required customer end stop – **c** = 36° ±3°
 Internal end stop – **d** = 40°

MDC torque

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

MDC operation

The MDC provides a mechanical dead-band required to overcome the tolerances in the mechanical actuation. The MDC contains an internal end stop to prevent turning the handle into any inappropriate position.

The MDC provides a permanent restoring moment appropriate for turning the MDC input shaft back to neutral position only. This is required to take the backlash out of the mechanical connections between the Bowden cable and the control.

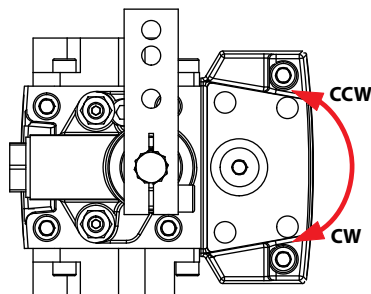
High case pressure may cause excessive wear and the NSS to indicate that the control is not in neutral position. In addition, if the case pressure exceeds 5 bar there is a risk of an insufficient restoring moment. The MDC is designed for a maximum case pressure of 5 bar and a rated case pressure of 3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

- Customers must install some support to limit the setting range of their Bowden cable to avoid an overload of the MDC.
- Customers can apply their own handle design but they must care about a robust clamping connection between their handle and the control shaft and avoid overload of the shaft.
- Customers can connect two MDC's on a tandem unit in such a way that the actuation force will be transferred from the pilot control to the second control. The kinematic of the linkages must ensure that either control shaft is protected from torque overload.

Caution

Using the internal spring force on the input shaft is not an appropriate way to return the customer connection linkage to neutral, or to force a Bowden cable or a joystick back to neutral position. It is not applicable for any limitation of the Bowden cable stroke, except the applied torque to the shaft will never exceed 20 N·m.

MDC shaft rotation



Pump shaft rotation*	Clockwise (CW)		Counter-clockwise (CCW)	
	CW	CCW	CW	CCW
Port A	in (low)	out (high)	out (high)	in (low)
Port B	out (high)	in (low)	in (low)	out (high)
Servo port high pressure	M5	M4	M5	M4

* As seen from shaft side.

Operation

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

$\Delta p = 250 \text{ bar}$ [3626 psi]

Charge pressure = 20 bar [290 psi]

Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]

Speed = 1800 min⁻¹ (rpm)

MP1 MDC response time

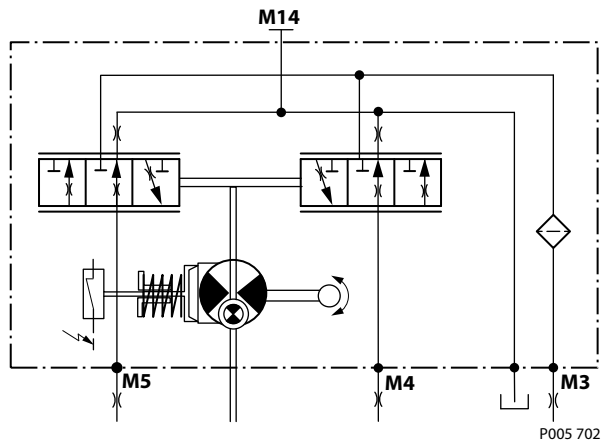
Code	Orifice description (mm)				Stroking direction (sec)			
	P	A	B	Tank (A +B)	Neutral to full flow		Full flow to neutral	
					28/32	38/45	28/32	38/45
C1	–	0.8	0.8	–	1.3	1.8	0.9	1.2
C2	–	1.3	1.3	–	0.5	0.7	0.4	0.5
C3	–	–	–	–	0.3	0.3	0.3	0.3
C4	–	1.0	1.0	–	0.8	1.1	0.6	0.8
C6	–	–	–	1.0	0.5	1.0	0.5	0.7
C7	–	–	–	1.3	0.4	0.7	0.5	0.5
C8	0.8	–	–	0.6	1.5	2.6	1.4	1.9
C9	1.0	–	–	0.6	1.3	2.4	1.1	1.8
D1	1.0	–	–	0.8	0.9	1.6	0.8	1.1
D2	1.3	–	–	0.8	0.8	1.5	0.7	1.1
D3	1.3	–	–	1.0	0.6	1.1	0.6	0.8
D4	1.3	1.3	1.3	1.0	0.8	1.3	0.7	0.9
D5	0.6	0.8	0.8	0.6	3.2	4.0	2.0	2.9
E2	1.0	0.8	0.8	0.8	2.1	2.9	1.2	1.7

Neutral start switch (NSS)

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

Operation

Neutral start switch schematic



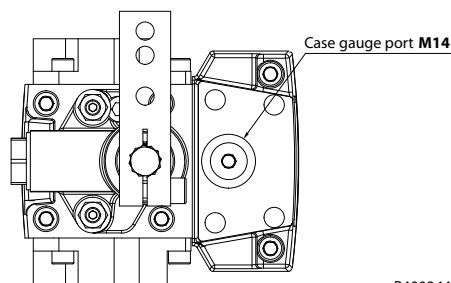
Neutral start switch data

Max. continuous current with switching	8.4 A
Max. continuous current without switching	20 A
Max. voltage	36 V _{DC}
Electrical protection class	IP67 / IP69K with mating connector

Case gauge port M14

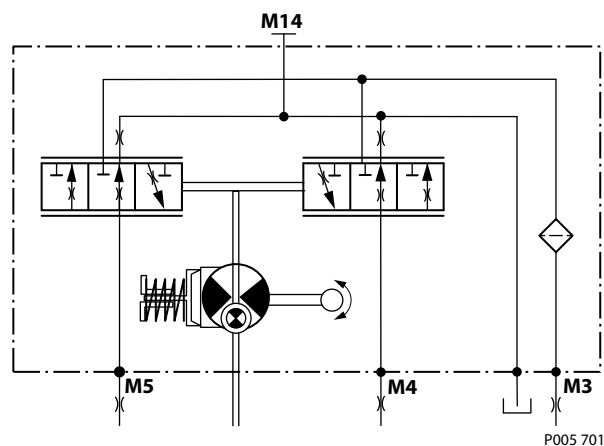
The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

MDC w/h drain port shown



Operation

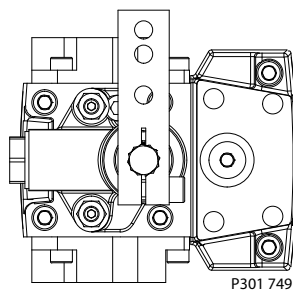
MDC schematic diagram



Lever

MDC controls are available with optional lever/handle. Align with Settings: Y module in the model code.

Standard orientation 90° from input shaft



Forward-neutral-reverse electric control (FNR)

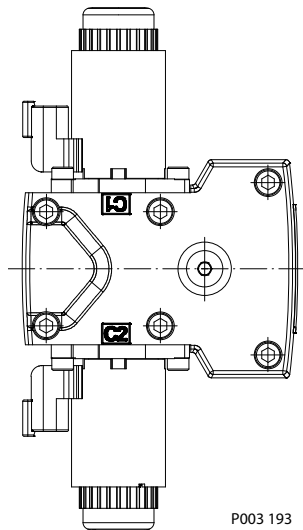
FNR principle

The 3-position **FNR** control uses an electric input signal to switch the pump to a full stroke position. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

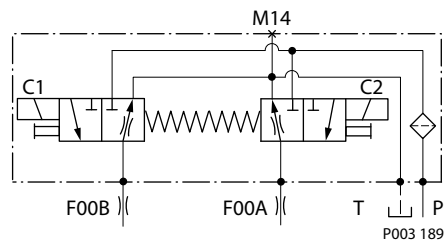
A 170 µm screen is located in the supply line immediately before the control porting spool.

Operation

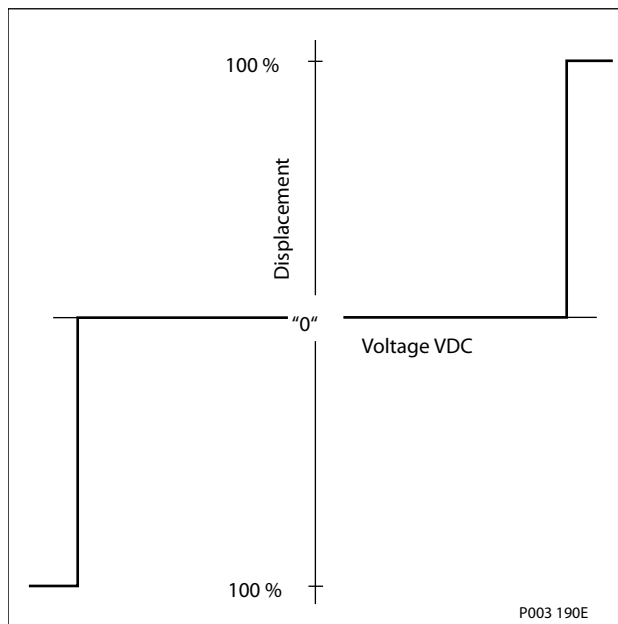
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



Pump displacement vs. electrical signal

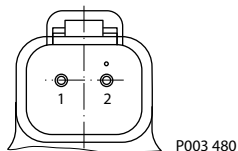


Operation

Control current

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

DEUTSCH connector, 2-pin



Connector ordering data

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

Solenoid data

Voltage	12 V	24 V
Minimum supply voltage	9.5 V _{DC}	19 V _{DC}
Maximum supply voltage (continuous)	14.6 V _{DC}	29 V _{DC}
Maximum current	1050 mA	500 mA
Nominal coil resistance @ 20 °C [70 °F]	8.4 Ω	34.5 Ω
PWM Range	70-200 Hz	
PWM Frequency (preferred)*	100 Hz	
IP Rating (IEC 60 529) + DIN 40 050, part 9	IP 67 / IP 69K (part 9 with mating connector)	
Bi-directional diode cut off voltage	28 V _{DC}	53 V _{DC}

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

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

* For coil location see Installation Drawings.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure.

Operation

A swash-plate response times table is available for each frame size. Testing should be conducted to verify the proper orifice selection for the desired response. Typical response times at the following conditions:

$\Delta p = 250 \text{ bar}$ [3626 psi]

Charge pressure = 20 bar [290 psi]

Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]

Speed = 1800 min⁻¹ (rpm)

Response time, FNR

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

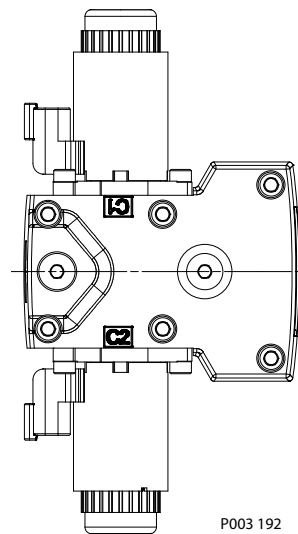
Non feedback proportional electric control (NFPE)

The Non Feedback Proportional Electric (**NFPE**) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

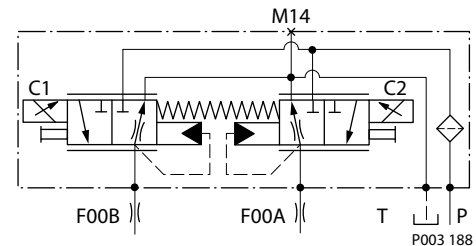
A serviceable 170 µm screen is located in the supply line immediately before the control porting spool.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

NFPE control



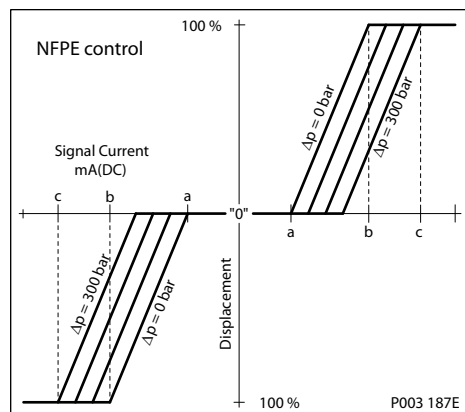
NFPE schematic



The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swashplate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Operation

NFPE pump displacement to input signal



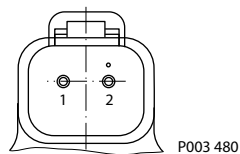
Control signal requirements

Control current

Voltage	a*	b	c	Pin connections
12 V	600 mA	1080 mA	1360 mA	any order
24 V	300 mA	540 mA	680 mA	

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

DEUTSCH connector, 2-pin



Connector ordering data

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

Description		12 V	24 V
Maximum current		1800 mA	920 mA
Nominal coil resistance	@ 20 °C [68 °F]	3.66 Ω	14.20 Ω
	@ 80 °C [176 °F]	4.52 Ω	17.52 Ω
Inductance		33 mH	140 mH
PWM signal frequency	Range	70 – 200 Hz	
	Recommended*	100 Hz	
IP Rating	IEC 60 529	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Connector color		Black	

* PWM signal required for optimum control performance.

Operation

Pump output flow direction vs. control signal

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

* For coil location see Installation drawings.

Control response

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

Typical response times at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm ² /s [141 SUS] and 50°C [122 °F]
Charge pressure	24 bar [348 psi]
Speed	1800 min ⁻¹ (rpm)

Response time

Stroking direction	0.8 mm [0.03] orifice		1.0 mm [0.04] orifice		1.3 mm [0.05] orifice	
	28/32	38/45	28/45	38/45	28/45	38/45
Neutral to full flow	1.5 s	2.2 s	0.9 s	1.4 s	0.6 s	0.8 s
Full flow to neutral	0.9 s	1.1 s	0.6 s	0.7 s	0.4 s	0.5 s

Non-feedback, proportional hydraulic control (NFPH)

The non-feedback proportional hydraulic (NFPH) control is a hydraulic proportional control in which an input pressure signal directly controls the pump servo piston to achieve pump displacement.

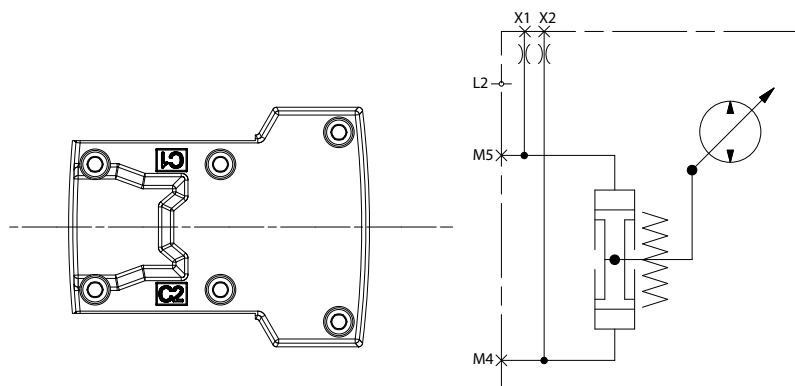
MP1 pumps with NFPH control have a special servo cylinder capable of providing proportional control with a hydraulic input.

Swashplate position is proportional to the differential signal pressure at ports X1 and X2, but displacement is also dependent on pump speed and system pressure. This characteristic of non-feedback controls provides a natural power limiting function by reducing the pump swashplate angle as system pressure increases. The accompanying graph shows typical operating characteristics.

The system may require tuning through the pump orifice combinations, control pressure supply line sizing, actuation device output pressure and flow adjustments to achieve proper vehicle performance characteristics.

Operation

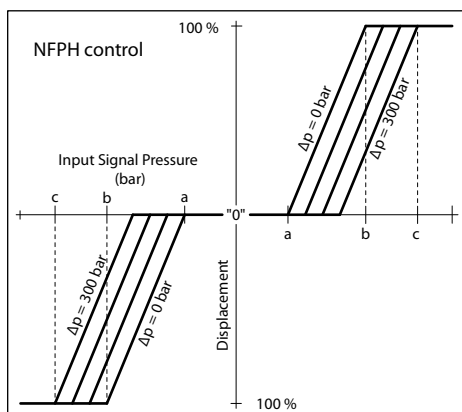
Non-feedback proportional hydraulic control schematic



Pump flow direction with NFPH control

Input Shaft Rotation	CW		CCW	
	Port A flow	Out	In	In
Port B flow	In	Out	Out	In
High servo gauge port	M4	M5	M4	M5

NFPH pump displacement to Input signal



NFPH input signal pressure (bar)

Frame size	a	b	c
28/32	5.5	13.7	17
38/45	5	12.75	16

The values provided in the table above are approximations at 1800 RPM and system delta pressures as indicated in the graph provided. The values are dependent on input speed and delta pressure operating conditions.

Control response

MP1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response

Operation

table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

Typical response times at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm ² /s [141 SUS] and 50°C [122 °F]
Charge pressure	24 bar [348 psi]
Speed	1800 min ⁻¹ (rpm)

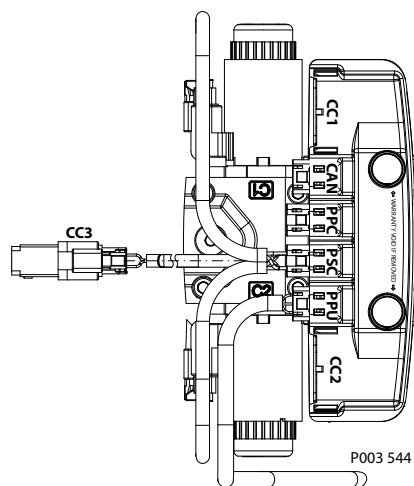
Response time

Stroking direction	0.8 mm [0.03] orifice		1.0 mm [0.04] orifice		1.3 mm [0.05] orifice	
	28/32	38/45	28/45	38/45	28/45	38/45
Neutral to full flow	1.5 s	2.2 s	0.9 s	1.4 s	0.6 s	0.8 s
Full flow to neutral	0.9 s	1.1 s	0.6 s	0.7 s	0.4 s	0.5 s

Automotive control (AC)

The Automotive control (AC) is an electric NFPE control with an integrated micro-controller, installed on the pump.

The integrated micro-controller enhanced control performance with a flexible, configurable control scheme for an entire single path propel transmission. It can be used in combination with fixed and variable displacement hydraulic motors. With the pre-installed application software and easily changeable control parameters, it is possible to tailor the vehicle's driving behavior to the individual requirements of the customer.



The H1 automotive control is divided into 2 systems:

- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as swash plate control.

Operation

Mode types

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.

Automotive Load dependent	Torque controlled driving behavior. Setpoint for the drive curve is the engine rpm.
Non-Automotive Load independent	Speed controlled driving mode. Setpoint for the drive curve is a joystick or drive pedal signal, independent of the engine rpm. The best performance will be achieved with an AC-2 Swash Plate Sensor.
Creep-Automotive Load dependent	Torque controlled driving behavior (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Basic functions

- Four selectable system modes, selectable via switch
- Individual settings for forward and reverse driving direction (4 x 2 curves)
- Independent pump and hydraulic motor profiling and ramping for each mode
- Electric drive pedal connection
- Electronic inching function without separate control valve
- Electric creep mode potentiometer
- Configurable System Mode and Direction change
- Load independent pump displacement control with integrated Swash Plate Angle Sensor (AC-2)
- Hydraulic motor displacement control including brake pressure defeat function

Performance functions

- ECO fuel saving mode with automatic reduction of the engine speed during transport (Cruise control)
- Vehicle constant speed drive control
- Vehicle speed limitation
- Dynamic brake light, automatic park brake, reverse buzzer and status LED outputs
- Vehicle speed controlled output function
- Temperature compensation for predictable performance
- Advanced CAN J1939 interface for the information exchange with the vehicle control system

Protection and safety functions

- Safety controlled vehicle start protection with engine speed check, battery check and FNR must be in neutral, etc.
- Operator presence detection
- Hydraulic system overheat and low-temperature protection
- Hydraulic motor over speed protection
- Park brake test mode for roller applications to fulfill SAE J1472/EN500-4
- SIL2 compliant

Operation

Engine control and protection

- CAN J1939 engine interface
- Engine speed control via drive pedal with safety controlled monitoring function
- Engine antistall protection
- Engine over speed protection during inching
- Engine speed dependent retarder control
- Engine cold start protection

Installation features

- Factory calibration for hysteresis compensation
- Starting current adjustment in the factory
- Pre-installed application software and parameter files

For more information, see [Integrated Automotive Control \(AC\) for MP1 and H1P Single Pumps 28-250 Technical Information, BC152986482596](#).

Operation

Control-cut-off valve (CCO valve)

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

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

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

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

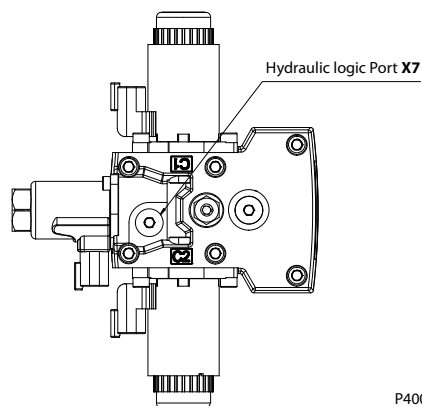
All EDC and MDC controls are available with a CCO valve.

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

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

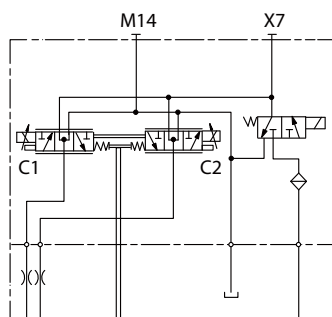
EDC with CCO

Control



P400346

Schematic

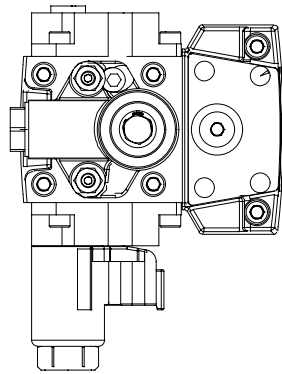


P400349

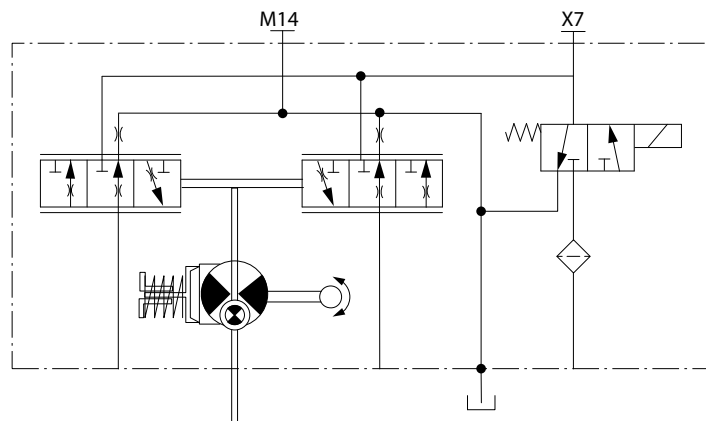
Operation

MDC with CCO

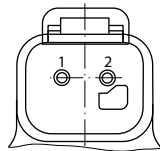
Control



Schematic



P005 703



CCO solenoid data

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

Operation

CCO solenoids are design for battery voltage application within the voltage range in the table above, in consideration of a wide range of environmental temperature common for known hydraulic applications. Closed loop PWM current supply can be also applied and is helpful in case that the voltage range is exceeded, or ambient temperature could rise in an unusual manner.

Brake gauge port with MDC

! Caution

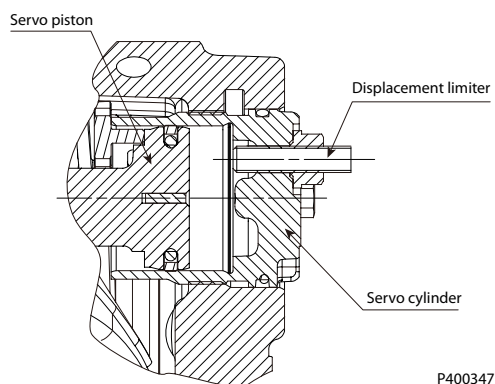
It is not recommended to use brake port for any external flow consumption to avoid malfunction of CCO function.

Displacement limiter

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

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

Displacement limiter



Displacement change (approximate)

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

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*, **BC152886482203**.

Temperature Range

Parameter	Minimum	Maximum
Operation 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.

Output pulses

The expected number of output pulses per revolution is shown below.

The number of output (speed) pulses

MP1P size	28/32	38/45
Pulses (per rev)	9	11

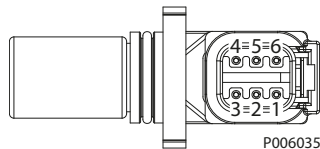
Mating connectors

There are available two types of mating connectors Assembly Bag DEUTSCH DTM06-6S, Black and Grey.

Ordering number	
11033865	11033863
Assembly Bag, DEUTSCH DTM06-6S-E004; black, (24-20 AWG) 0.21 -0.52 mm ²	Assembly Bag, DEUTSCH DTM06-6S, gray, (24-20 AWG) 0.21 -0.52 mm ²

Speed sensor 4.5 – 8 V

Speed sensor connector, 6-pin



1. Speed signal 2
2. NC
3. Speed signal 1
4. Supply
5. Ground
6. Temperature

Technical data

Parameter	Min.	Nom.	Max.	Note
Supply voltage	4.5 V _{DC}	5 V _{DC}	8 V _{DC}	Regulated supply voltage. Reverse polarity protected.
Supply protection	–	–	30 V _{DC}	Shuts off above 9 V.
Max. required supply current	–	–	25 mA	At supply voltage
Max. output current	–	–	50 mA	
Operation mode	NPN & PNP			Push-Pull amplifier
Temperature signal	-40°C = 2.318V	–	100°C = 0.675V	
Output low	5 %	8.5 %	12 %	Ratiometric output voltage Low state > 0 V to provide wire fault detection

Operation

Technical data (continued)

Parameter	Min.	Nom.	Max.	Note
Output high	88 %	91.5 %	95 %	
Detectable frequency range	1 Hz	–	10 000 Hz	
Ordering number	149055			
Color of connector	Black			

Temperature Signal

For calculation of the case fluid temperature and the output signal voltage, see the formulas below:

V_o – Measured output voltage (V)

$$V_o = (-3.88 \cdot 10^{-6} \cdot T^2) + (-1.15 \cdot 10^{-2} \cdot T) + 1.8639$$

T – Temperature (°C)

$$T = -1481.96 + \sqrt{2.1962 \cdot 10^6 + \frac{(1.8639 - V_o)}{3.88 \cdot 10^{-6}}}$$

Output signal voltage vs. Temperature

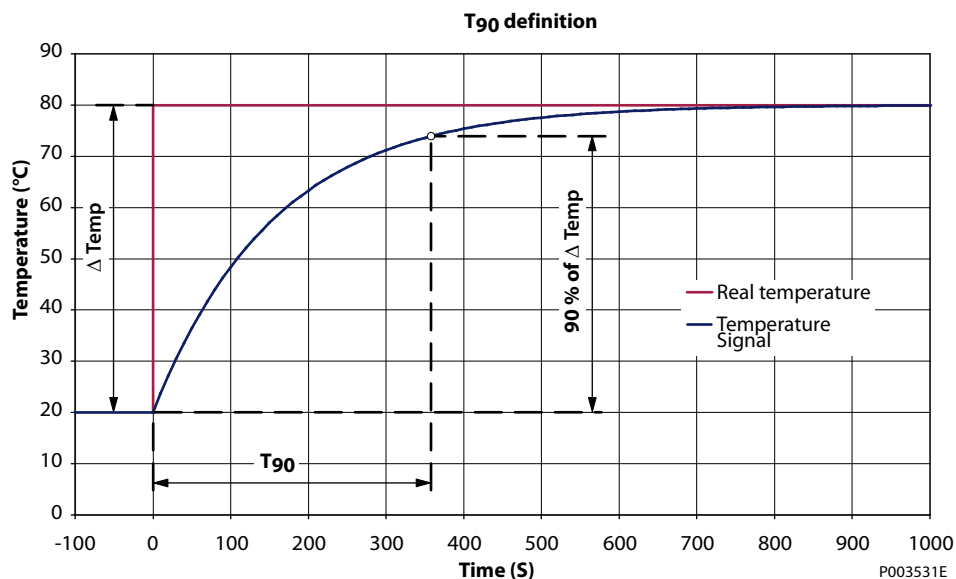
Temperature range							
-55 °C**	-40 °C	-30 °C	0 °C	+30 °C*	+80 °C	+100 °C	+130 °C**
2.485 V	2.318 V	2.205 V	1.864 V	1.515 V	0.919 V	0.675 V	0.303 V

* Accuracy: ± 1.5 to ± 4 °C

** Accuracy: ± 2.5 to ± 5 °C

Response time in fluid

T_{90} definition



Response time in fluid (T_{90}) = 360 s

Operating parameters

Input speed

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

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

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

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

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

Warning

Unintended vehicle or machine movement hazard.

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

System Pressure

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

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

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

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

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

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

Operating parameters

Charge pressure

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

The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating at 1800 min^{-1} [rpm], and with a fluid viscosity of $32 \text{ mm}^2/\text{s}$ [150 SUS]. Pumps configured with no charge pump (external charge supply) are set with a charge flow of 18.9 l/min [5.0 US gal/min] and a fluid viscosity of $32 \text{ mm}^2/\text{s}$ [150 SUS].

The charge pressure setting is referenced to case pressure.

Charge pump inlet pressure

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

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

Maximum charge pump inlet pressure may be applied continuously.

Case pressure

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

 **Caution**

Possible component damage or leakage

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

Temperature

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

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

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

The **minimum temperature** relates to the physical properties of component materials. Size heat exchangers to keep the fluid within these limits. Danfoss recommends testing to verify that these temperature limits are not exceeded.

Ensure fluid temperature and viscosity limits are concurrently satisfied.

Operating parameters

Viscosity

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

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

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

System design parameters

Filtration system

To prevent premature wear, ensure that only clean fluid enters the hydrostatic transmission circuit. A filter capable of controlling the fluid cleanliness to ISO 4406, class 22/18/13 (SAE J1165) or better, under normal operating conditions, is recommended. These cleanliness levels cannot be applied for hydraulic fluid residing in the component housing/case or any other cavity after transport.

Filtration strategies include suction or pressure filtration. The selection of a filter depends on a number of factors including the contaminant ingress rate, the generation of contaminants in the system, the required fluid cleanliness, and the desired maintenance interval. Filters are selected to meet the above requirements using rating parameters of efficiency and capacity.

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

Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. Please see *Design Guidelines for Hydraulic Fluid Cleanliness Technical Information, BC152886482150* for more information.

Cleanliness level and β_x -ratio ¹			
Filtration (recommended minimum)	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β -ratio	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
	Efficiency (suction and return line filtration)		$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
	Recommended inlet screen mesh size	μm	100 – 125

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

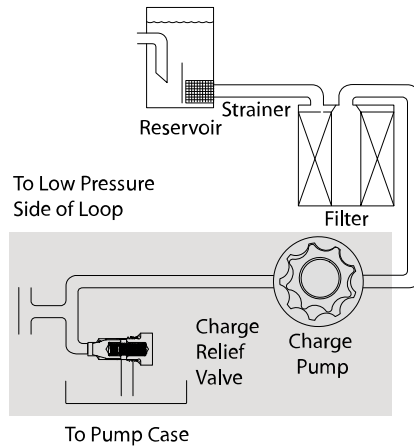
Filtration

Suction filtration

A suction circuit uses an internal charge pump. The filter is placed between the reservoir and the charge pump inlet. Do not exceed the inlet vacuum limits during cold start conditions.

System design parameters

Suction filtration



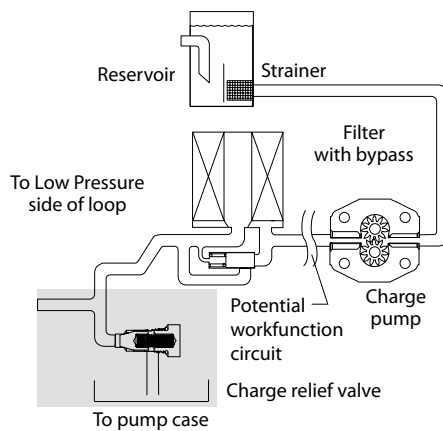
P400032

Charge pressure filtration

In a pressure filtration system the pressure filter is remotely mounted in the circuit, downstream of the charge supply. Pressure filtration is possible with, and without, an internal charge pump. Filters used in charge pressure filtration circuits should be rated to at least 35 bar [508 psi] pressure. Danfoss recommends locating a 100 – 125 micron screen in the reservoir or in the charge inlet when using charge pressure filtration.

A filter bypass valve is necessary to prevent damage to the hydrostatic system. In the event of high pressure drop associated with a blocked filter or cold start-up conditions, fluid may bypass the filter temporarily. Avoid working with an open bypass for an extended period. A visual or electrical bypass indicator is preferred. Proper filter maintenance is mandatory.

Charge pressure filtration



P400031

System design parameters

Independent braking system

Warning

Unintended vehicle or machine movement hazard.

The loss of hydrostatic drive line power, in any mode of operation (forward, neutral, or reverse) may cause the system to lose hydrostatic 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.

Fluid selection

Ratings and performance data published in this Technical Information and Service Manuals are based on operating with mineral oil based hydraulic fluids containing set of different additives. These fluids possess good thermal stability, high load-carrying capacity and wear protection in hydraulic systems.

More information about Fluids and Lubricants you can find in our Technical Information “Hydraulic Fluids and Lubricants” (BC00000093)

[Any warranty applicable for failures related to components of Danfoss Power Solutions does not apply for any fluid related damages, unless such warranty has been expressly and specifically granted.](#)

Caution

It is not permissible to mix lubricants, different additive packages may cause negative interactions. If lubricant mixing cannot be avoided, contact your fluid manufacturer for recommendations.

Reservoir

The hydrostatic system reservoir should accommodate maximum volume changes during all system operating modes and promote de-aeration of the fluid as it passes through the tank.

A suggested minimum total reservoir volume is 5/8 of the maximum charge pump flow per minute with a minimum fluid volume equal to 1/2 of the maximum charge pump flow per minute. This allows 30 seconds fluid dwell for removing entrained air at the maximum return flow. This is usually adequate to allow for a closed reservoir (no breather) in most applications.

Locate the reservoir outlet (charge pump inlet) above the bottom of the reservoir to take advantage of gravity separation and prevent large foreign particles from entering the charge inlet line. A 100-125 µm screen over the outlet port is recommended.

Position the reservoir inlet (fluid return) to discharge below the normal fluid level, toward the interior of the tank. A baffle (or baffles) will further promote de-aeration and reduce surging of the fluid.

Case drain

The pump housing must remain full of oil at all times. The MP1 pump is equipped with two case drain ports to provide flexibility for hose routing and pump installation. Connect a line from one of the case drain ports to the reservoir. Case drain fluid is typically the hottest fluid in the system.

Charge pump

Charge flow is required on MP1 pumps. The charge pump provides flow to make up for system leakage, maintain a positive pressure in the main circuit, and provide flow for cooling and filtration.

Many factors influence the charge flow requirements and the resulting charge pump size selection. These factors include system pressure, pump speed, pump swashplate angle, type of fluid, temperature, size of heat exchanger, length and size of hydraulic lines, auxiliary flow requirements, hydrostatic motor type, etc. When initially sizing and selecting hydrostatic units for an application, it is frequently not possible to have all the information necessary to accurately evaluate all aspects of charge pump size selection.

System design parameters

Unusual application conditions may require a more detailed review of charge pump sizing. Charge pressure must be maintained at a specified level under all operating conditions to prevent damage to the transmission. Danfoss recommends testing under actual operating conditions to verify this.

Charge pump sizing/selection

In most applications a general guideline is that the charge pump displacement should be at least 10 % of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. Please refer to *Selection of Drive line Components*, **BC157786484430** for a detailed procedure.

System features and conditions which may invalidate the 10 % guideline include (but are not limited to):

- Continuous operation at low input speeds {< 1500 min⁻¹ (rpm)}
- High shock loading and/or long loop lines
- High input shaft speeds
- LSHT motors with large displacement and/or multiple LSHT motors
- High flushing flow requirements
- Automotive style operation where input speeds fluctuate or operate below 800 min⁻¹ (rpm)

Contact your Danfoss representative for application assistance if your application includes any of these conditions.

System design parameters

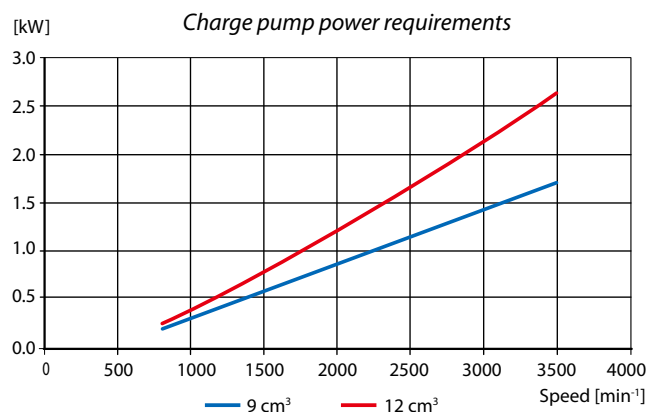
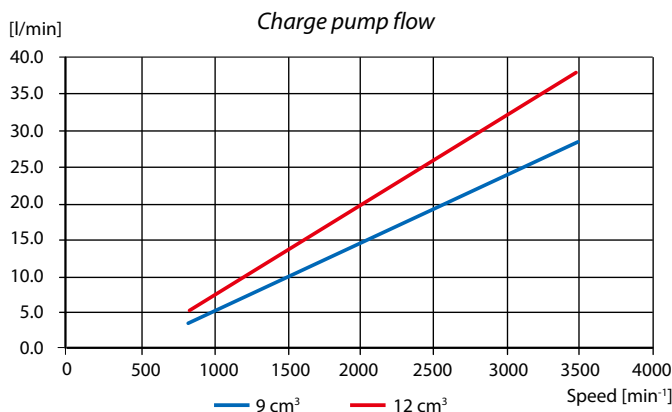
Charge pump output flow

Charge pump flow and power curves, 9/12 cm³

Charge pressure: 20 bar [290 psi]

Viscosity: 11 mm²/s [63 SUS]

Temperature: 80 °C [176 °F]



P400354

Bearing life and external shaft loading

Bearing life is a function of speed, system pressure, charge pressure, and swashplate angle, plus any external side or thrust loads. Other life factors include oil type and viscosity. The influence of swashplate angle includes displacement as well as direction. External loads are found in applications where the pump is driven with side/thrust load (belt or gear) as well as in installations with misalignment and improper concentricity between the pump and drive coupling. All external side loads will act to reduce the normal bearing life of a pump.

In vehicle propel drives with no external shaft loads and where the system pressure and swashplate angle are changing direction and magnitude regularly, the normal B10 bearing life (90% survival) will exceed the hydraulic load-life of the unit.

In non propel drives such as vibratory drives, conveyor drives, or fan drives, the operating speed and pressure are often nearly constant and the swashplate angle is predominantly at maximum. These drives have a distinctive duty cycle compared to a propulsion drive. In these types of applications a bearing life review is recommended.

MP1 pumps are designed with bearings that can accept some external radial. When external loads are present, the allowable radial shaft loads are a function of the load position relative to the mounting flange, the load orientation relative to the internal loads, and the operating pressures of the hydraulic unit. In applications where external shaft loads can not be avoided, the impact on bearing life can be minimized by proper orientation of the load. Optimum pump orientation is a consideration of the net loading on the shaft from the external load, the pump rotating group, and the charge pump load.

System design parameters

- In applications where the pump is operated such that nearly equal amounts of forward vs reverse swashplate operation is experienced; bearing life can be optimized by orientating the external side load to the 0 or 180 deg position (90 deg to rotating group load F_b). See drawing.
- In applications where the pump is operated such that the swashplate is predominantly (>75%) on one side of neutral (e.g. vibratory, conveyor, typical propel); bearing life can be optimized by orientating the external side load generally opposite of the internal rotating group load, F_b . The direction of the internal loading is a function of rotation and system port, which has flow out.
- Avoid axial thrust loads in either direction.

The **maximum allowable radial loads** (R_e), based on the **maximum external moment** (M_e) and the distance (L) from the mounting flange to the load, may be determined from the tables below and the cross section drawing.

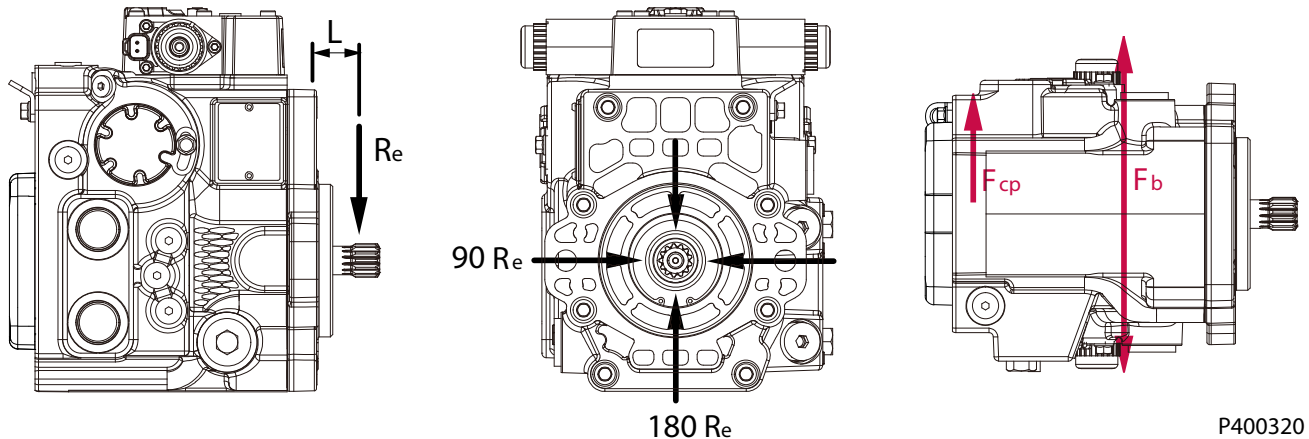
The maximum allowable radial load is calculated as: $R_e = M_e / L$

Contact your Danfoss representative for an evaluation of unit bearing life if continuously applied external radial loads are 25% or more of the maximum allowable, or if thrust loads are known to exist. Use tapered output shafts or clamp-type couplings where radial shaft side loads are present.

Shaft loading parameters

Re	Maximum external radial load
Me	Maximum external moment
L	Distance from mounting flange to point of load
Fb	Internal rotating group load
Te	Thrust external load
Fcp	Force of charge pump

External radial shaft load



System design parameters

Hydraulic unit life

Hydraulic unit life is defined as the fatigue life expectancy of the hydraulic components. It is a function of speed and system pressure; however, system pressure is the dominant variable. High pressure, which results from high load, reduces expected hydraulic unit life.

System component selection is based on determination of the application maximum loads and speeds. Testing is recommended to secure duty cycle data in which to predict hydraulic unit life. Contact your Danfoss representative for assistance in unit life determination. If duty cycle data is not available, normal input power and maximum pump displacement can be used to determine an application pressure in which to predict life.

MP1 pumps will meet most application hydraulic unit life expectancies if applied within the parameters specified in this manual and chosen considering the guidelines within Danfoss publication *Selection of Driveline Components* **BC157786484430**. For more detailed information on hydraulic unit life, see Danfoss publication *Pressure and Speed Limits* **BC152886484313**.

Mounting flange loads

Shock load moment is the result of an instantaneous jolt to the system. **Continuous load moments** are generated by the typical vibratory movement of the application. Avoid excessive loading of the mounting flange such as adding tandem mounted auxiliary pumps and/or subjecting pumps to high shock loads. Design pump applications to stay within the allowable shock load moment and allowable continuous load moment.

Use the following formulas to estimate overhung load moment for multiple pump mountings:

$$M_s = G_s (W_1 L_1 + W_2 L_2 + \dots + W_n L_n)$$

$$M_c = G_c (W_1 L_1 + W_2 L_2 + \dots + W_n L_n)$$

Refer to the *Installation Drawings* section to find pump length (L). Refer to the table *Technical Specifications* in the *Specifications* section, to find pump weight (W). An exact measure of W will depend on the pump's features.

Overhung loading parameters

M_s	Shock load moment
M_c	Continuous load moment
G_s	Maximum shock acceleration (Gs)
G_c	Continuous (vibratory) acceleration (Gs)
W_n	Weight of nth pump
L_n	Distance from mounting flange to center of gravity of nth pump

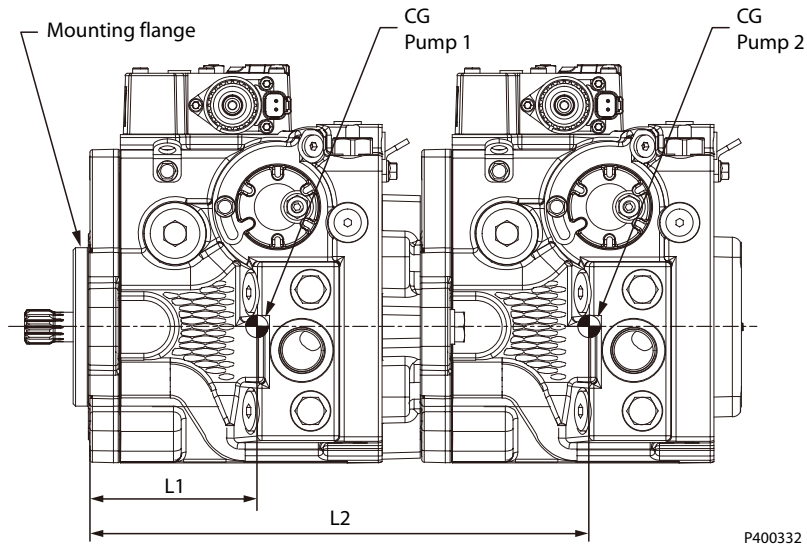
The tables below show allowable overhung load moment values. If system parameters exceed these values add additional pump support.

Allowable overhung parameters

Frame size	Continuous load moment (M _c) 10 ⁷ cycles N•m [in•lbf]	Shock load moment (M _s) 10 ³ cycles N•m [in•lbf]
28/32	1100 [9736]	2000 [17702]
38/45	1500 [13276]	2800 [24782]

System design parameters

Shaft loading parameters



This illustration shows two single pumps in tandem.

Estimated maximum and continuous acceleration factors for some typical applications are shown. Applications which experience extreme resonant vibrations may require additional pump support. Typical continuous (vibratory) values can vary significantly due to changes in engine and pump configuration and mounting methods.

G-factors for sample applications

Application	Continuous (vibratory) acceleration (G_c)	Maximum (shock) acceleration (G_s)
Trencher (rubber tires)	3	8
Asphalt paver	2	6
Windrower	2	5
Aerial lift	1.5	4
Turf care vehicle	1.5	4
Vibratory roller	6	10

* Applications which experience extreme resonant vibrations require addition pump support.

System design parameters

Shaft torques

Shaft selection

Base shaft selection on a review of the maximum torque required by the application and the maximum torque available from the prime mover. Application duty cycle and continuous torque rating of the prime mover are the main variable to consider when selecting a shaft.

Shaft torque and splines lubrication

The **rated torque** is a measure of tooth wear and is the torque level at which a normal spline life of 1×10^7 shaft revolutions can be expected. The rated torque presumes a regularly maintained minimum level of lubrication via a moly-disulfide grease in order to reduce the coefficient of friction and to restrict the presence of oxygen at the spline interface. It is also assumed that the mating spline has a minimum hardness of $R_c 55$ and full spline depth. The rated torque is proportional to the minimum active spline length.

However, a spline running in oil-flooded environment provides superior oxygen restriction in addition to contaminant flushing. The rated torque of a flooded spline can increase to that of the maximum published rating. A flooded spline would be indicative of a pump driven by a pump drive or plugged into an auxiliary pad of a pump.

Maximum torque ratings are based on torsional fatigue strength considering 1×10^5 full load reversing cycles.

Maintaining a spline engagement at least equal to the pitch diameter will also maximize spline life. Spline engagements of less than $\frac{3}{4}$ pitch diameter are subject to high contact stress and spline fretting.

Shaft torque for tapered shafts

The **rated torque** is based on the contact pressure between the shaft and hub surfaces with poor contact areas. With increased quality of the contact areas, the contact pressure between shaft and hub is increased, allowing higher torque to be transmitted.

A key is intended as an installation aid only. Any torque carried by the key as a result of poor contact area or mis-alignment will limit the torque carrying capability of the shaft significantly.

Maximum torque rating is based on an ideal contact area of 100% and the retaining nut properly torqued. This allows for the highest contact pressure between the shaft and the mating hub.

System design parameters

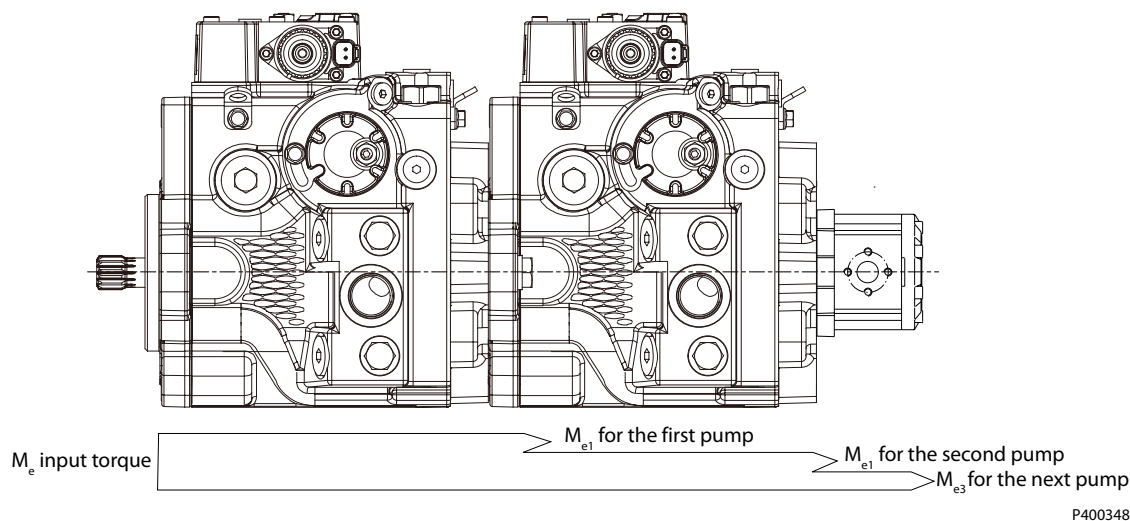
Shaft availability and torque ratings

Alignment between the mating spline's Pitch Diameters is another critical feature in determining the operating life of a splined drive connection. Plug-in, or rigid spline drive installations can impose severe radial loads on the shafts.

The radial load is a function of the transmitted torque and shaft eccentricity. Increased spline clearance will not totally alleviate this condition; BUT, increased spline clearance will prevent mechanical interference due to misalignment or radial eccentricity between the pitch diameters of the mating splines. Spline life can be maximized if an intermediate coupling is introduced between the bearing supported splined shafts.

Multiple pump installations must consider the loads from the entire pump stack and all torques are additive. Charge pumps loads must also be included.

Through torque diagram



Attention

Torque required by auxiliary pumps is additive. Ensure requirements do not exceed shaft torque ratings.

Understanding and minimizing system noise

Noise is transmitted in fluid power systems in two ways: as fluid borne noise, and structure borne noise.

Fluid-borne noise (pressure ripple or pulsation) is created as pumping elements discharge oil into the pump outlet. It is affected by the compressibility of the oil, and the pump's ability to transition pumping elements from high to low pressure. Pulsations travel through the hydraulic lines at the speed of sound until there is a change (such as an elbow) in the line. Amplitude varies with overall line length and position.

Structure borne noise is transmitted wherever the pump casing connects to the rest of the system. The way system components respond to excitation depends on their size, form, material, and mounting.

[System lines and pump mounting can amplify pump noise.](#)

Follow these suggestions to help minimize noise in your application:

- Use flexible hoses.
- Limit system line length.
- If possible, optimize system line position to minimize noise.

System design parameters

- If you must use steel plumbing, clamp the lines.
- If you add additional support, use rubber mounts.
- Test for resonance in the operating range; if possible avoid them.

System design parameters

Sizing equations

The following equations are helpful when sizing hydraulic pumps. Generally, the sizing process is initiated by an evaluation of the machine system to determine the required motor speed and torque to perform the necessary work function.

	Based on SI units	Based on US units
Flow	Output flow Q = $\frac{V_g \cdot n \cdot \eta_v}{1000}$ (l/min)	Output flow Q = $\frac{V_g \cdot n \cdot \eta_v}{231}$ (US gal/min)
Torque	Input torque M = $\frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m}$ (N·m)	Input torque M = $\frac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m}$ (lbf·in)
Power	Input power P = $\frac{M \cdot n \cdot \pi}{30\,000} = \frac{Q \cdot \Delta p}{600 \cdot \eta_t}$ (kW)	Input power P = $\frac{M \cdot n \cdot \pi}{198\,000} = \frac{Q \cdot \Delta p}{1714 \cdot \eta_t}$ (hp)

Variables

SI units [US units]

V_g	= Displacement per revolution cm ³ /rev [in ³ /rev]
p_o	= Outlet pressure bar [psi]
p_i	= Inlet pressure bar [psi]
Δp	= p _o - p _i (system pressure) bar [psi]
n	= Speed min ⁻¹ (rpm)
η_v	= Volumetric efficiency
η_m	= Mechanical efficiency
η_t	= Overall efficiency (η _v · η _m)

First, the motor is sized to transmit the maximum required torque. The pump is then selected as a flow source to achieve the maximum motor speed. Refer to *Selection of Drive Line Components*, **BC157786484430**, for a more complete description of hydrostatic drive line sizing.

Model code

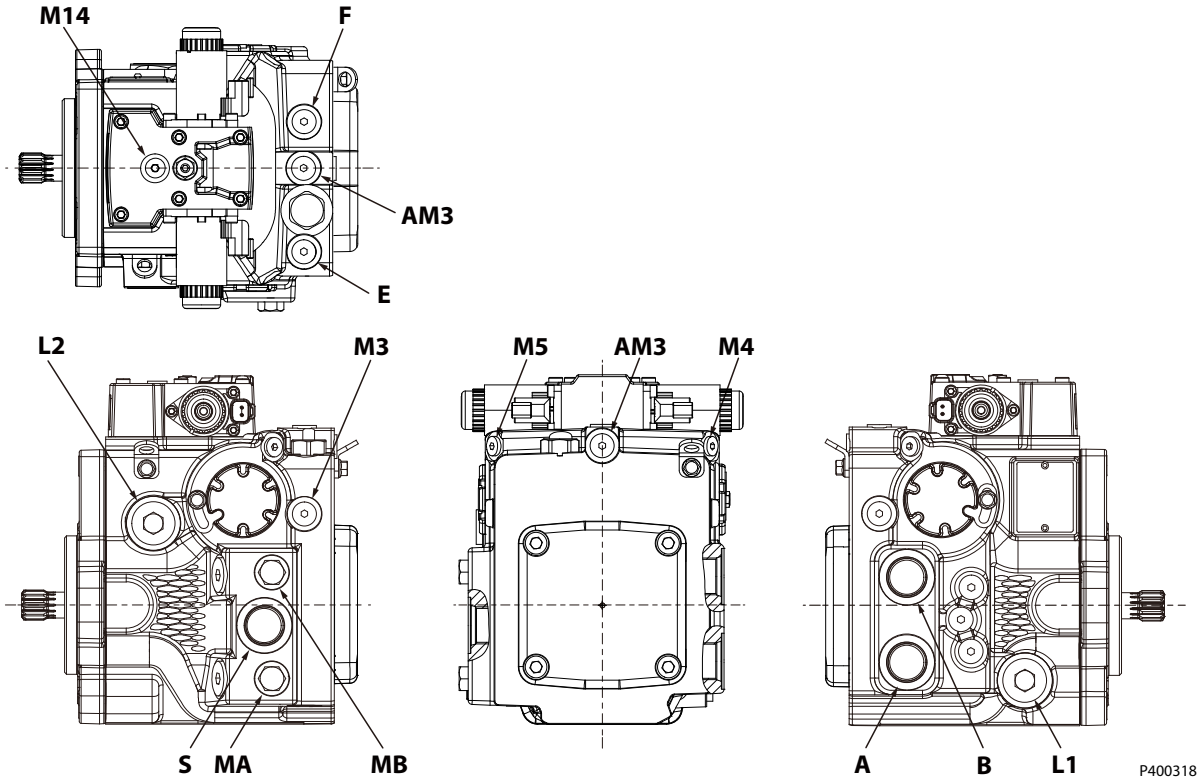
W - special hardware features (continued)

Code	Description
RAE	Standard valve plate, CW, 38 cm ³
LAE	Standard valve plate, CCW, 38 cm ³
RAF	Standard valve plate, CW, 45 cm ³
LAF	Standard valve plate, CCW, 45 cm ³
RBC	NFPE/NFPH/AC valve plate, CW, 28cm ³
LBC	NFPE/NFPH/AC valve plate, CCW, 28cm ³
RBD	NFPE/NFPH/AC valve plate, CW, 32cm ³
LBD	NFPE/NFPH/AC valve plate, CCW, 32cm ³
RBE	NFPE/NFPH/AC valve plate, CW, 38cm ³
LBE	NFPE/NFPH/AC valve plate, CCW, 38cm ³
RBF	NFPE/NFPH/AC valve plate, CW, 45cm ³
LBF	NFPE/NFPH/AC valve plate, CCW, 45cm ³

Align with **A**: displacement and rotation : and **D**: controls

Installation drawings

28/32 ports

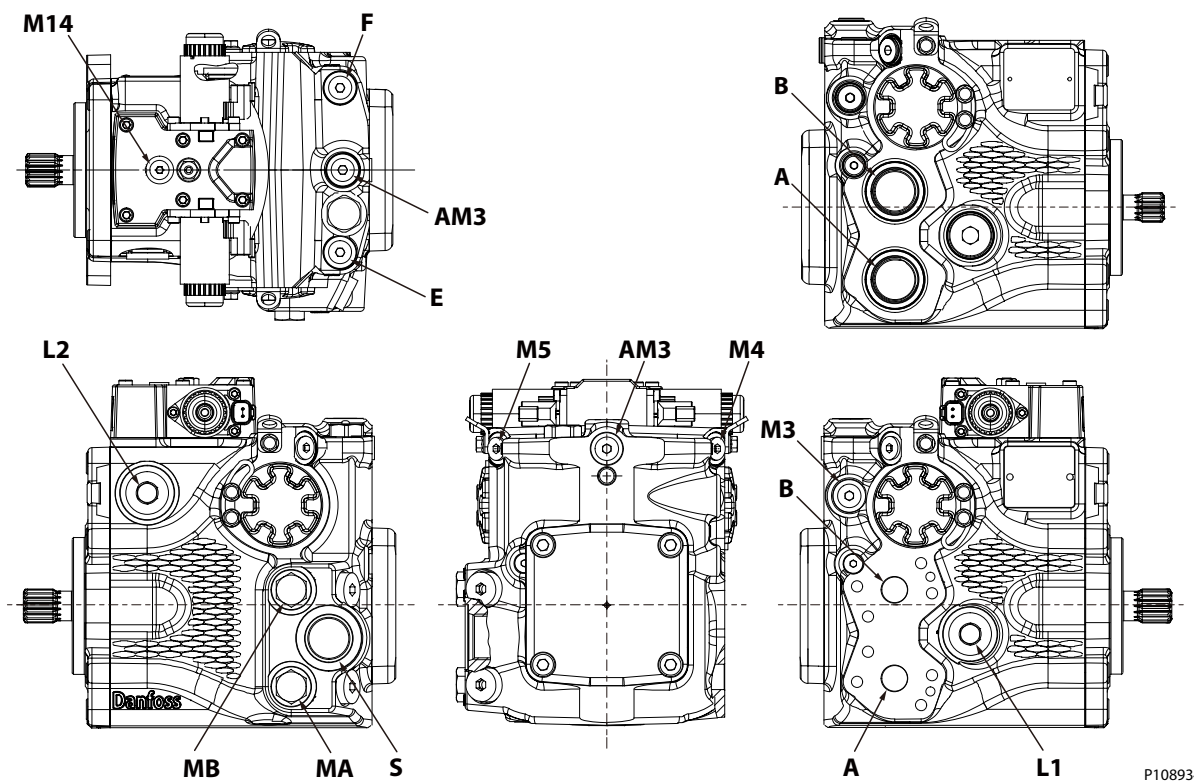


Port description

Port	Description	Code		Size
A/B	System	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2
AM3	Alternative charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
E/F	Filtration inlet/outlet	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
L1/L2	Case drain	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2
MA/MB	System gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M3	Charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M4/M5	Servo gauge	Inch	ISO 11926-1	7/16-20
		Metric	ISO 6149-1	M12x1.5
M14	Case gauge port	Inch	ISO 11926-1	7/16-20
		Metric	ISO 6149-1	M12x1.5
S	Charge pump inlet	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2

Installation drawings

38/45 ports



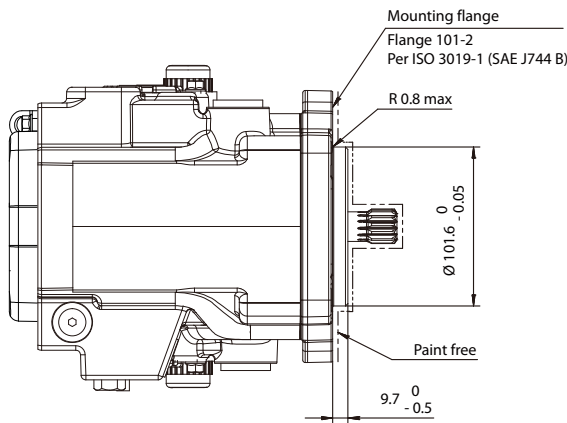
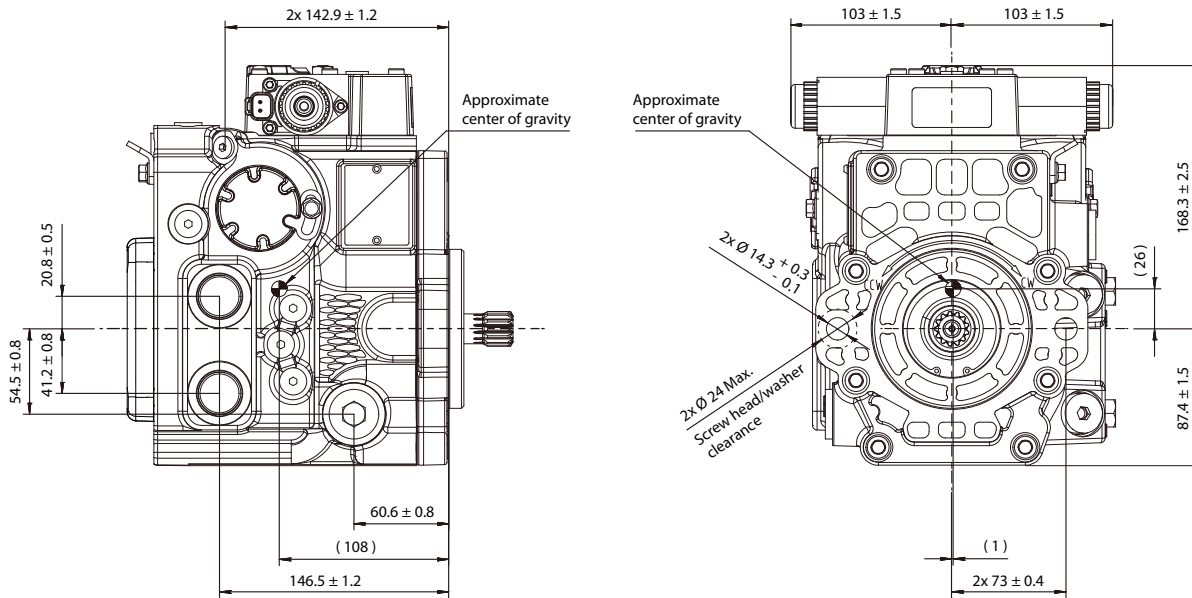
P108934

Port description

Port	Description	Code		Size
A/B	System	Inch	ISO 11926-1	1 5/16-12
		Metric	ISO 6149-1	M33x2
		Split flange port	ISO 6162-2	DN19 M10x1.5
AM3	Alternative charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
E/F	Filtration inlet/outlet	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
L1/L2	Case drain	Inch	ISO 11926-1	1 1/16-12
		Metric	ISO 6149-1	M27x2
MA/MB	System gauge	Inch	ISO 11926-1	3/4-16
		Metric	ISO 6149-1	M18x1.5
M3	Charge gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M4/M5	Servo gauge	Inch	ISO 11926-1	9/16-18
		Metric	ISO 6149-1	M14x1.5
M14	Case gauge port	Inch	ISO 11926-1	7/16-20
		Metric	ISO 6149-1	M12x1.5
S	Charge Pump Inlet	Inch	ISO 11926-1	1 5/16-12
		Metric	ISO 6149-1	M33x2

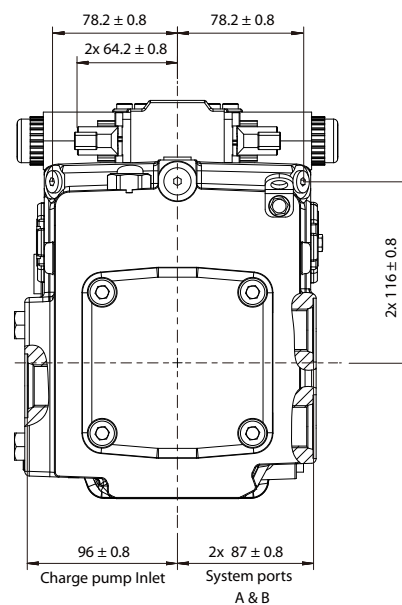
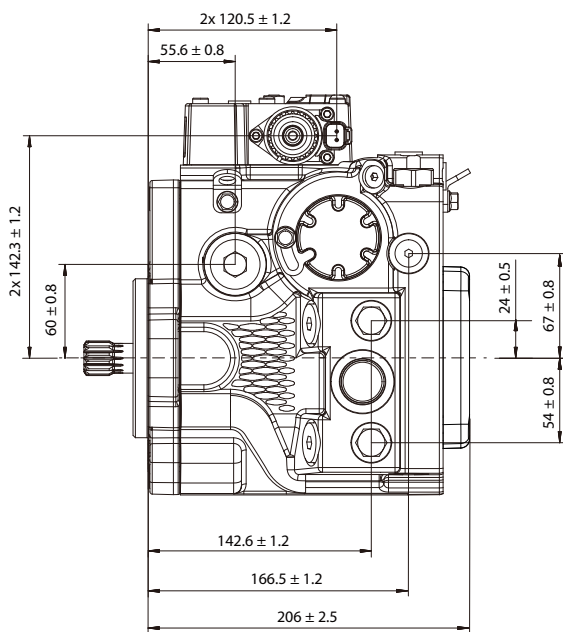
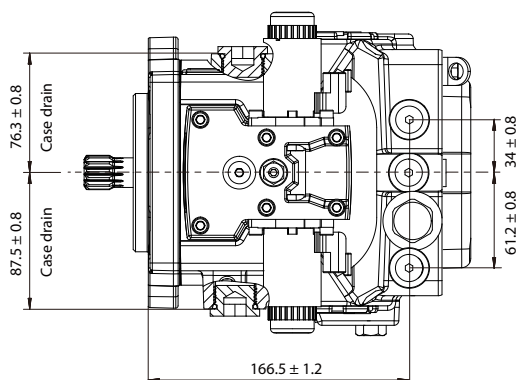
Installation drawings

28/32 dimensions



P400312

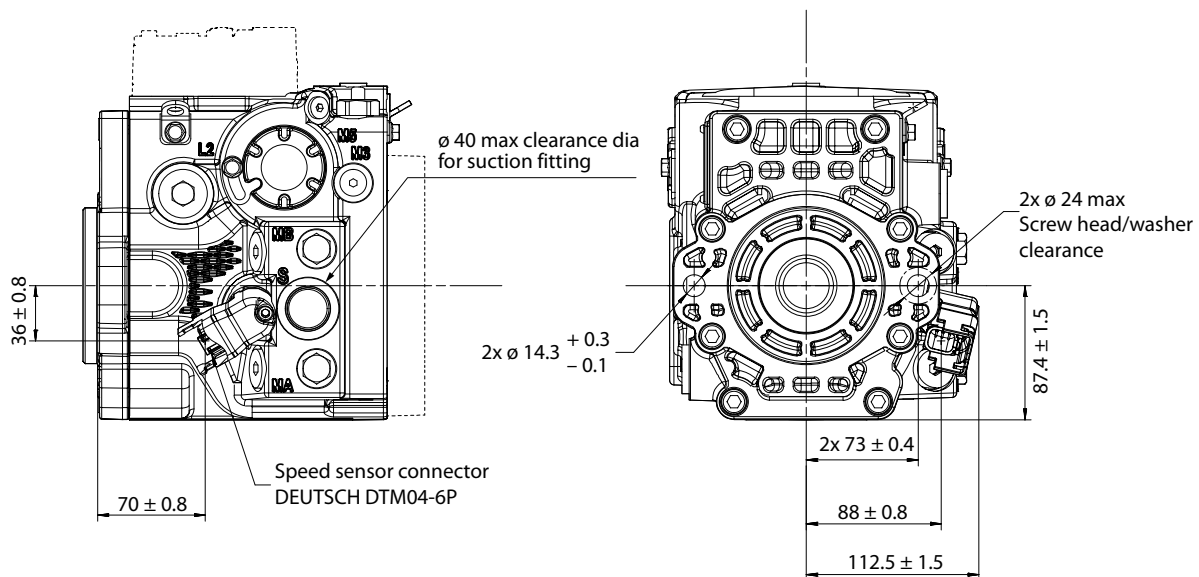
Installation drawings



Please contact Danfoss representative for specific installation drawings.

Installation drawings

28/32 dimensions with speed sensor



Please contact Danfoss representative for specific installation drawings.

Speed sensor connector

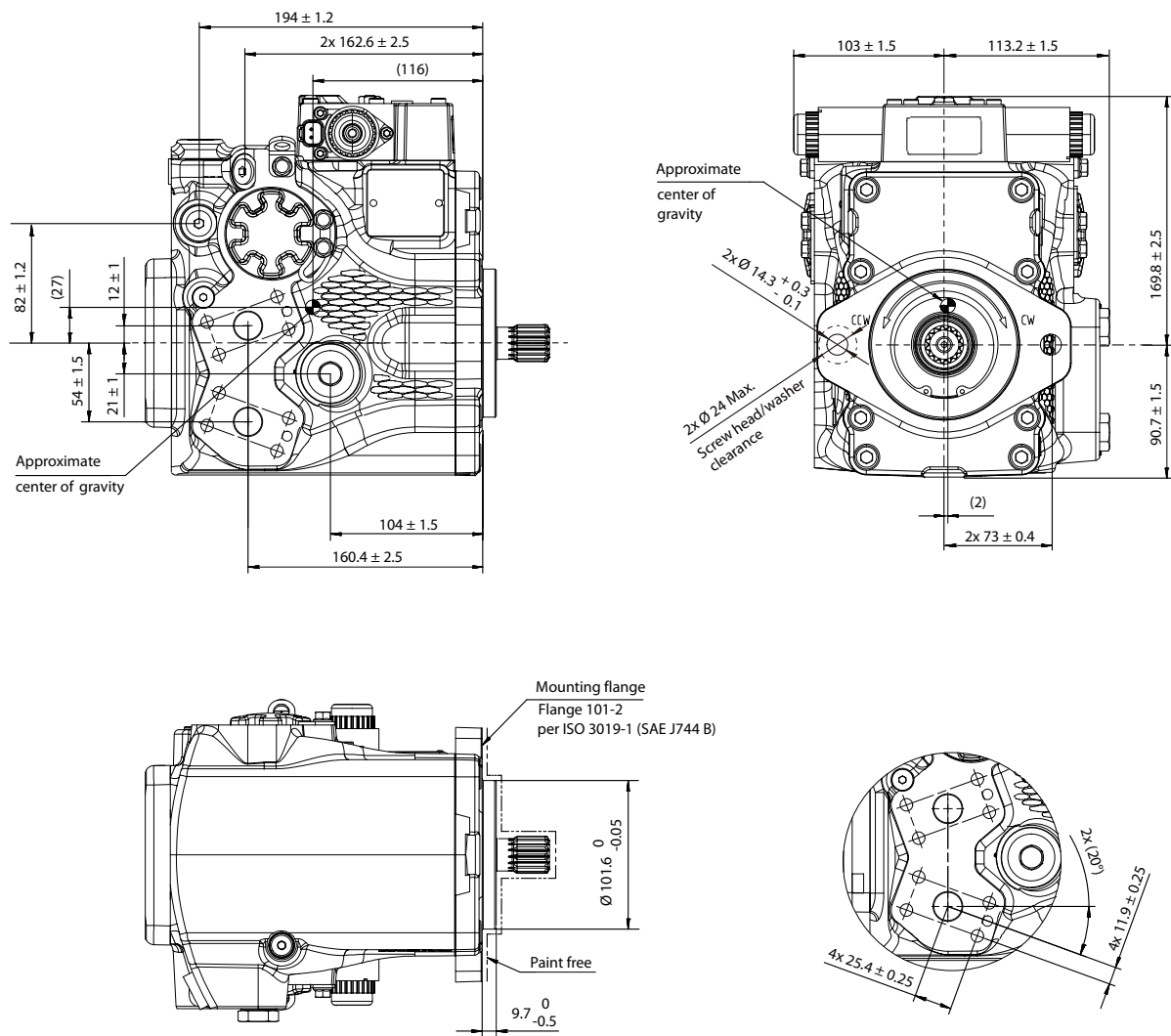


Pin	Assignment
1	Speed signal 1
2	NC
3	Speed signal 2
4	Supply
5	Ground
6	Temperature

Installation drawings

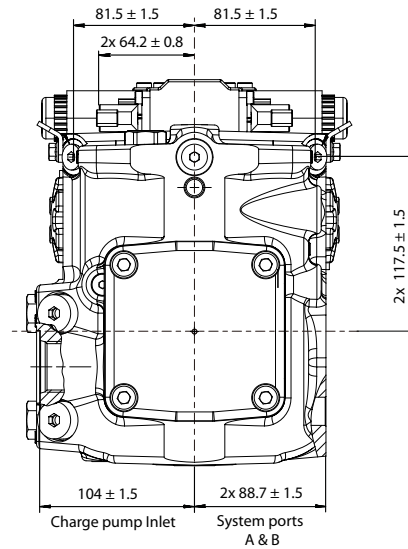
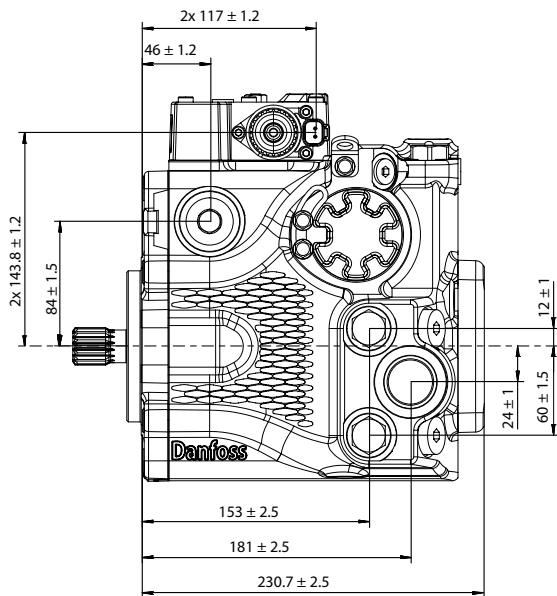
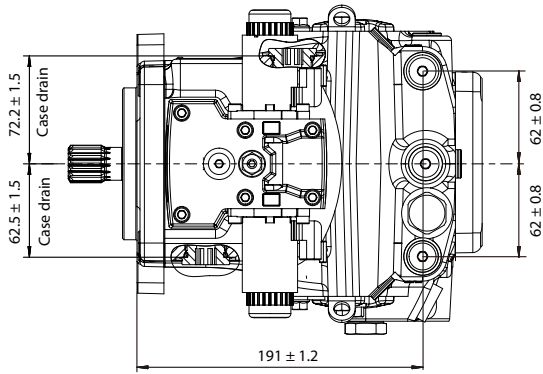
38/45 dimensions

Split flange type



P108935

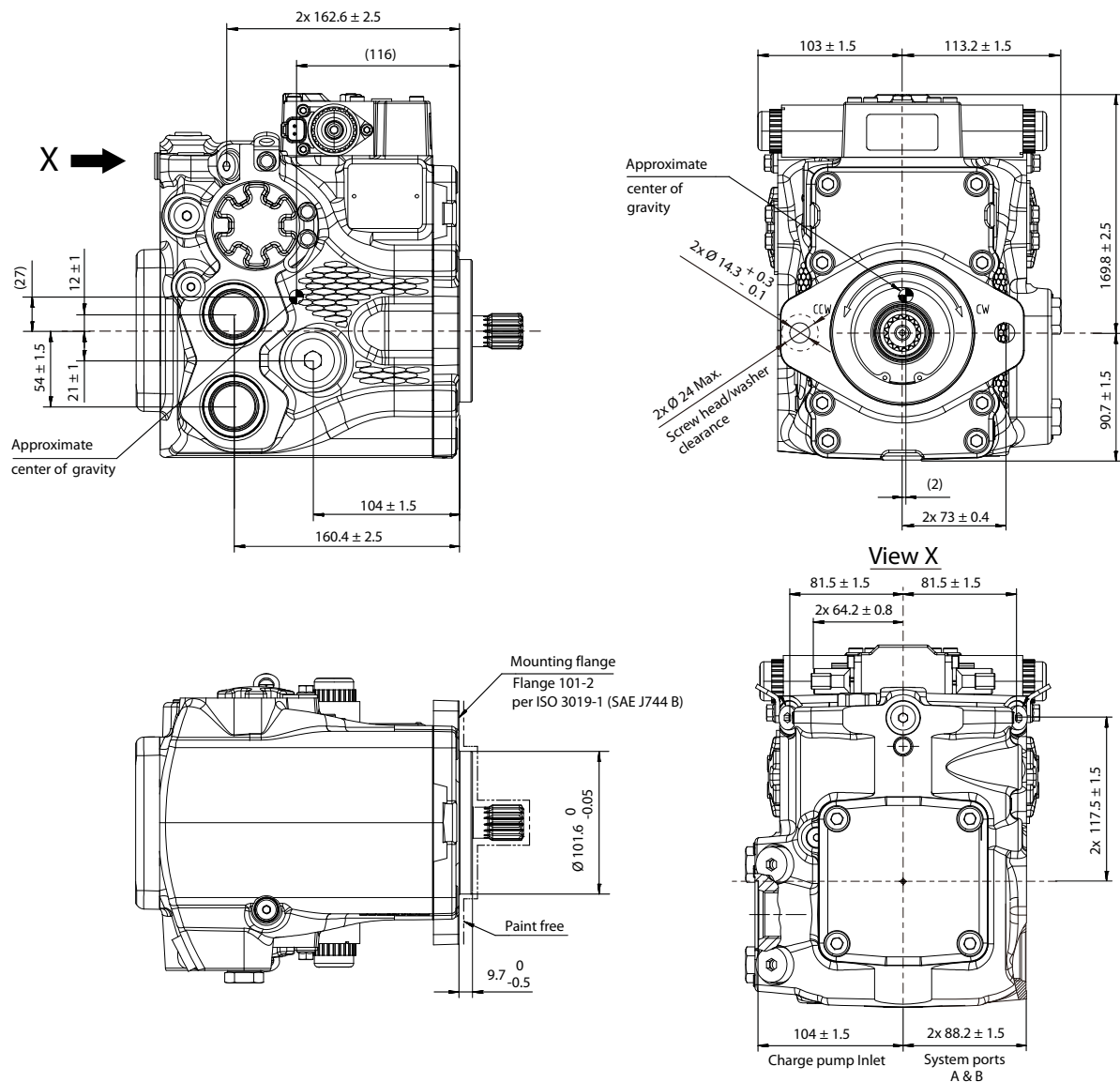
Installation drawings



P108957

Installation drawings

O-ring boss type

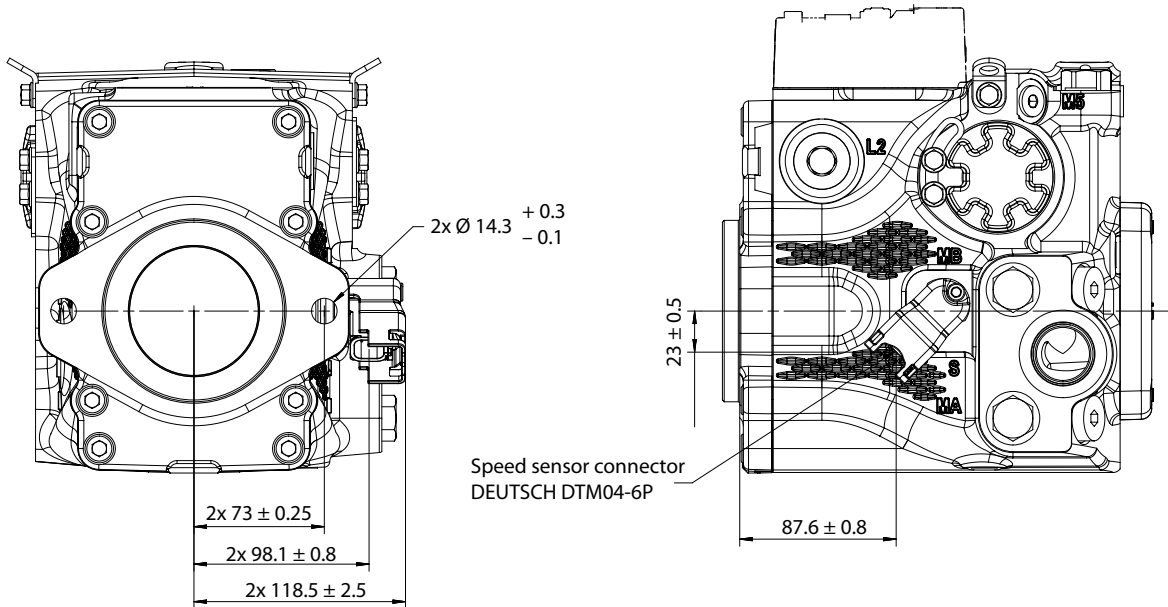


P400351

Please contact Danfoss representative for specific installation drawings.

Installation drawings

38/45 dimensions with speed sensor



Please contact Danfoss representative for specific installation drawings.

Speed sensor connector

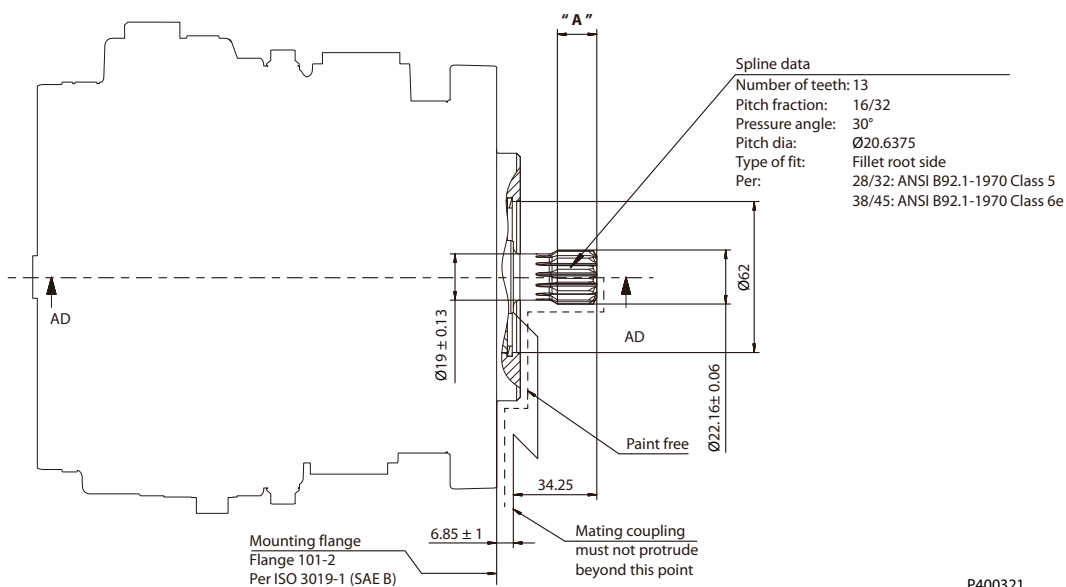


Pin	Assignment
1	Speed signal 1
2	NC
3	Speed signal 2
4	Supply
5	Ground
6	Temperature

Installation drawings

Input shafts: option G4, F6 (SAE B, 13 teeth)

Option G4, F6, ISO 3019-1, Outer dia 22 mm



Min. active spline length ¹⁾	28/32	38/45
A	16.17 ± 0.5	16.17 ± 0.15

¹⁾ Minimum active spline length for the specified torque ratings.

Specifications

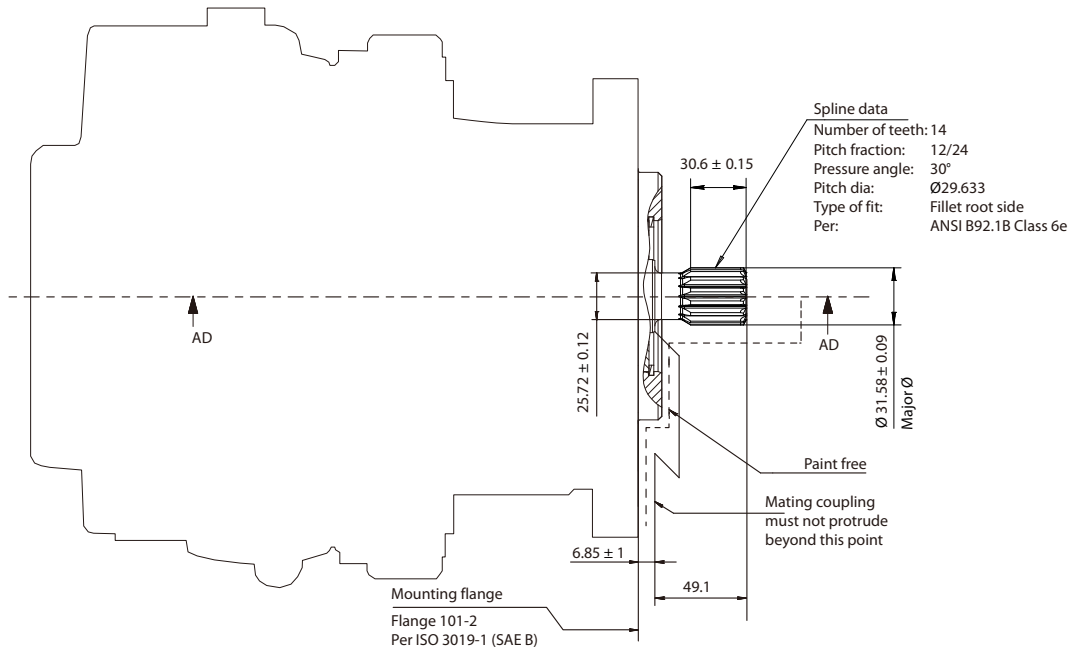
Option	G4, F6
Spline	13 teeth, 16/32 pitch
Maximum torque rating	226 N·m

[Please contact Danfoss representative for specific installation drawings.](#)

Installation drawings

Input shafts: option G1, F1 (SAE B, 14 teeth)

Option G1, F1, ISO 3019-1, Outer dia 31.58 mm (38/45 only)



Specifications

Option	G1, F1
Spline	14 teeth, 12/24 pitch
Min. active spline length¹⁾	30.6 ± 0.15
Maximum torque rating	592 N·m [437 lbf·ft]

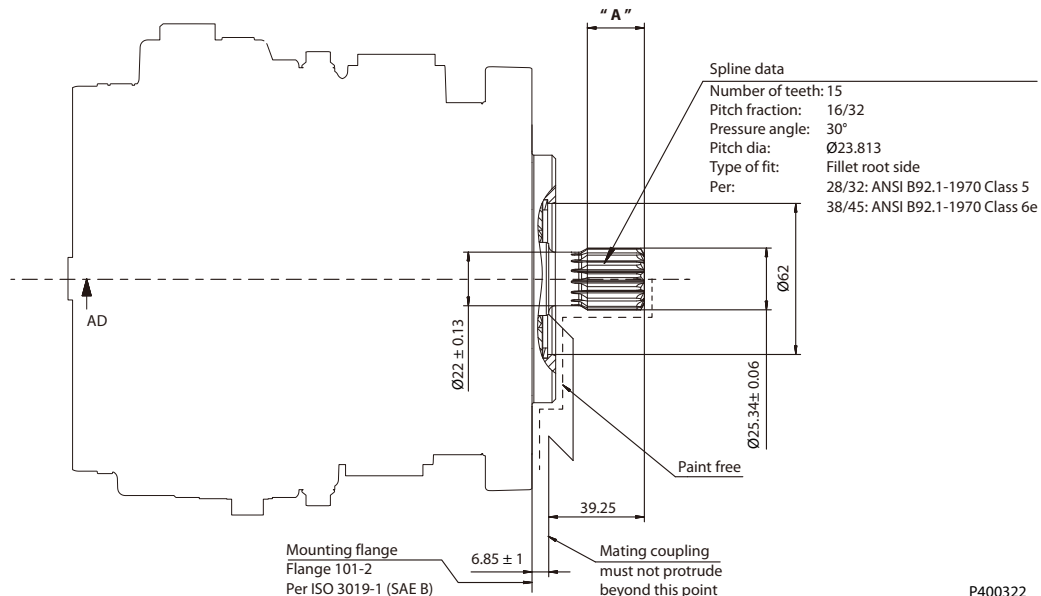
¹⁾ Minimum active spline length for the specified torque ratings.

[Please contact Danfoss representative for specific installation drawings.](#)

Installation drawings

Input shafts: option G5, F5 (SAE B, 15 teeth)

Option G5, F5, ISO 3019-1, outer dia 23 mm



Min. active spline length ¹⁾	28/32	38/45
A	23.4 ± 0.5	22.0 ± 0.15

¹⁾ Minimum active spline length for the specified torque ratings.

Specifications

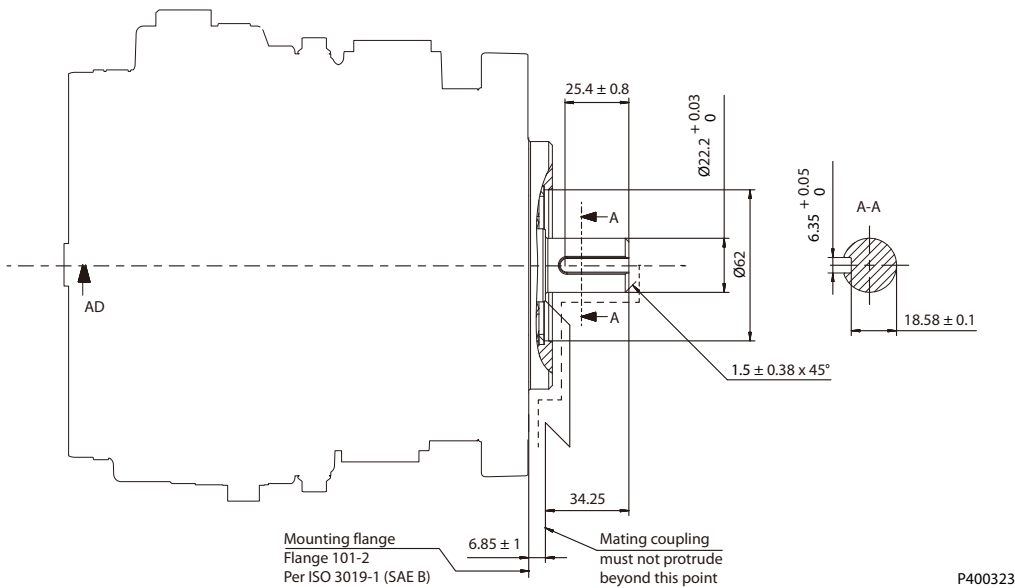
Option	G5, F5
Spline	15 teeth, 16/32 pitch
Maximum torque rating	362 N·m

[Please contact Danfoss representative for specific installation drawings.](#)

Installation drawings

Input shafts: option A7, A9 (SAE B, straight key shaft)

Option A7, A9, ISO 3019-1, outer dia 22 mm (28/32 only)



Specifications

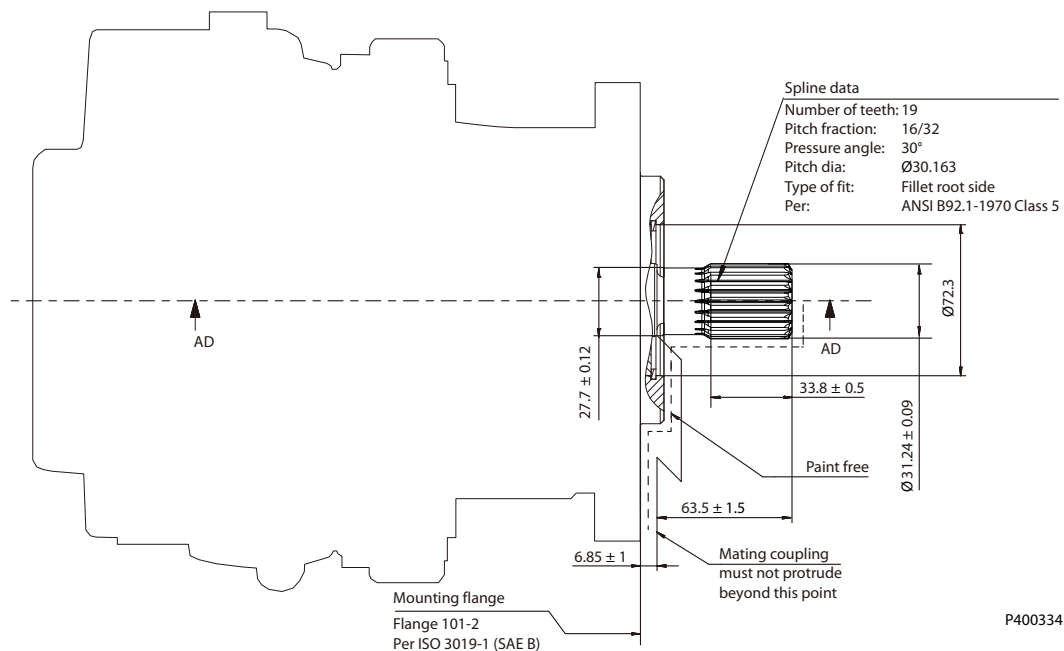
Option	A7, A9
Maximum torque rating	226 N·m

[Please contact Danfoss representative for specific installation drawings.](#)

Installation drawings

Input shafts: option G6, G7 (SAE B, 19 teeth)

Option G6, G7, ISO 3019-1, outer dia 31.24 mm (38/45 only)



Specifications

Option	G6, G7
Spline	19 teeth, 16/32 pitch
Min. active spline length¹⁾	33.8 ± 0.5
Maximum torque rating	734 N•m

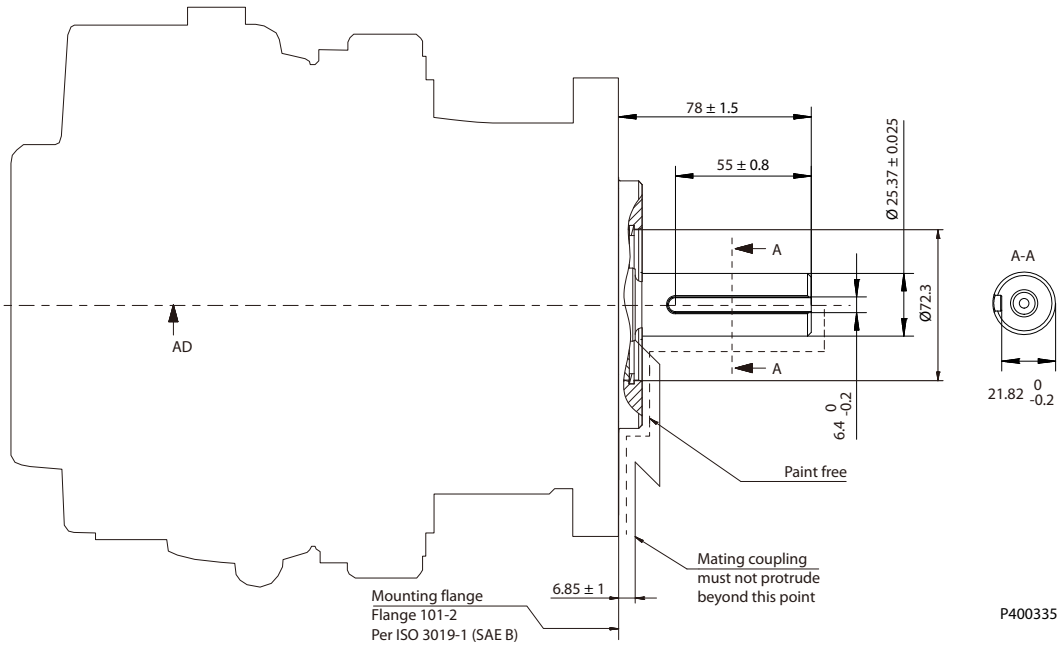
¹⁾ Minimum active spline length for the specified torque ratings.

[Please contact Danfoss representative for specific installation drawings.](#)

Installation drawings

Input shafts: option A6, A8 (SAE B, straight key shaft)

Option A8, A6, ISO 3019-1, outer dia 1 inch (38/45 only)



Specifications

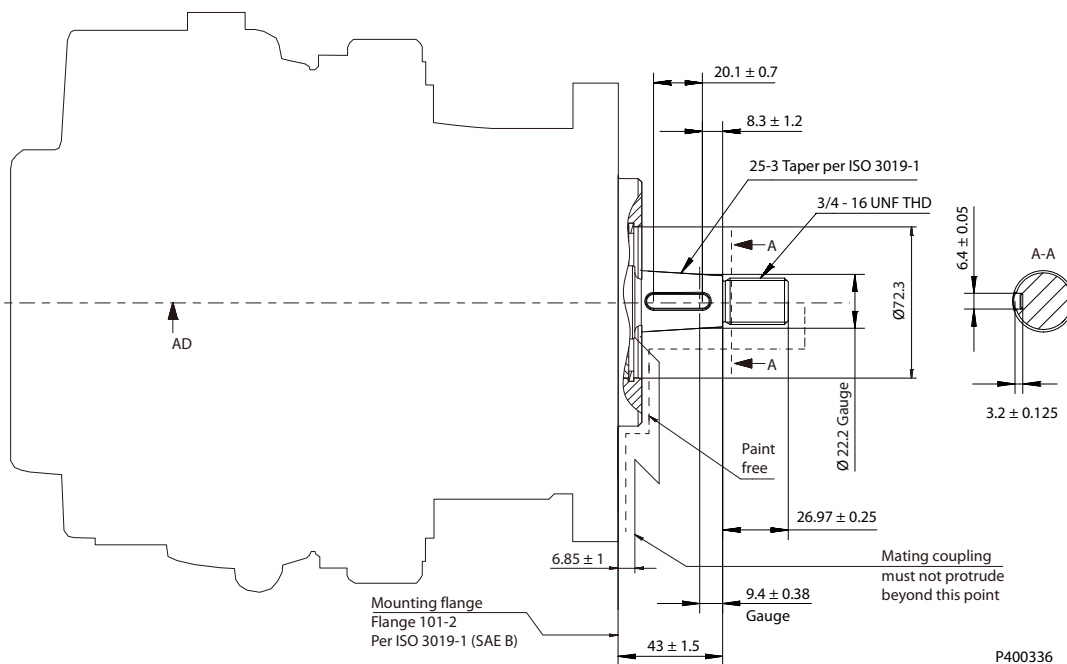
Option	A6, A8
Maximum torque rating	362 N·m

[Please contact Danfoss representative for specific installation drawings.](#)

Installation drawings

Input shafts: option F2, F3 (SAE B, taper key shaft)

Option F2, F3, ISO 3019-1, Code 25-3, Dia 22.2 Taper 1:8, without key, no through-hole in the end of the shaft (38/45 only)



Specifications

Option	F2, F3
Maximum torque rating	497 N·m

[Please contact Danfoss representative for specific installation drawings.](#)

Tapered shaft customer acknowledgement

The Danfoss MP1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied.

The specified torque rating of the tapered shaft documented above is based on the cross-sectional diameter of the shaft, through the keyway, and assumes the proper clamp and fit between shaft and coupling. Danfoss guarantees the design and manufactured quality of the tapered shaft. The customer is responsible for the design and manufactured quality of the mating female coupling and key and applied torque on the nut. Danfoss has made provisions for the key in accordance to the ISO specification with the understanding that the key is solely to assist in the installation of the mating coupling.

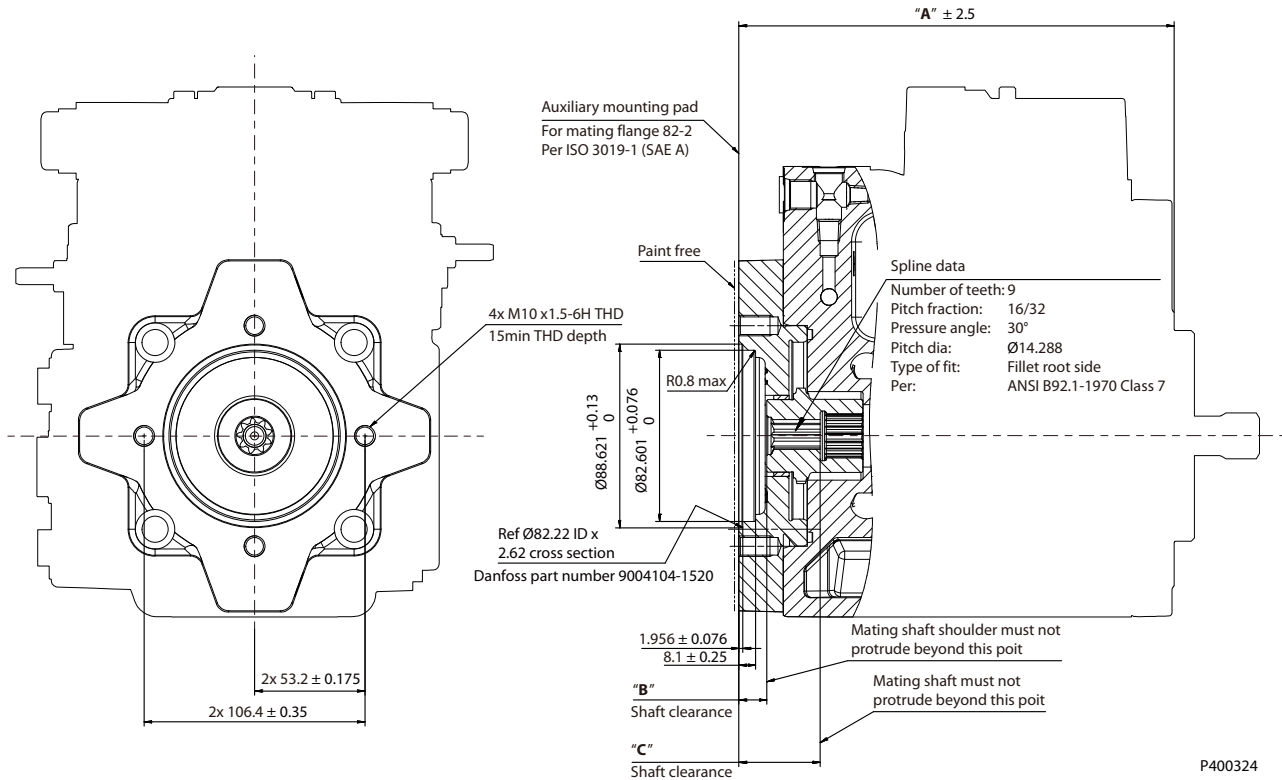
Caution

Torque must be transmitted by the taper fit between the shaft and its mating coupling, not the key. Torque or loading inadvertently transmitted by the customer supplied key may lead to premature shaft failure.

Installation drawings

Auxiliary mounting: option A16, B16, C16, D16, E16, F16 (SAE A, 9 teeth)

Option A16, B16, C16, D16, E16, F16, ISO 3019-1, flange 82-2 (SAE A, 9 teeth)



Location	28/32	38/45
A	210	234.5
B	11.8 min shaft clearance	12.0 min shaft clearance
C	39.0 min shaft clearance	50.0 min shaft clearance

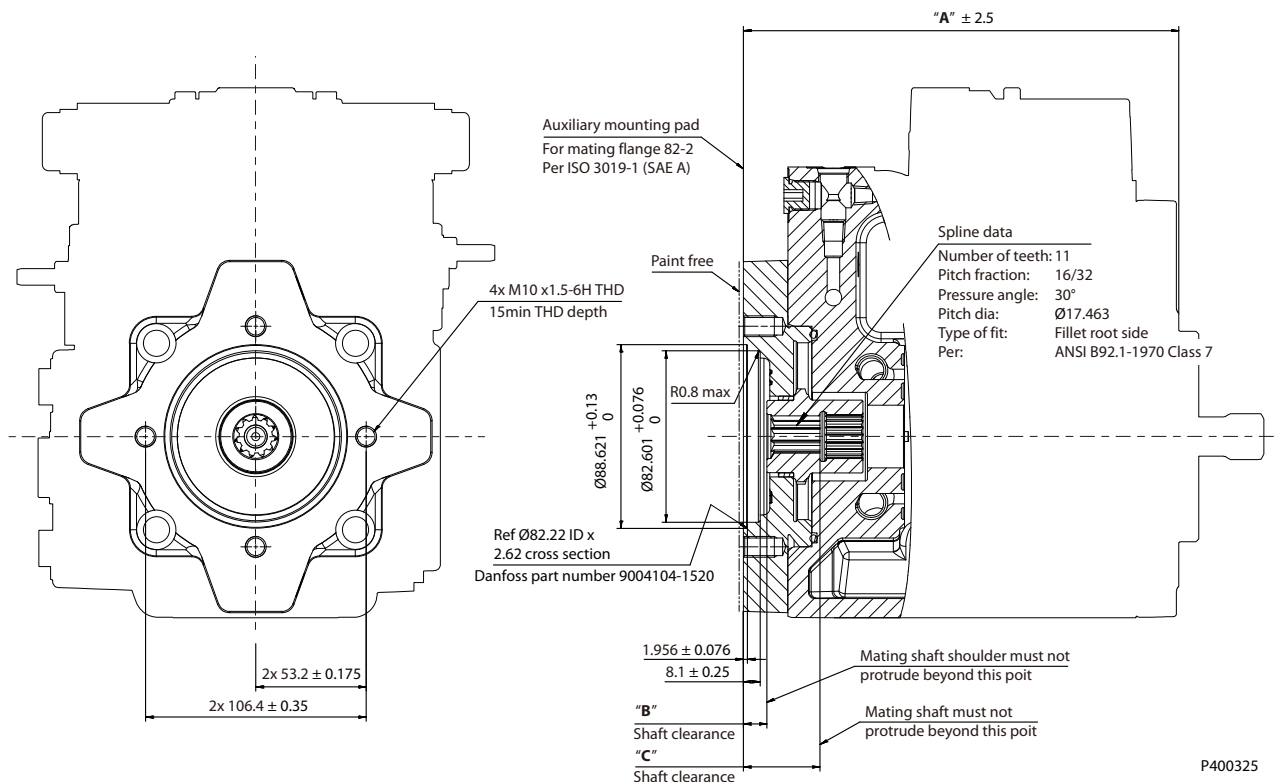
Specifications

Option	A16, B16, C16, D16, E16, F16
Spline	9 teeth, 16/32 pitch
Maximum torque	107 N•m

Installation drawings

Auxiliary mounting: option A19, B19, C19, D19, E19, F19 (SAE A, 11 teeth)

Option A19, B19, C19, D19, E19, F19, ISO 3019-1, flange 82-2 (SAE A, 11 teeth)



Location	28/32	38/45
A	210	234.5
B	11.8 min shaft clearance	12.0 min shaft clearance
C	39.0 min shaft clearance	50.0 min shaft clearance

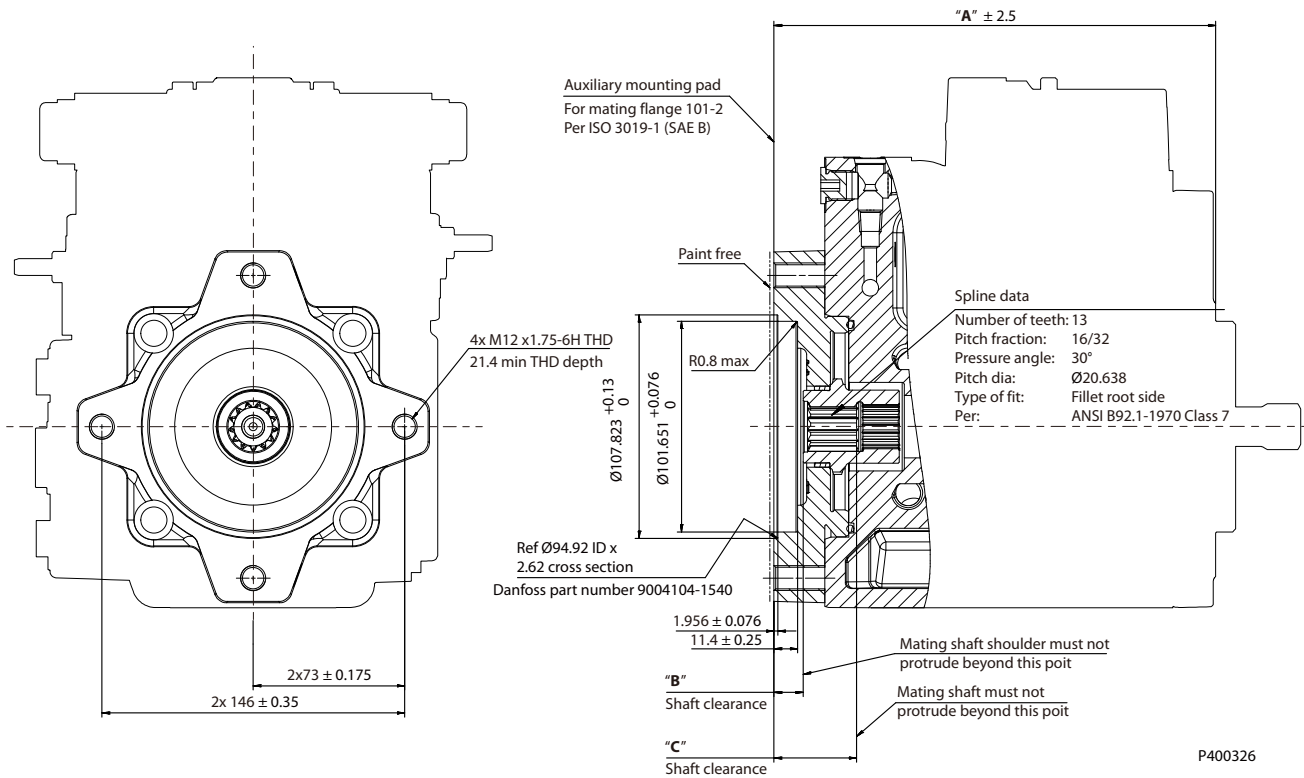
Specifications

Option	A19, B19, C19, D19, E19, F19
Spline	11 teeth, 16/32 pitch
Maximum torque	147 N·m

Installation drawings

Auxiliary mounting: option A22, B22, C22, D22, E22, F22 (SAE B, 13 teeth)

Option A22, B22, C22, D22, E22, F22, ISO 3019-1, flange 101-2 (SAE B, 13 teeth)



Location	28/32	38/45
A	213	234.5
B	14.8 min shaft clearance	12.0 min shaft clearance
C	42.0 min shaft clearance	50.0 min shaft clearance

Specifications

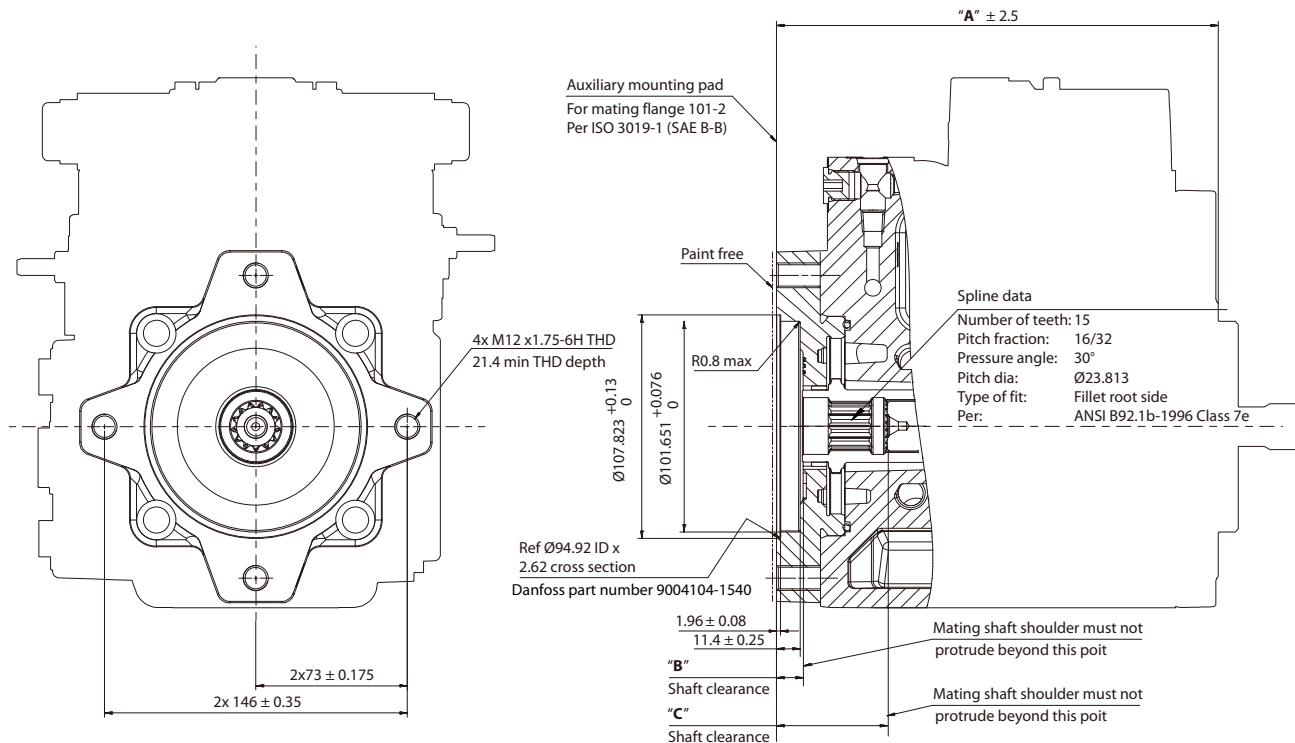
Option	A22, B22, C22, D22, E22, F22
Spline	13 teeth, 16/32 pitch
Maximum torque	248 N·m

Bolt length greater than 21.4 mm could result in a leak or damage the unit.

Installation drawings

Auxiliary mounting: option A25, B25, C25, D25, E25, F25 (SAE B-B 15 teeth)

Option A25, B25, C25, D25, E25, F25, ISO 3019-1, flange 101-2 (SAE B-B, 15 teeth) (38/45 only)



P400337

Location	38/45
A	234.5
B	12.0 min shaft clearance
C	50.0 min shaft clearance

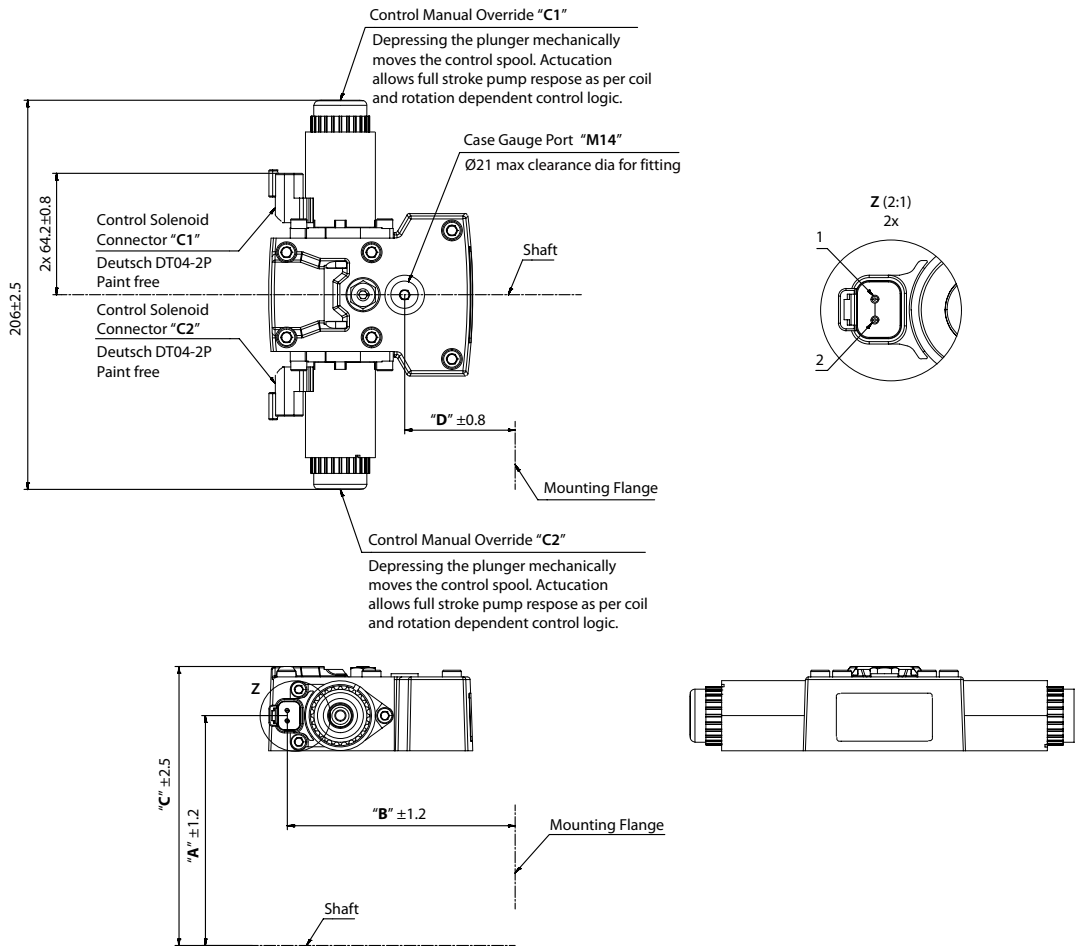
Specifications

Option	A25, B25, C25, D25, E25, F25
Spline	15 teeth, 16/32 pitch
Maximum torque	347 N·m

Bolt length greater than 21.4 mm could result in a leak or damage the unit.

Controls

Electric displacement control (EDC)



P400314

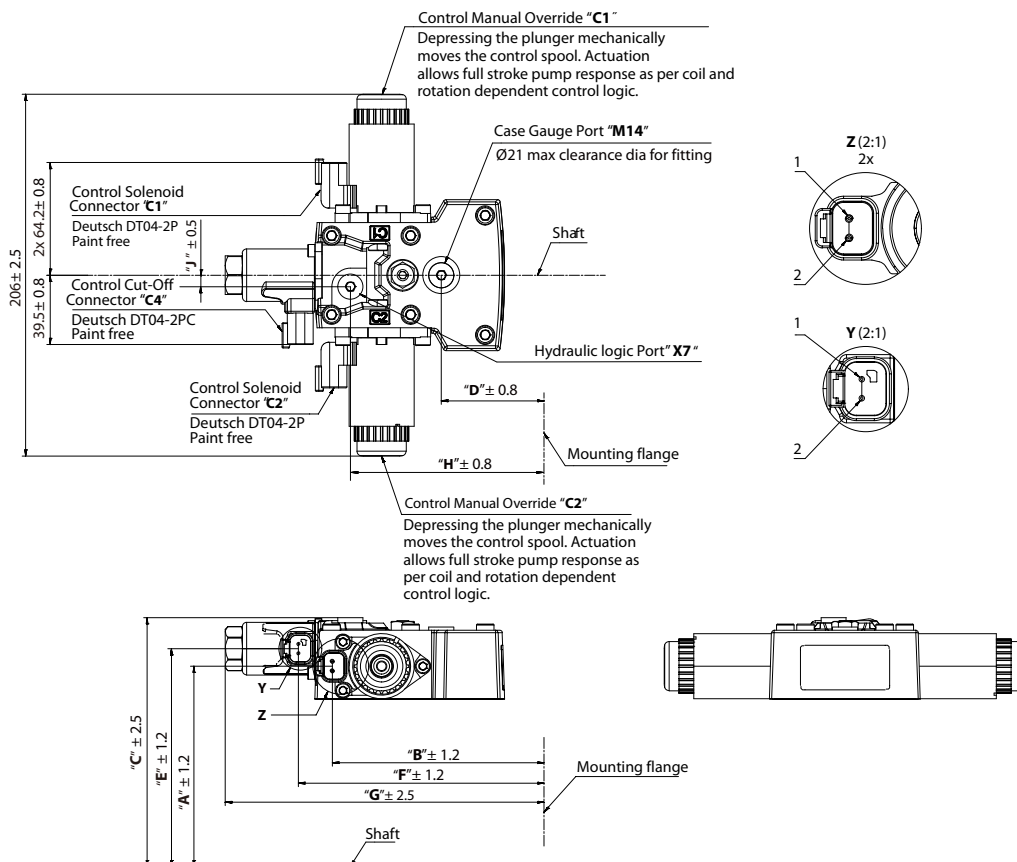
Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Location	28/32	38/45
A	142.3	143.8
B	120.5	117
C	168.3	169.8
D	58.4	54.9

Please contact Danfoss representative for specific installation drawings.

Controls

Electric displacement control with CCO (EDC+CCO)



P400331

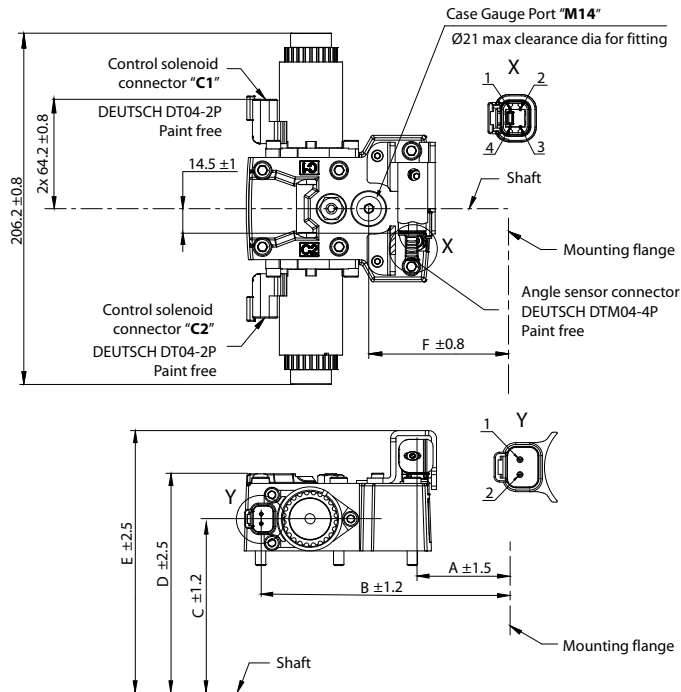
Control solenoid connector "C1" & "C2" & "C4"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Location	28/32	38/45
A	142.3	143.8
B	120.5	117
C	169.6	171.4
D	58.4	54.9
E	152.3	153.8
F	139.8	136.3
G	181.4	178
H	110.2	106.7
J		6.5

Please contact Danfoss representative for specific installation drawings.

Controls

EDC with ASNSR



Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Angle sensor connector pinout

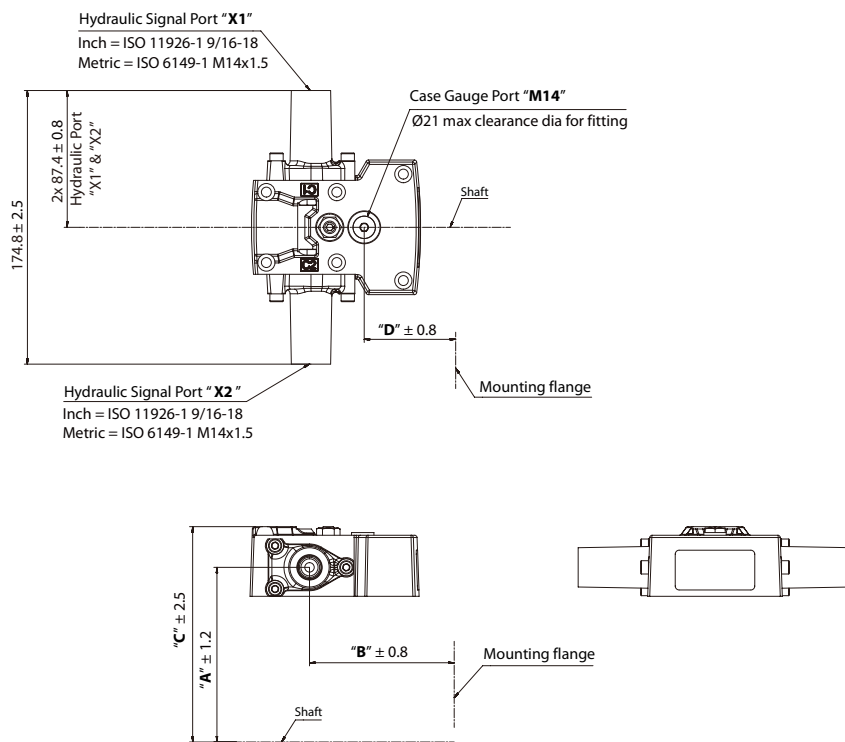
Pin	Assignment
1	Ground (GND)
2	Not connected
3	Output signal 1 (SIG 1)
4	Supply (V+)

Dimensions

Reference	28/32	38/45
A	32.7	29.2
B	120.5	117
C	142.3	143.8
D	169.6	171.4
E	193.3	194.8
F	58.4	54.9

Controls

Hydraulic displacement control (HDC)



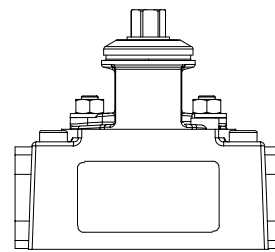
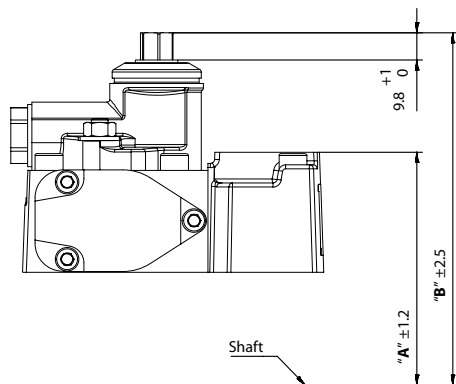
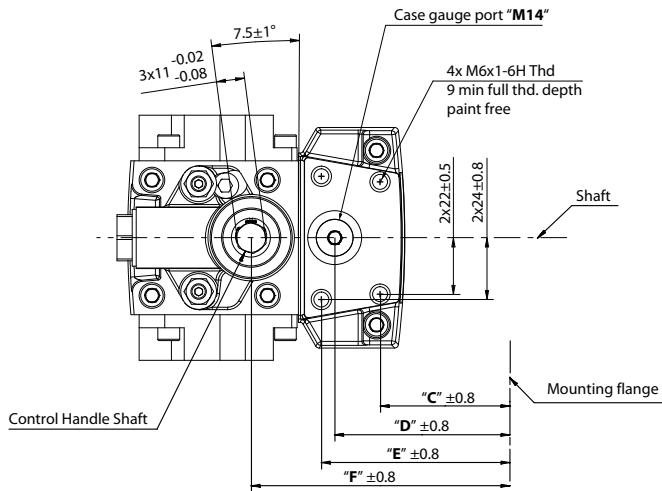
P400518

Legend

Dimension	28/32	38/45
A	142.3	143.8
B	92.4	88.9
C	168.3	169.8
D	58.4	54.9

Controls

Manual displacement control (MDC)



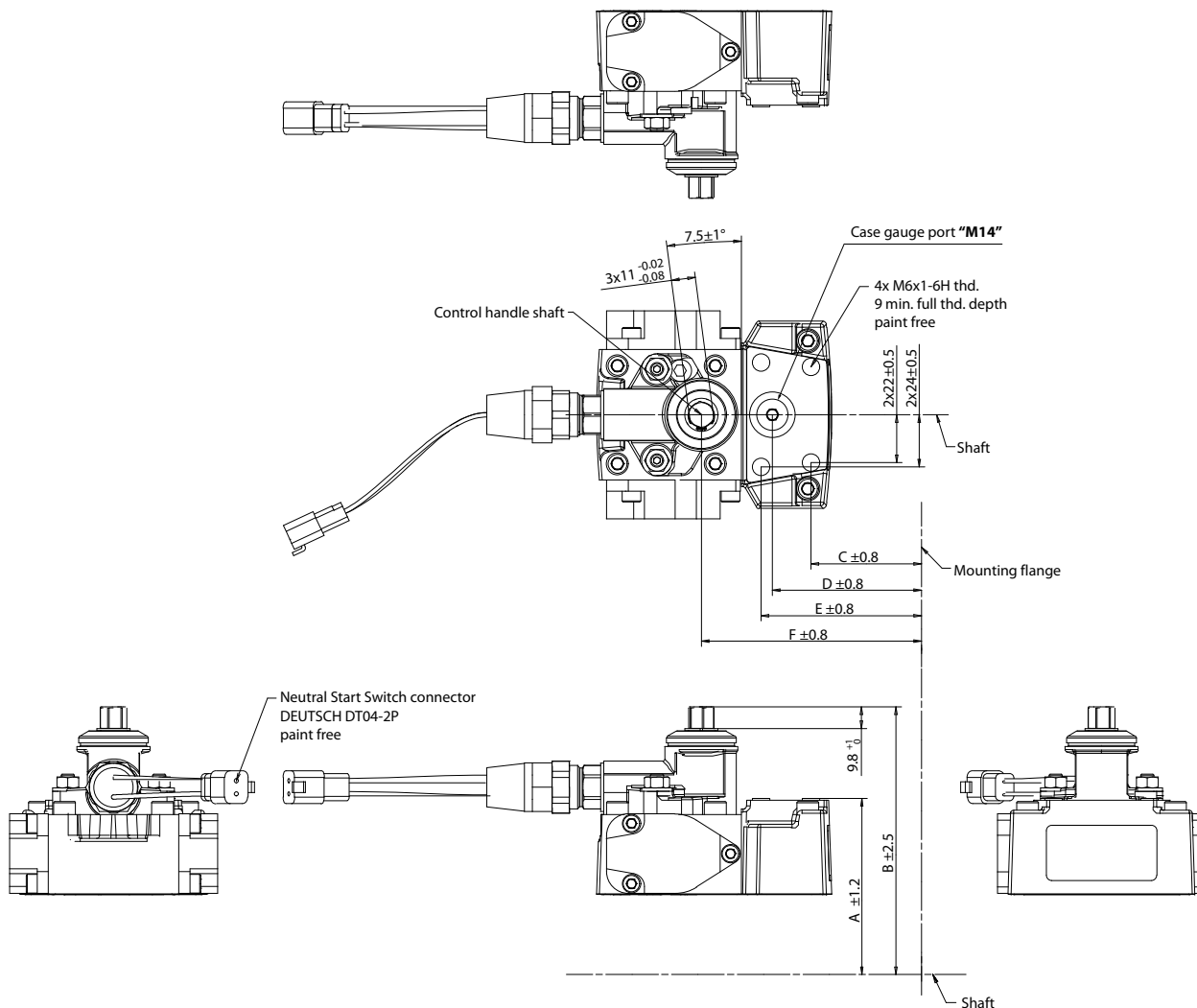
P400315

Location	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

Please contact Danfoss representative for specific installation drawings.

Controls

MP1 MDC with neutral start switch option: M2



Neutral start switch connector

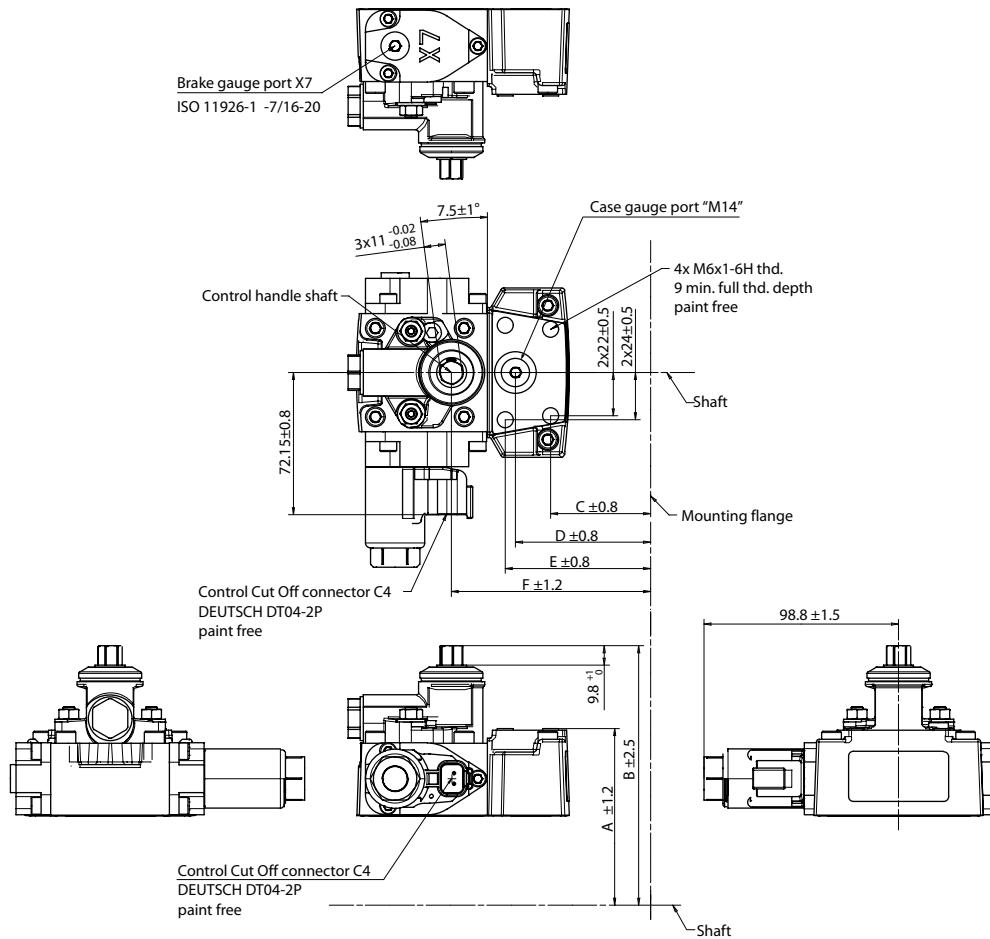
Pin	Assignment	Alternate	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

[Please contact Danfoss representative for specific installation drawings.](#)

Controls

MP1 MDC with CCO, options: M3, M4



Control cut off connector (C4)

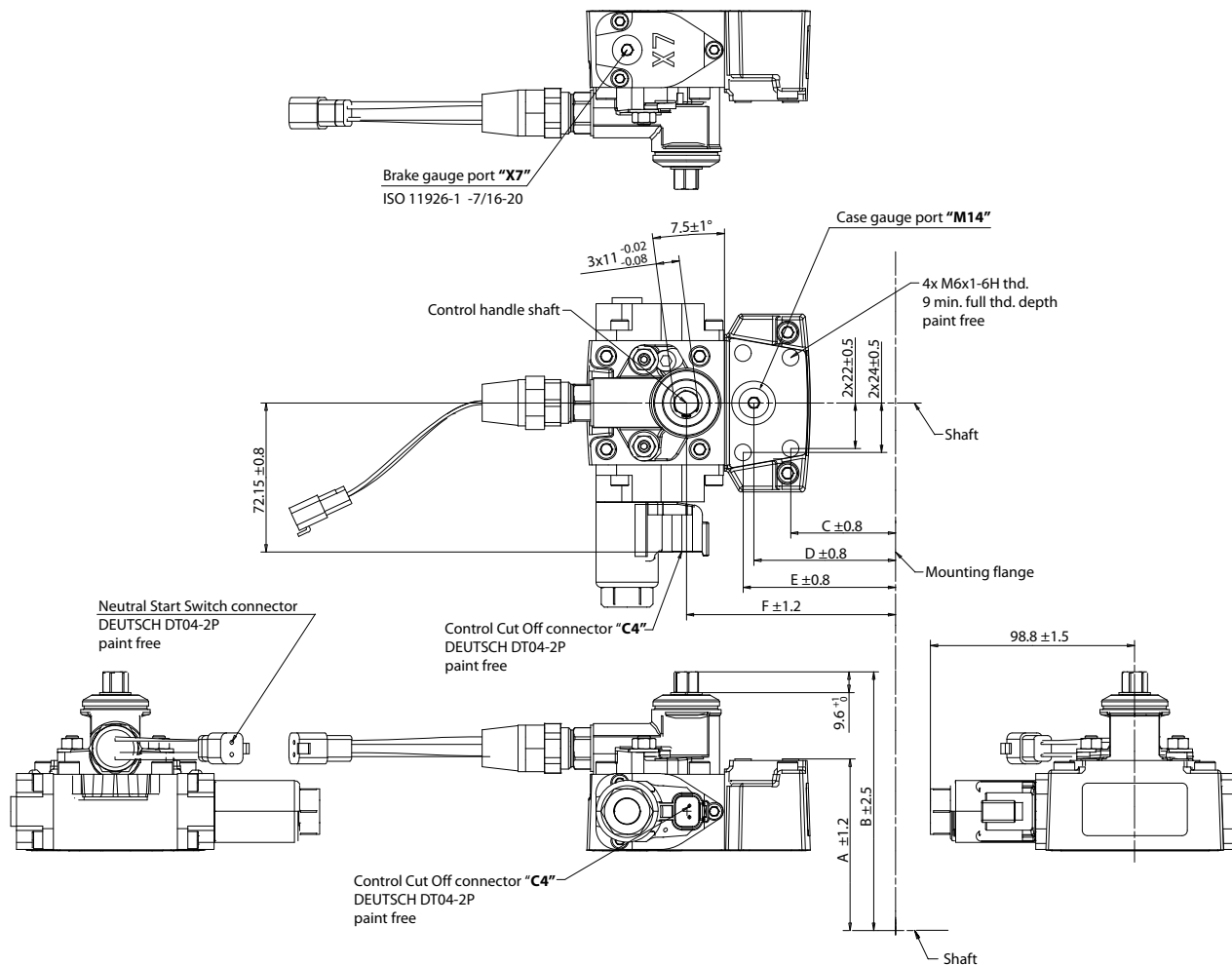
Pin	Assignment	Alternate	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

Please contact Danfoss representative for specific installation drawings.

Controls

MP1 MDC with NSS and CCO options: M5, M6



Neutral start switch, control cut off connectors

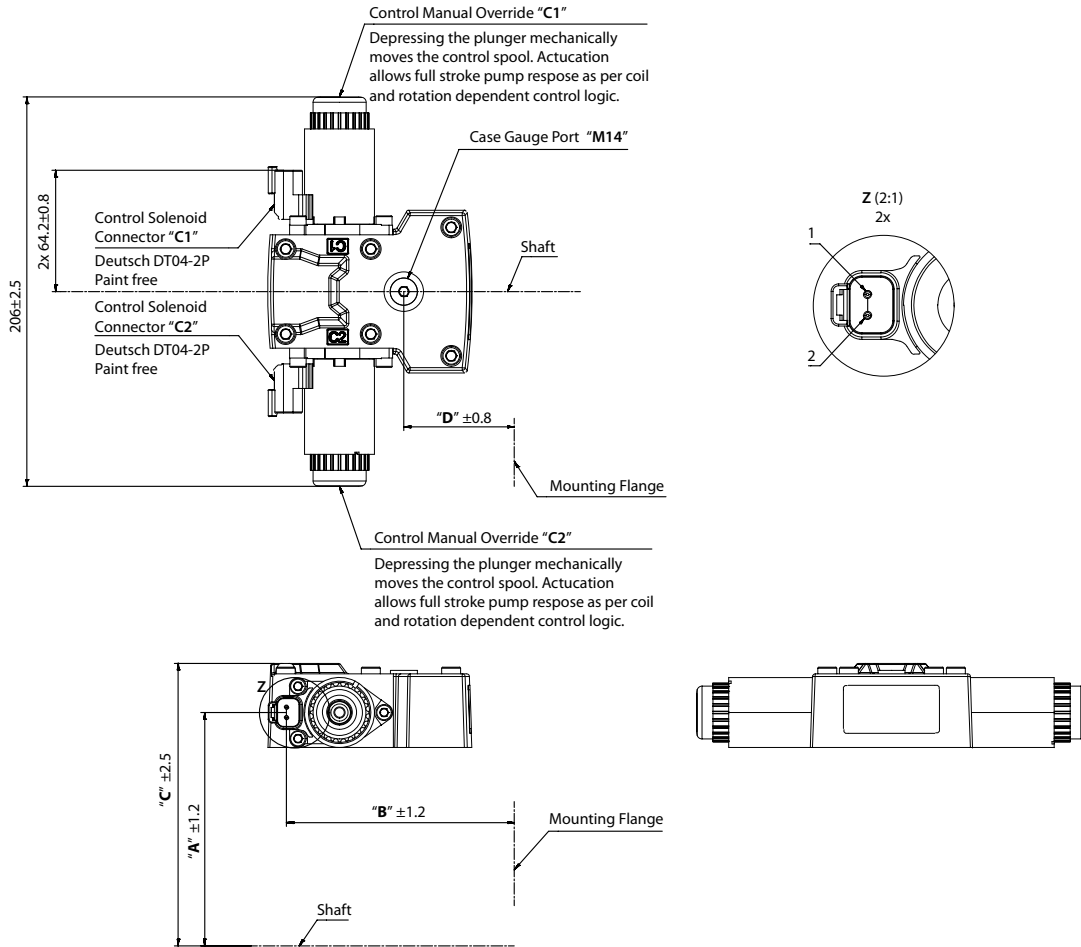
Pin	Assignment	Alternate	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	166.8	168.3
B	209.7	211.2
C	31.9	28.4
D	49.7	46.2
E	54.9	51.4
F	82.3	78.8

Please contact Danfoss representative for specific installation drawings.

Controls

Forward-neutral-reverse (FNR)



P400316

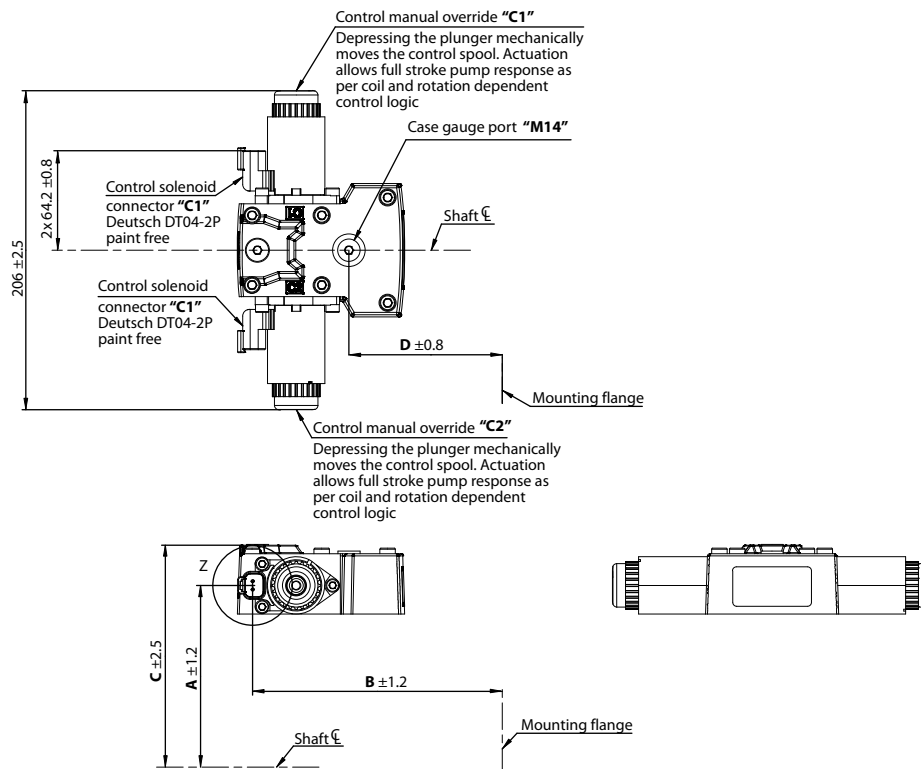
Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	142.3	143.8
B	120.5	117
C	168.3	169.8
D	58.4	54.9

[Please contact Danfoss representative for specific installation drawings.](#)

Controls

Non-feedback proportional electric (NFPE)



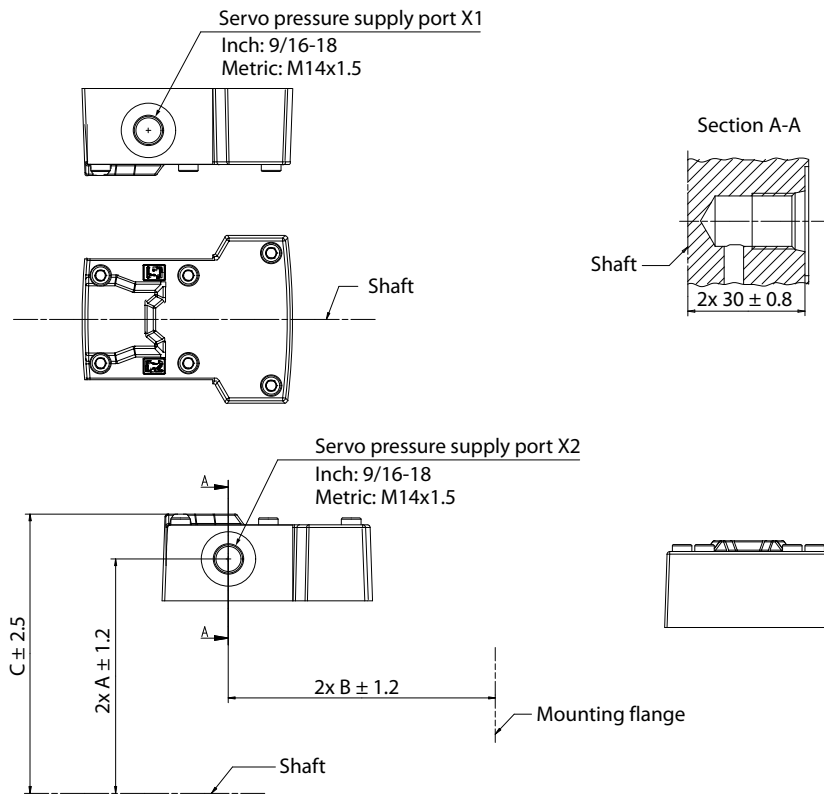
Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Dimension	28/32	38/45
A	142.3	143.8
B	120.5	117
C	168.3	169.8
D	58.4	54.9

[Please contact Danfoss representative for specific installation drawings.](#)

Controls

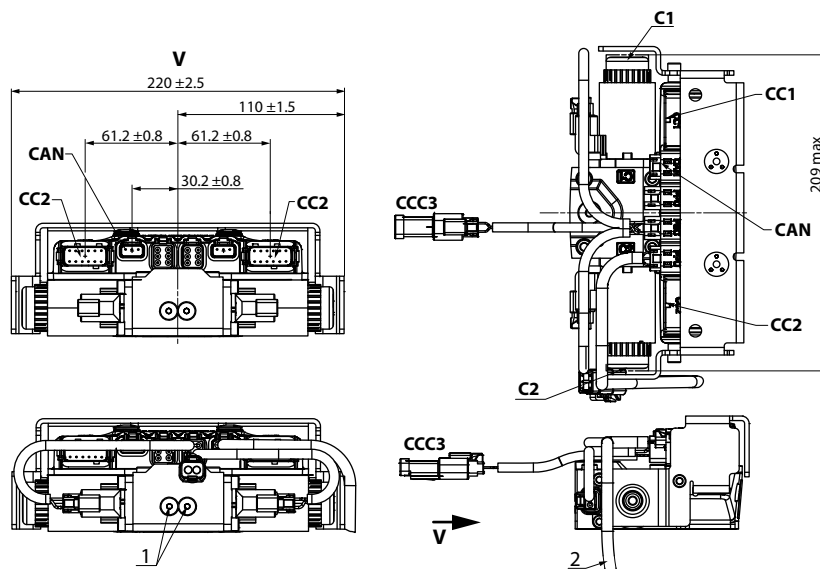
MP1 Non-feedback proportional hydraulic (NFPH)



Dimension	28/32	38/45
A	145.3	146.8
B	96.4	92.9
C	168.3	169.8

Controls

Automotive control (AC)



- 1 Plug removing can cause contamination issues
- 2 PPU wire harness is factory installed to speed sensor

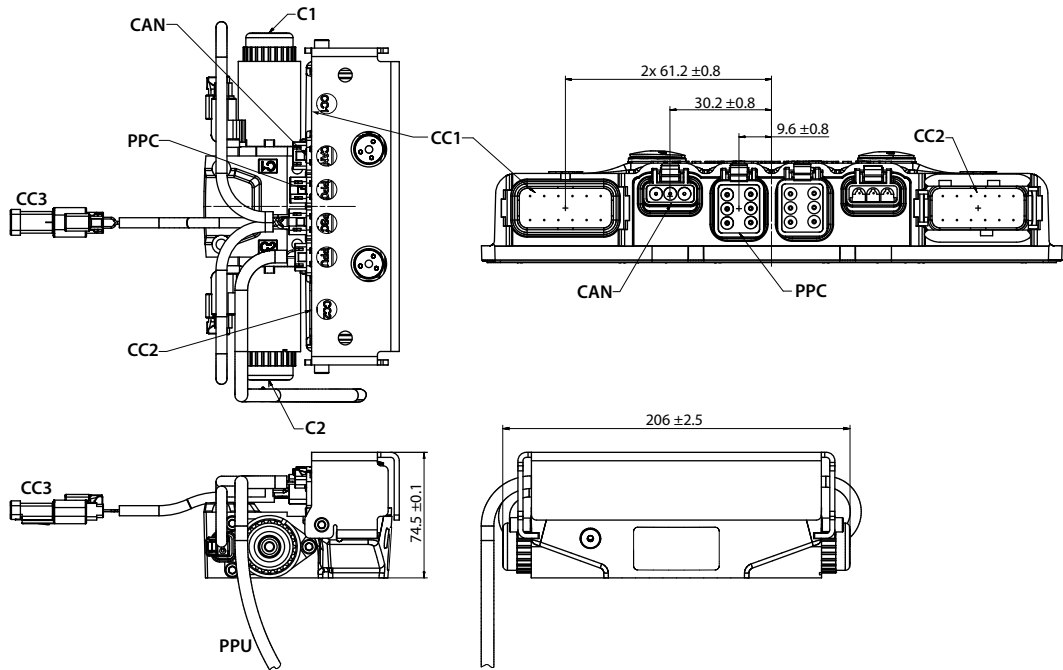
Connectors description

Port	Description
C1 and C2	1. Control manual override C1 2. Control Manual Override C2
CC1	Port A control connector DEUTSCH DTM04-12P; paint free
CC2	Port B control connector DEUTSCH DTM04-12P; paint free
CC3	Control connector DEUTSCH DT06-2S; paint free; For using connector, the plug may be removed.
CAN	Control connector DEUTSCH DTM04-3P; paint free; For using connector, the plug may be removed.

Please contact Danfoss representative for specific installation drawings.

Controls

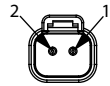
AC connectors dimensions



PPU wire harness is factory installed to speed sensor.

CC3

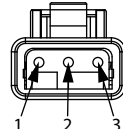
Connector DEUTSCH, 2-pin



1. Digital output A1 (+)
2. Digital output A2 (-)

CAN

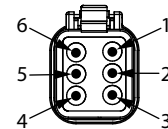
Connector DEUTSCH, 3-pin



1. CAN High
2. CAN Low
3. CAN Shield

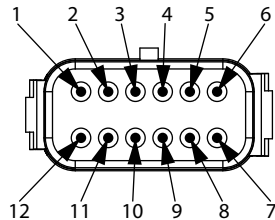
PPC

Connector DEUTSCH, 6-pin



1. Sensor A (+)
2. Analog input A
3. Sensor A (-)
4. Sensor B (-)
5. Analog input B
6. Sensor B (+)

Connector DEUTSCH, 12-pin



CC1

1. Battery (-)
2. Battery (+)
3. Sensor (+)
4. Sensor (-)
5. Motor rpm input (frequency)
6. Forward input (digital)
7. Reverse input (digital)
8. Sensor (+)
9. Sensor (-)
10. Drive pedal input (analog – nominal)
11. Drive pedal input (analog – red)
12. Neural input (digital)

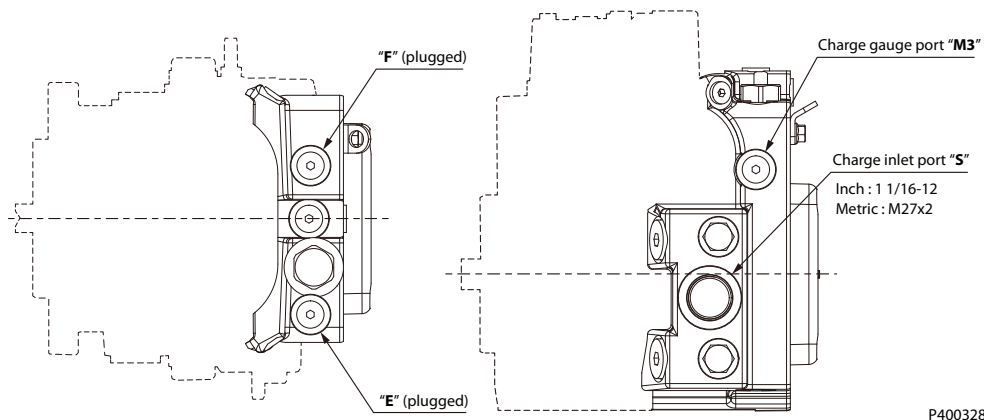
CC2

1. Inch input (analog – red)
2. Mode switch B input (digital – nominal)
3. Motor prop/PCOR driver
4. Motor direction input (analog)
5. Sensor (+)
6. Sensor (-)
7. Inch input (analog – nominal)
8. Motor BPD driver
9. Digital output B2 (-)
10. Digital output B1 (+)
11. Mode switch A input (digital)
12. Mode switch B input (digital – red)

Filtration

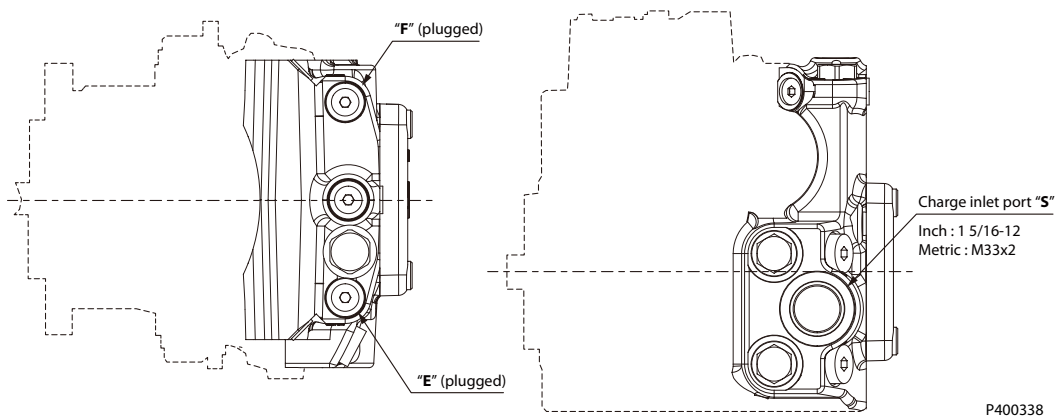
Suction filtration: option S

28/32



Please contact Danfoss representative for specific installation drawings.

38/45

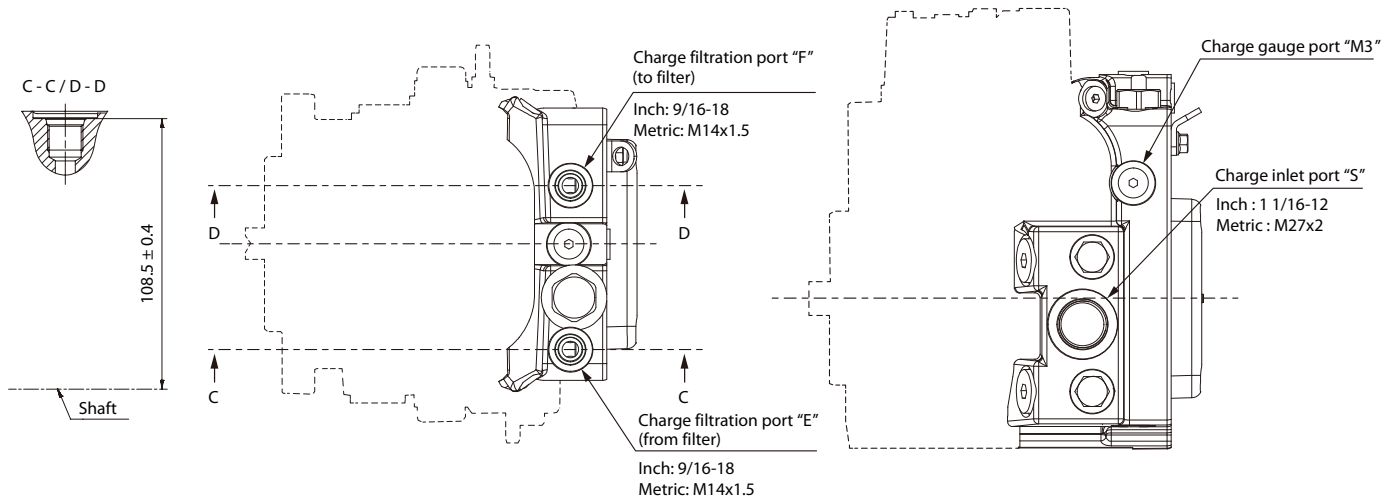


Please contact Danfoss representative for specific installation drawings.

Filtration

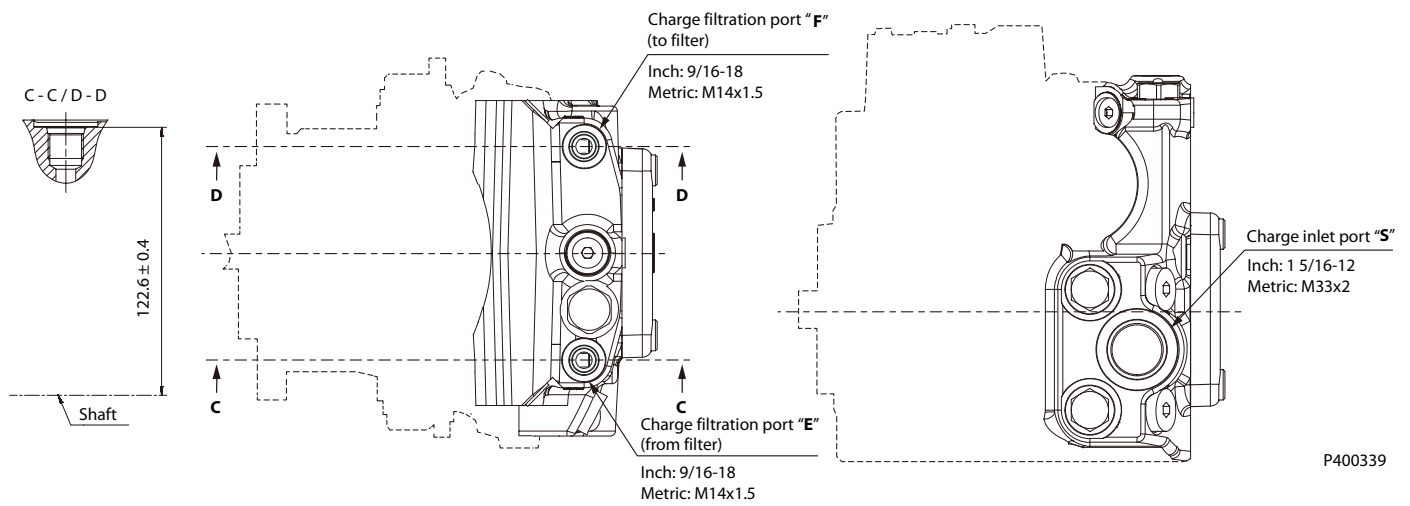
Remote full flow charge pressure filtration: option R

28/32



Please contact Danfoss representative for specific installation drawings.

38/45



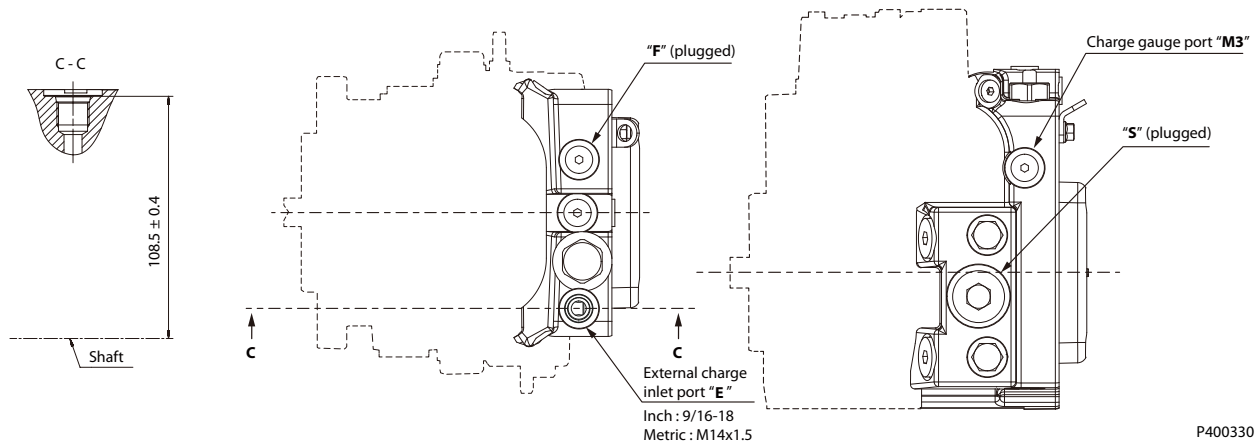
P400339

Please contact Danfoss representative for specific installation drawings.

Filtration

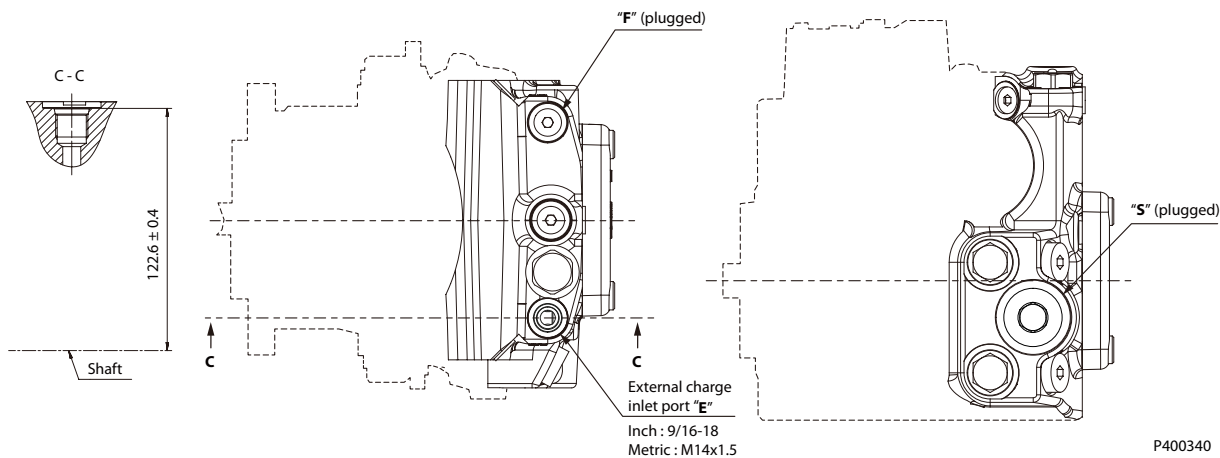
External full flow charge pressure filtration: option E

28/32



Please contact Danfoss representative for specific installation drawings.

38/45



Please contact Danfoss representative for specific installation drawings.

Products we offer:

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

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

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

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

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

Local address:

Hydro-Gear

www.hydro-gear.com

Daikin-Sauer-Danfoss

www.daikin-sauer-danfoss.com

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

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

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

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

Danfoss can accept no responsibility for possible errors in catalogues, brochures and other printed material. Danfoss reserves the right to alter its products without notice. This also applies to products already on order provided that such alterations can be made without subsequent changes being necessary in specifications already agreed. All trademarks in this material are property of the respective companies. Danfoss and the Danfoss logotype are trademarks of Danfoss A/S. All rights reserved.