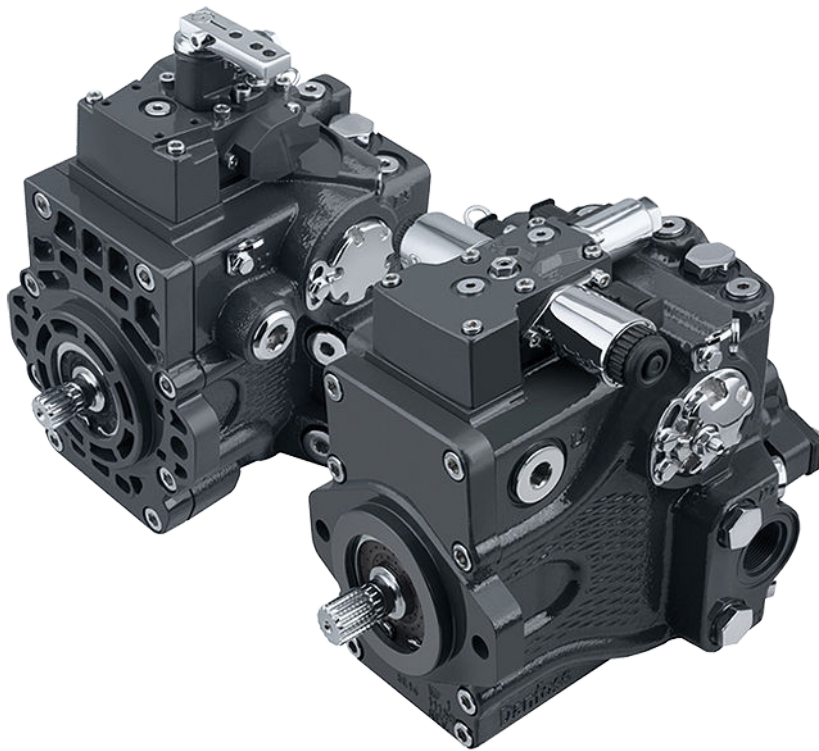ENGINEERING
TOMORROW

Danfoss

Technical Information

MP1 Axial Piston Pumps
Size 28/32, 38/45

Revision history   *Table of revisions*

Date	Changed	Rev
January 2018	add NFPE control	0104
October 2017	Third Edition	0103
April 2017	Second Edition	0102
August 2016	First Edition	0101

Contents

Contents

General Description

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 mechanically or electrically actuated feedback controls and a three-position electric control. These controls feature low hysteresis and responsive performance.

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)
- Forward-Neutral-Reverse (FNR)
- Non-Feedback Proportional Electric (NFPE)
- Manual displacement control (MDC)
- Common control across entire family

Expanded Functionality

- PLUS+1® Compliant control and options
- Easy integration with Telematics
- Integrated Flushing valve available (28/32 only)

Modularity

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

General Description

System Diagram
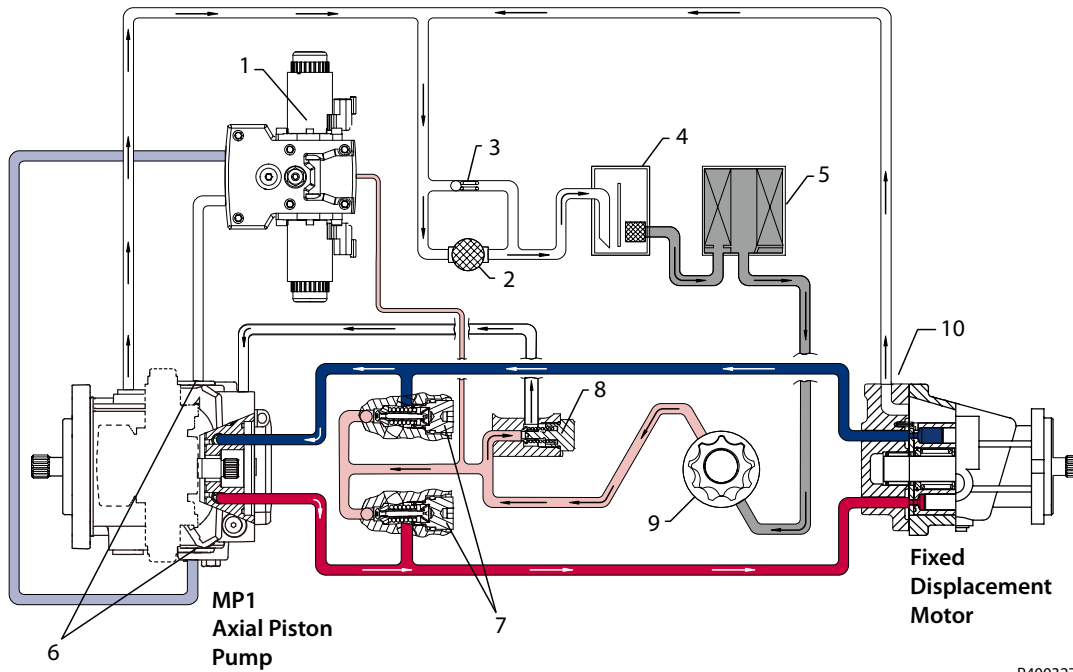
P400327

■ 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
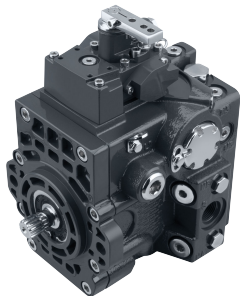
MP1 38/45

General Description

Schematic Diagram
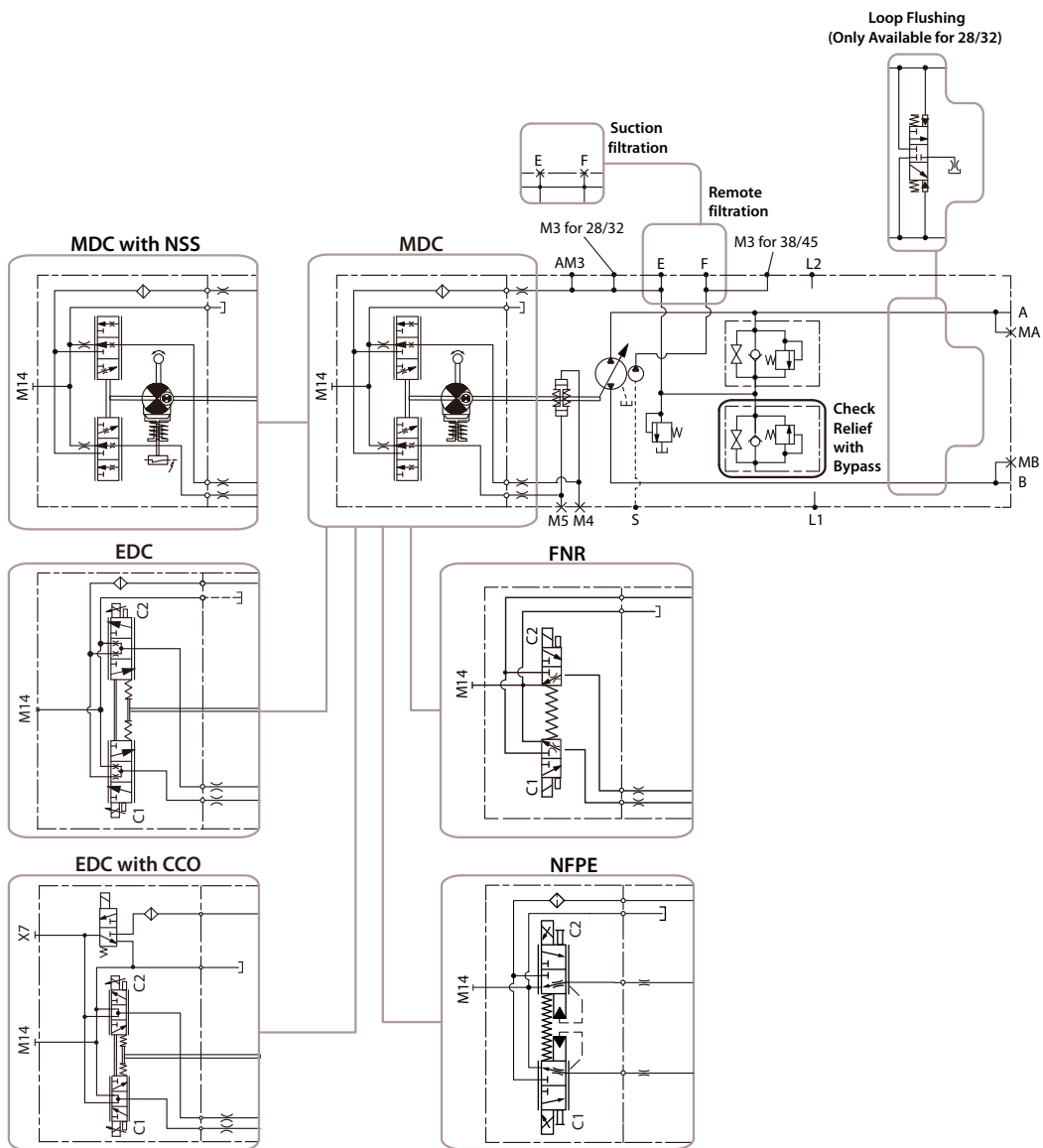
Technical Specification

Design Specifications

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

Technical Data

Feature	28	32	38	45
Displacement (cm^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 (theoretical) ($N{\cdot}m$/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 ($kg{\cdot}m^2$ [slug·ft^2])	0.0020 [0.0015]		0.0030 [0.0022]	
Mass (Weight) dry (kg [lb])	29.6 [65.3]		38 [83.8]	
Oil volume (liter [US gal])	1.5 [0.40]		2.0 [0.53]	
Mounting flange	ISO 3019-1 flange 101-2 (SAE B)			
Input shaft outer diameter, splines and tapered shafts	ISO 3019-1, outer Ø22mm - 4 (SAE B, 13 teeth) ISO 3019-1, outer Ø25mm - 4 (SAE B-B, 15 teeth)			
	ISO 3019-1, outer Ø22mm - 1 (Straight Key)		ISO 3019-1, outer Ø31mm - 4 (19 teeth) ISO 3019-1, outer Ø25mm - 4 (Straight Key) ISO 3019-1, outer Ø25mm -3 (Conical keyed, taper 1:8)	
Auxiliary mounting flange with metric fasteners, shaft outer diameter and splines	ISO 3019-1, flange 82-2, outer Ø16mm - 4 (SAE A, 9 teeth) ISO 3019-1, flange 82-2, outer Ø19mm - 4 (SAE A, 11 teeth) ISO 3019-1, flange 101-2, outer Ø22mm - 4 (SAE B, 13 teeth) ISO 3019-1, flange 101-2, outer Ø25mm - 4 (SAE B-B, 15 teeth)			
Main port configuration **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 Specification

Operating Parameters

For definitions of the following specifications, see *Operating Parameters* on page 31

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.

Fluid Specifications

Features		Units	28/32/38/45
Viscosity	Intermittent[1]	mm²/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	β15-20=75(β10≥10)
	Efficiency (suction filtration)		β35-45=75(β10≥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

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.

Low Pressure   High Pressure
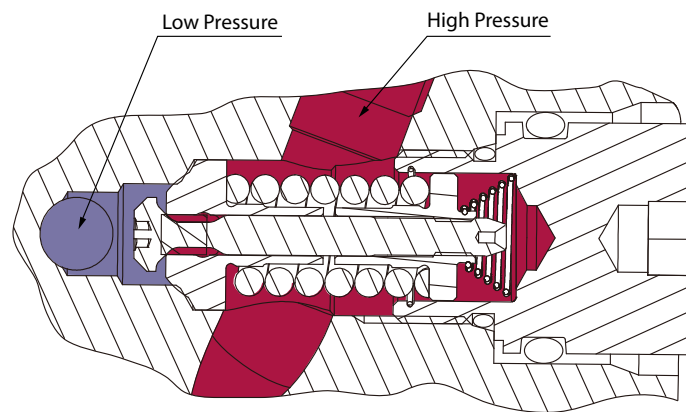
P400353

Bypass Function

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

⊘ **Caution**

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

Operation

Charge Pressure Relief Valve (CPRV)

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

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

Case Drain

Charge Pressure
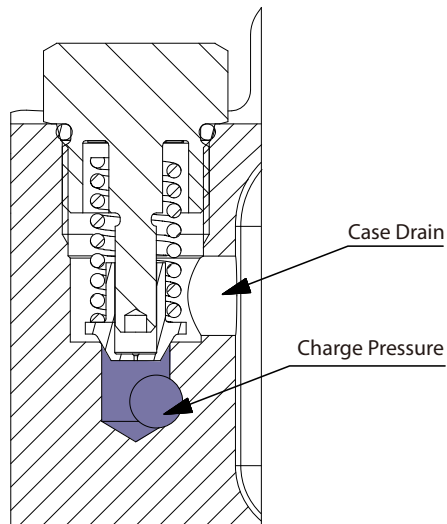
P400341

Operation

Loop Flushing Valve

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

The MP1 loop flushing design is a simple spring centered shuttle spool with an orifice plug. The shuttle shifts at approximately 3.9 bar [55.7 psi]. The flushing flow is a function of the low loop system pressure (charge) and the size of the plug.
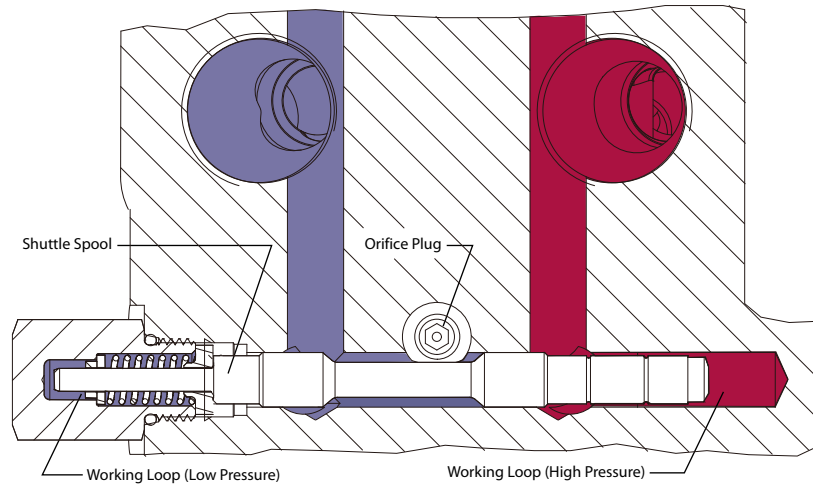
P400342

Loop flushing performance
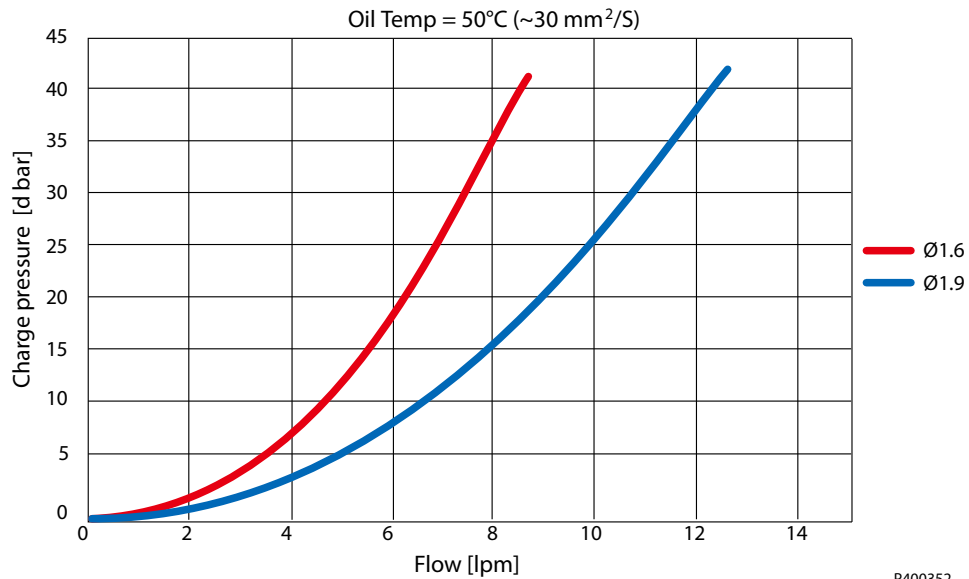
P400352

⚠ **Caution**

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

Operation

Electrical Displacement Control (EDC)

EDC principle

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

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

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

EDC control

P003 191

EDC schematic

P003 478E
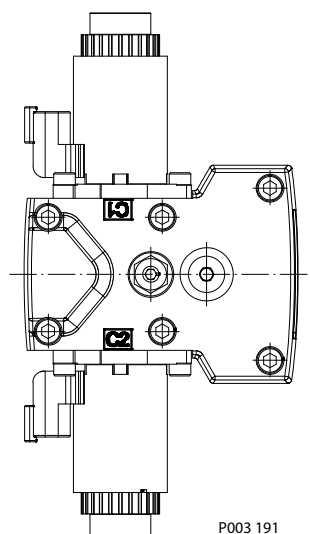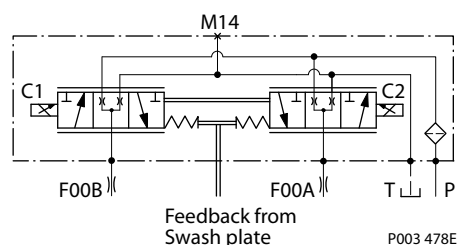
EDC operation

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

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

Operation

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

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

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

Pump displacement vs. control current

P003 479E
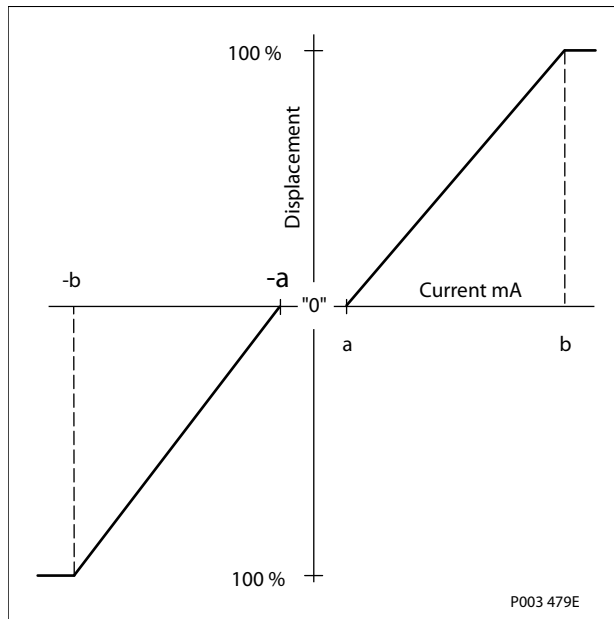
EDC Control Signal Requirements

Control minimum current to stroke pump

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

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

P003 480
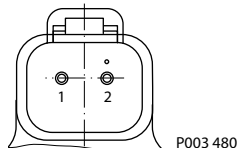
Connector ordering data

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

Operation

Connector ordering data (continued)

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

EDC Solenoid Data

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

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

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

* For coil location see Installation drawings.

Control response

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

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

Typical response times shown below at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm²/s [141 SUS] and 50 °C [122 °F]
Charge pressure	20 bar [290 psi]
Speed	1800 min⁻¹ (rpm)

Operation

Response time, EDC

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

Manual Over Ride (MOR)

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

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

⚠ Warning

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

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

P003 204
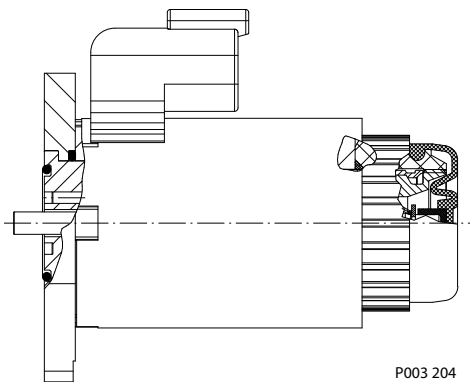
MOR-Schematic diagram (EDC shown)

P003 205E
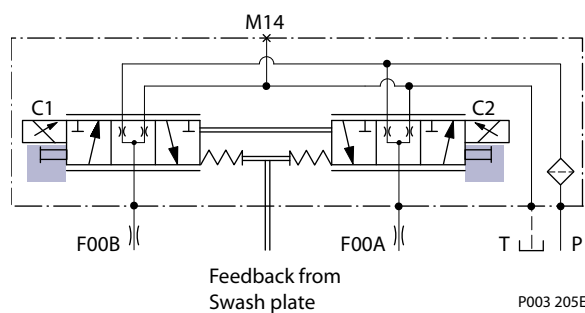
Operation

Manual Displacement Control (MDC)

MDC principle

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

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

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

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

A serviceable 125 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
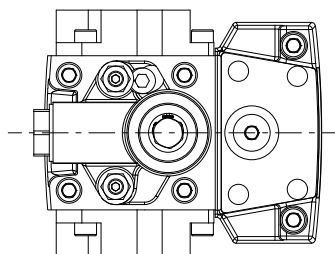
P301 749

Pump displacement vs. control lever rotation

P301 752

Operation

MDC schematic diagram

P005 701
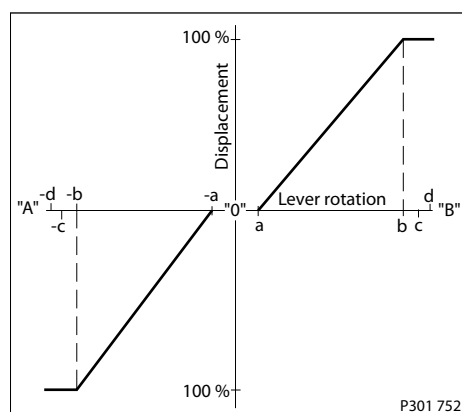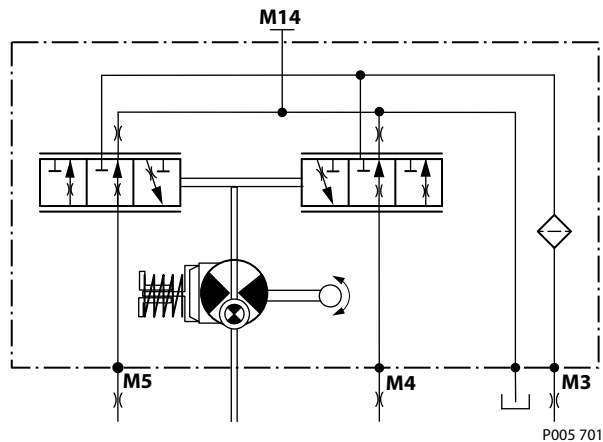
Where:

Deadband on **B** side – **a** = 3° ±1°

Maximum pump stroke – **b** = 30° +2/-1°

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

Internal end stop – **d** = 40°

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

MDC torque

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

MDC General Information

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

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

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

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

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

⊘ Caution

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

Operation

MDC Shaft Rotation

P301 753
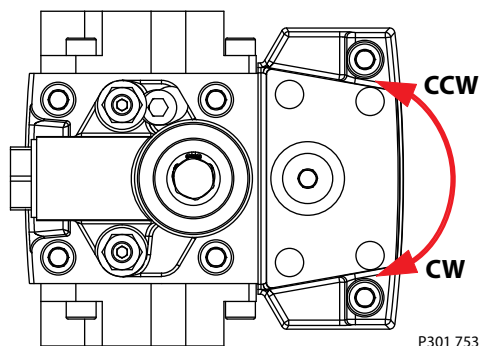
MDC shaft rotation data

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

* As seen from shaft side.

Control Response

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

Typical response times shown below at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm²/s [141 SUS] and 50 °C [122 °F]
Charge pressure	20 bar [290 psi]
Speed	1800 min⁻¹ (rpm)

Response time, MDC

Code	Orifice description (mm)				Stroking direction (sec)			
	P	**A**	**B**	**Tank (A+B)**	**Neutral to full flow**		**Full flow to neutral**	
					28/32	**38/45**	**28/32**	**38/45**
C3	–	–	–	–	0.3	0.3	0.3	0.3
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

Operation

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
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

Neutral Start Switch (NSS)

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

Neutral Start Switch schematic

P005 702
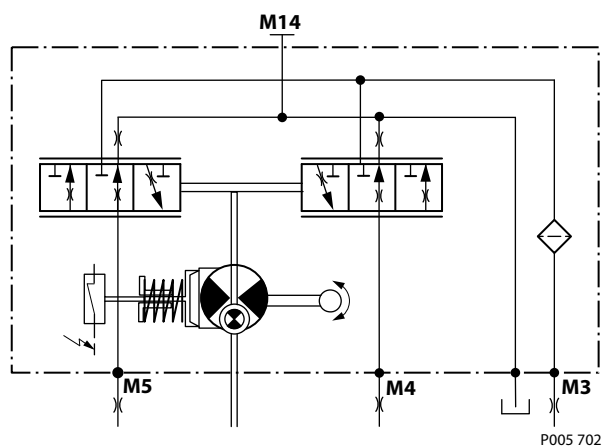
Neutral Start Switch data

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

Case gauge port **M14**

P400344

Operation

MDC schematic diagram

P005 701
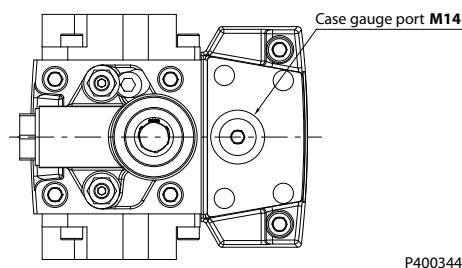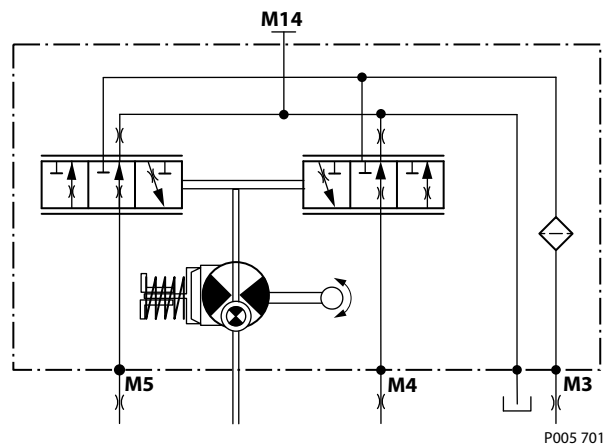
Lever

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

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

P400345
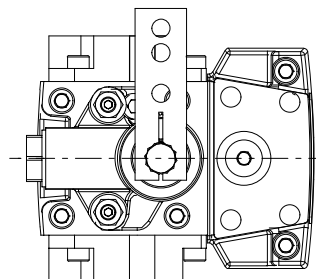
Operation

Forward-Neutral-Reverse electric control (FNR)

FNR principle

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

Forward-Neutral-Reverse electric control (FNR)

P003 193
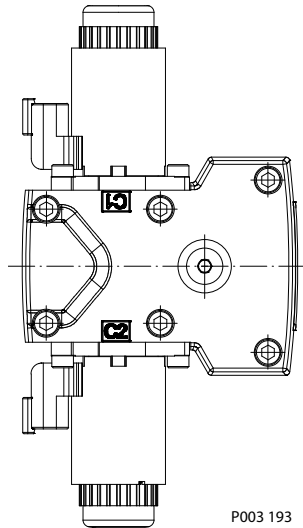
FNR hydraulic schematic

P003 189
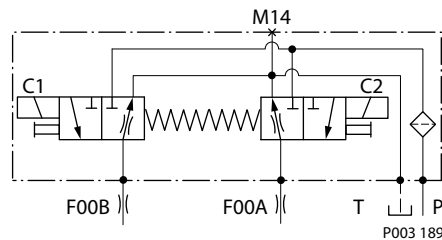
Operation

Pump displacement vs. electrical signal
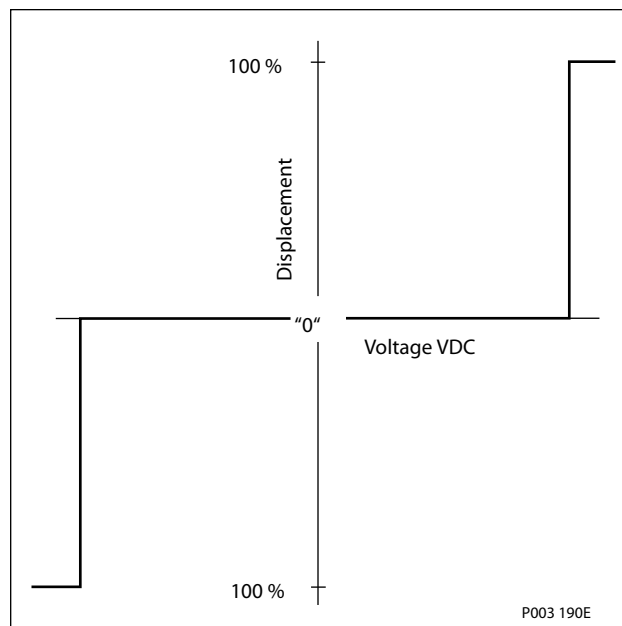
Control current

Voltage	Min. current to stroke pump	Pin connections
12 V	750 mA	any order
24 V	380 mA	
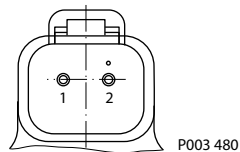
P003 480

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	

Operation

Solenoid data (continued)

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

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

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

* For coil location see Installation Drawings.

Control Response

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

Typical response times shown below at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm²/s [141 SUS] and 50 °C [122 °F]
Charge pressure	20 bar [290 psi]
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.

Operation

Non Feedback Proportional Electric Control

P003 192

NFPE schematic

P003 188
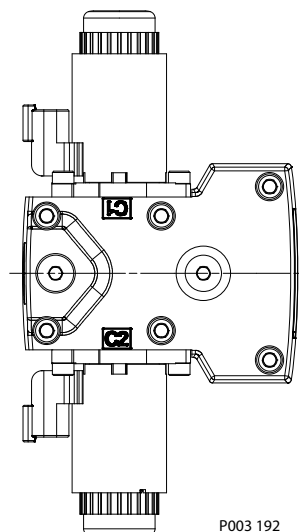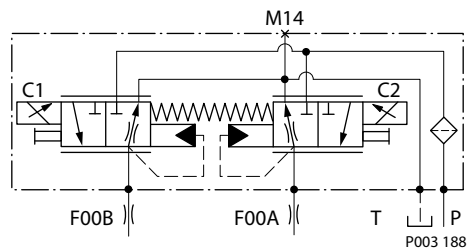
The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swashplate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

Pump displacement vs. input signal

P003 187E
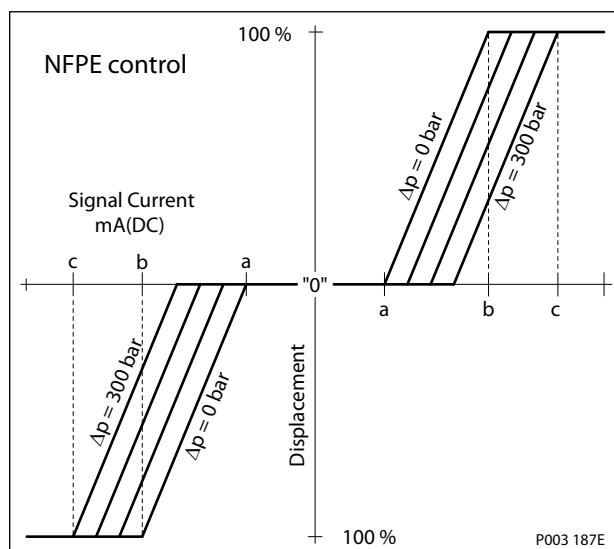
Operation

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.

P003 480
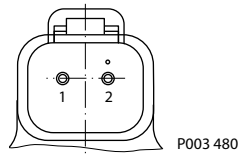
Connector ordering data

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.

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.

Operation

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

Operation

Control-Cut-Off valve (CCO valve)

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

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

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

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

EDC controls are available with a CCO valve.

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

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

EDC+CCO

Hydraulic logic Port **X7**
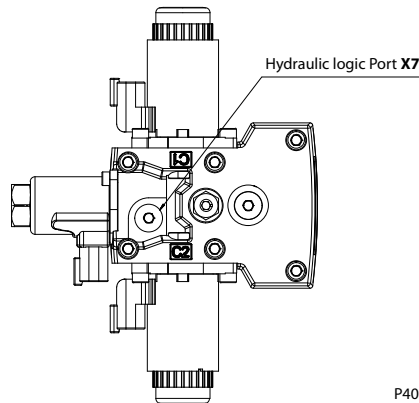
P400346

EDC+CCO schematic
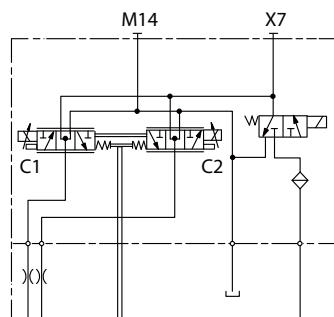
P400349

Operation

CCO connector
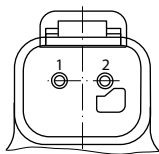
Connector ordering data

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

CCO solenoid data

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

Displacement limiter

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

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

Displacement limiter
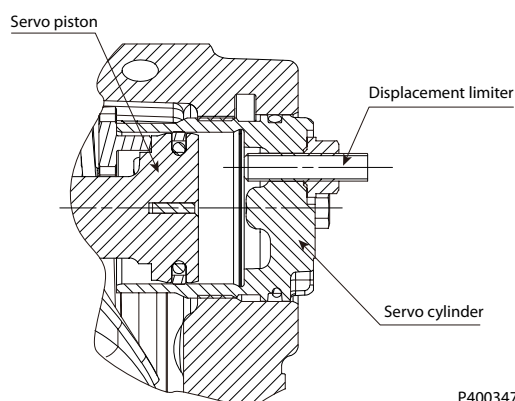
Operation

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]			

Operating Parameters

Overview

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

Input Speed

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

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

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

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

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

⚠ Warning

Unintended vehicle or machine movement hazard.

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

System Pressure

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

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

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

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

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

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

Operating Parameters

Charge Pressure

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

The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating at 1800 min^{-1} [rpm], and with a fluid viscosity of 32 mm^2/s [150 SUS]. Pumps configured with no charge pump (external charge supply) are set with a charge flow of 15.0 l/min [4.0 US gal/min] and a fluid viscosity of 32 mm^2/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 °C [30 °F] above the pour point of the hydraulic fluid.

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

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 ingression rate, the generation of contaminants in the system, the required fluid cleanliness, and the desired maintenance interval. Filters are selected to meet the above requirements using rating parameters of efficiency and capacity.

Filter efficiency can be measured with a Beta ratio (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,* **520L0467** 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
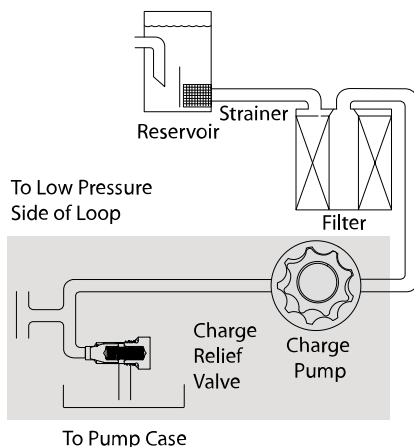
P400032

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
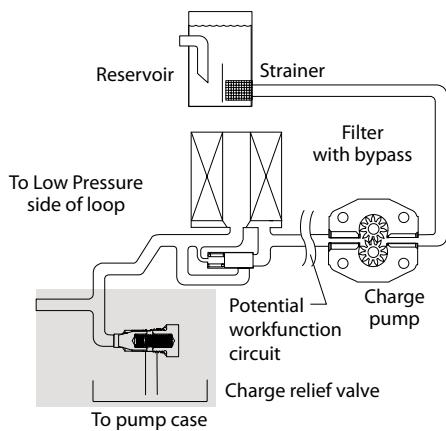
P400031

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 are based on operating with hydraulic fluids containing oxidation, rust and foam inhibitors. These fluids must possess good thermal and hydrolytic stability to prevent wear, erosion, and corrosion of pump components.

> ❗ **Caution**
>
> Never mix hydraulic fluids of different types.

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.

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.

System Design Parameters

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*, **BLN-9885** 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.

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 ℃ [176 °F]
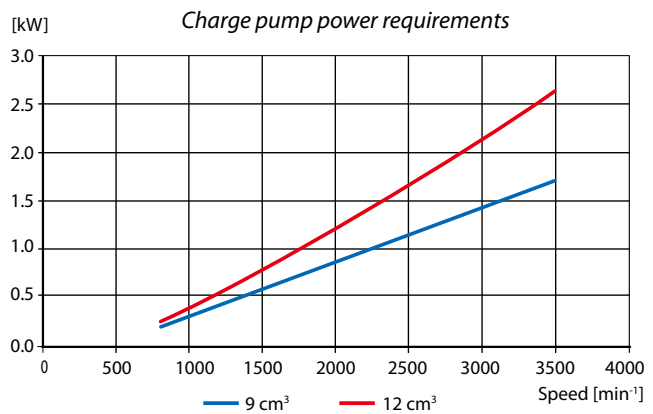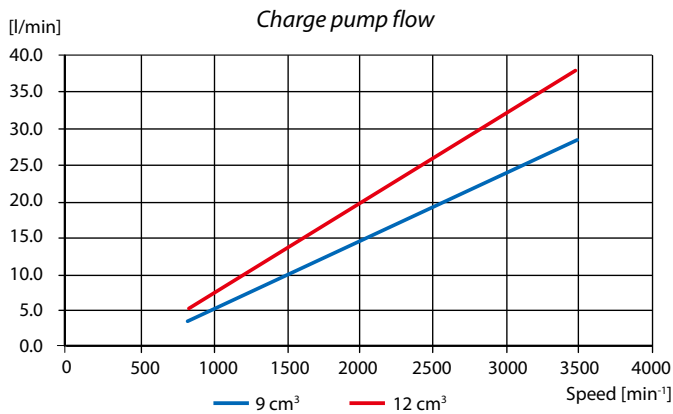
P400354

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 orienting the external side load to the 0 or 180 deg position (90 deg to rotating group load Fb). 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 orienting the external side load generally opposite of the internal rotating group load, Fb. 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** (Re), based on the **maximum external moment** (Me) 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
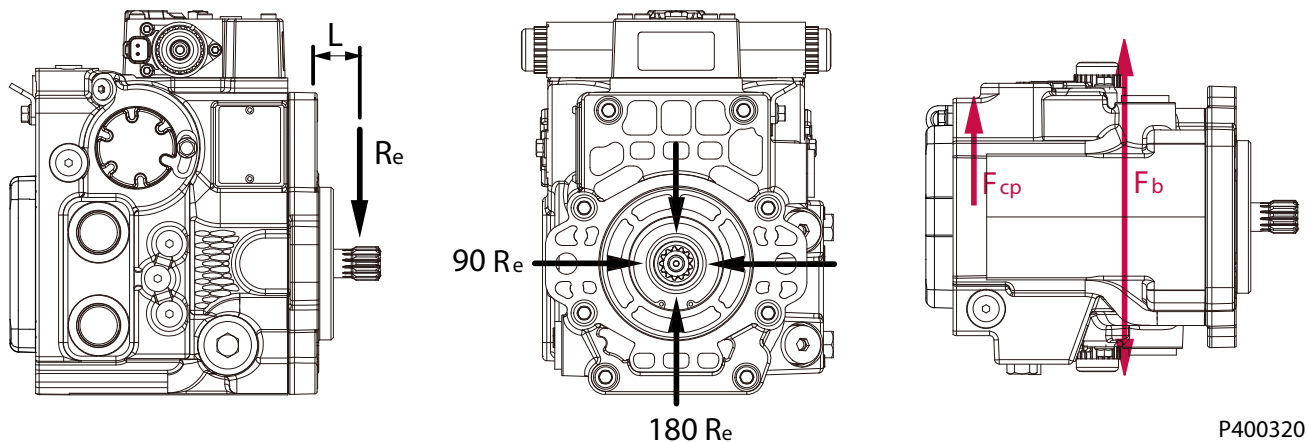
P400320

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* **BLN-9885**. For more detailed information on hydraulic unit life, see Danfoss publication *Pressure and Speed Limits* **BLN-9884**.

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:

$M_S = G_S (W_1 L_1 + W_2 L_2 + ... + W_n L_n)$

$M_C = G_C (W_1 L_1 + W_2 L_2 + ... + W_n L_n)$

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
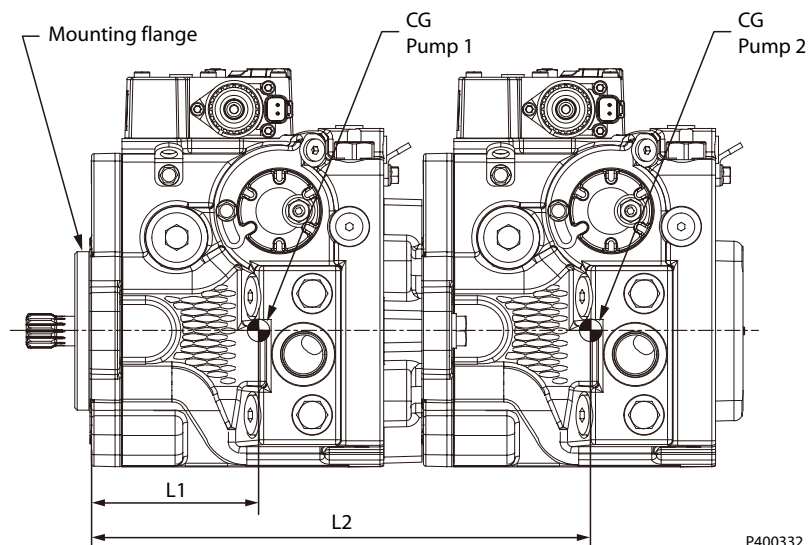
This illustration shows two single pumps in tandem.

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 x 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 x 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 ¾ 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

M_e input torque

M_{e1} for the first pump

M_{e1} for the second pump

M_{e3} for the next pump

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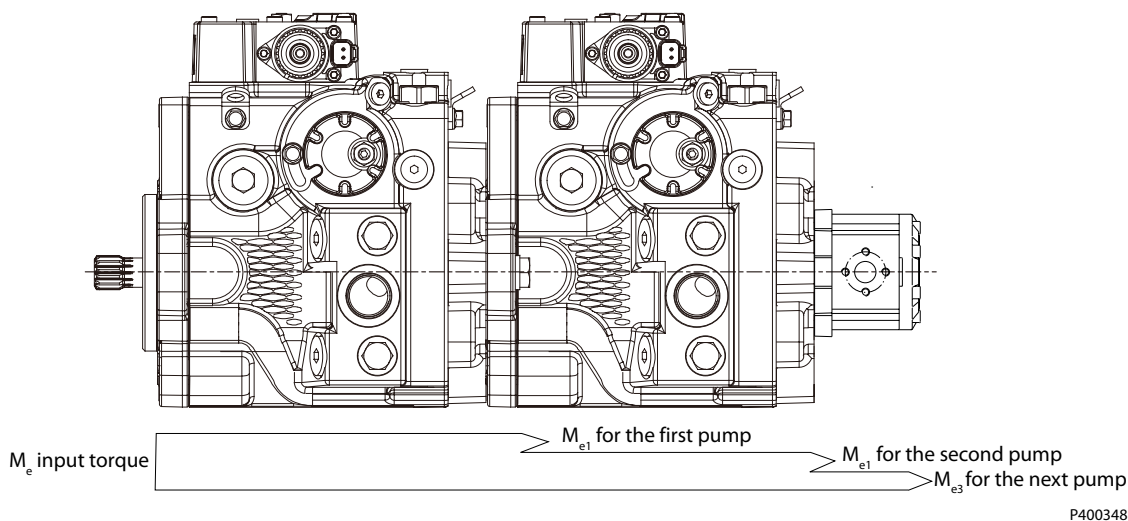
⚠️ **Attention**

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 (about 1400 m/s [4600 ft/sec] in oil) 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 $=$	$\dfrac{V_g \cdot n \cdot \eta_v}{1000}$ (l/min)		Output flow Q $=$	$\dfrac{V_g \cdot n \cdot \eta_v}{231}$ (US gal/min)
Torque	Input torque M$=$	$\dfrac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m}$ (N·m)		Input torque M$=$	$\dfrac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m}$ (lbf·in)
Power	Input power P $= \dfrac{M \cdot n \cdot \pi}{30\,000} = \dfrac{Q \cdot \Delta p}{600 \cdot \eta_t}$ (kW)			Input power P $= \dfrac{M \cdot n \cdot \pi}{198\,000} = \dfrac{Q \cdot \Delta p}{1714 \cdot \eta_t}$ (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 ($\eta_v \cdot \eta_m$)

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*, **BLN-9885**, for a more complete description of hydrostatic drive line sizing.

Model Code

Model Code (A - B - C)

Prod	A	B	C	D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y

MP1 P ▢▢▢ N N N ▢▢▢▢ F ▢▢▢▢▢▢▢▢▢▢ N N ▢▢▢▢▢▢▢▢▢▢▢

A - Displacement and Rotation

Code	Description
28R	28 cm^3, clockwise (right hand)
28L	28 cm^3, counterclockwise (left hand)
32R	32 cm^3, clockwise (right hand)
32L	32 cm^3, counterclockwise (left hand)
38R	38 cm^3, clockwise (right hand)
38L	38cm^3, counterclockwise (left hand)
45R	45 cm^3, clockwise (right hand)
45L	45 cm^3, counterclockwise (left hand)

B - Product Version and Unit

Code	Description
AS	Product Version "A", Inch, Customer port sealing according to ISO 11926-1
AM	Product Version "A", Metric , Customer port sealing according to ISO 6149-1

C - Automotive Control and Inching

Code	Description
NNN	None

Model Code

Model Code (D)

Prod	A	B	C	D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y
MP1 P				NNN			F						NN						

D - Controls

Code	Control Type	Voltage	Manual Override; CCO	Port	Connector
SA2		12V	—	Inch	Deutsch
SA3		24V	—	Inch	Deutsch
SA4		12V	Manual Over-Ride	Inch	Deutsch
SA5		24V	Manual Over-Ride	Inch	Deutsch
SE7		12V	Control Cut-Off	Inch	Deutsch
SE8	**EDC**	24V	Control Cut-Off	Inch	Deutsch
SG8	Electric Displacement Control	12V	Manual Over-Ride, Control Cut-Off	Inch	Deutsch
SH1		24V	Manual Over-Ride, Control Cut-Off	Inch	Deutsch
MA4		12V	Manual Over-Ride	Metric	Deutsch
MA5		24V	Manual Over-Ride	Metric	Deutsch
MG8		12V	Manual Over-Ride, Control Cut-Off	Metric	Deutsch
MH1		24V	Manual Over-Ride, Control Cut-Off	Metric	Deutsch
SM1		-	Standard	Inch	-
SM2	**MDC**	-	Neutral Start Switch	Inch	Deutsch
MM1	Manual Displacement Control	-	Standard	Metric	-
MM2		-	Neutral Start Switch	Metric	Deutsch
SA9		12V	Manual Over-Ride	Inch	Deutsch
SB1	**FNR**	24V	Manual Over-Ride	Inch	Deutsch
MA9	Forward-Neutral-Reverse	12V	Manual Over-Ride	Metric	Deutsch
MB1		24V	Manual Over-Ride	Metric	Deutsch
SN1		12V	Manual Over-Ride	Inch	Deutsch
SN2	**NFPE**	24V	Manual Over-Ride	Inch	Deutsch
MN1	Non-Feedback Proportional Electric	12V	Manual Over-Ride	Metric	Deutsch
MN2		24V	Manual Over-Ride	Metric	Deutsch

Align each with options **B**: Product Version, **E**: Displacement limitation, **F**: Orifices, and **W** : Special hardware features

Model Code

Model Code (F)

```
Prod  A   B   C     D   F  H  J   T   K   E   M     N   Z   L   V   G   W   X     Y
MP1 [P][ ][ ][ ][N][N][N][ ][ ][ ][F][ ][ ][ ][ ][ ][ ][ ][ ][ ][N][N][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]
```

F – Orifices

Code	Orifice			Controls: To be used for (●) / NOT to be used for (–)		
	Tank (A+B)	**P**	**A / B**	**EDC, FNR**	**MDC**	**NFPE**
C3	No orifice			●	●	–
C1	–	–	0.8 mm	●	●	●
C2	–	–	1.3 mm	●	●	●
C4	–	–	1.0 mm	●	●	●
C6	1.0 mm	–	–	–	●	–
C7	1.3 mm	–	–	–	●	–
C8	0.6 mm	0.8 mm	–	–	●	–
C9	0.6 mm	1.0 mm	–	–	●	–
D1	0.8 mm	1.0 mm	–	–	●	–
D2	0.8 mm	1.3 mm	–	–	●	–
D3	1.0 mm	1.3 mm	–	–	●	–
D4	1.0 mm	1.3 mm	1.3 mm	–	●	–
D5	0.6 mm	0.6 mm	0.8 mm	–	●	–
E2	0.8 mm	1.0 mm	0.8 mm	–	●	-

Model Code

Model Code (H - J - T)

Prod	A	B	C	D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y
MP1 P				NNN		F							NN						

H - Mounting Flange

Code	Description
F	ISO 3019-1, flange 101-2 (SAE B)

J - Input Shaft

Code	Description	28	32	38	45
G4	ISO 3019-1, outer dia. 22 mm (SAE B, 13 teeth splined shaft 16/32 pitch)	●	●	●	●
F6	ISO 3019-1, outer dia. 22 mm (SAE B, 13 teeth splined shaft 16/32 pitch -SPCL Bearing (High Capacity)	●	●	●	●
G5	ISO 3019-1, outer dia. 23 mm (SAE B 15 teeth splined shaft 16/32 pitch)	●	●	●	●
F5	ISO 3019-1, outer dia. 23 mm (SAE B 15 teeth splined shaft 16/32 pitch -SPCL Bearing (High Capacity)	●	●	●	●
F2	Conical keyed shaft similar to ISO 3019-1 code 25-3, taper*			●	●
A8	Round straight keyed Ø25.4 mm*			●	●
A7	Round straight keyed Ø22.23 mm*	●	●		
A9	Round straight keyed Ø22.23 mm in-SPCL Bearing (High Capacity)*	●	●		
G6	ISO 3019-1, outer dia. 31.24 mm (SAE B 19 teeth splined shaft 16/32 pitch)			●	●
G7	ISO 3019-1, outer dia. 31.24 mm (SAE B 19 teeth splined shaft 16/32 pitch - SPCL Bearing (High Capacity)			●	●
F3	Conical keyed shaft similar to ISO 3019-1 code 25-3, taper - SPCL Bearing (High Capacity)			●	●
A6	Round Straight keyed Ø25.4mm - SPCL Bearing (High Capacity)			●	●

* (key not supplied with shaft)

T - Filtration

Code	Description	Note
E	External charge flow filtration	Align with K: Charge Pump and Auxiliary Pad (no charge pump options)
R	Remote full charge flow filtration	Align with K: Charge Pump and Auxiliary Pad (9 cc or 12 cc charge pump options)
S	Suction filtration	

Model Code

Model Code (K)

Prod	A	B	C	D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y
MP1 P	☐	☐	☐	N N	☐ ☐ ☐ ☐	F	☐ ☐	▨ ▨	☐ ☐	☐	☐	N N	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐	☐ ☐	☐ ☐

K - Charge pump and Auxiliary pad

Code	Description	28	32	38	45
A16	9 cm³/rev Charge Pump, SAE A 9tooth (w/Shipping Cover), Inch	●	●	●	●
B16	9 cm³/rev Charge Pump, SAE A 9tooth (w/Shipping Cover), Metric	●	●	●	●
A19	9 cm³/rev Charge Pump, SAE A 11tooth (w/Shipping Cover), Inch	●	●	●	●
B19	9 cm³/rev Charge Pump, SAE A 11tooth (w/Shipping Cover), Metric	●	●	●	●
A22	9 cm³/rev Charge Pump, SAE B 13tooth (w/Shipping Cover), Inch	●	●	●	●
B22	9 cm³/rev Charge Pump, SAE B 13tooth (w/Shipping Cover), Metric	●	●	●	●
A25	9 cm³/rev Charge Pump, SAE B-B 15tooth (w/Shipping Cover), Inch			●	●
B25	9 cm³/rev Charge Pump, SAE B-B 15tooth (w/Shipping Cover), Metric			●	●
ANN	9 cm³/rev Charge Pump, None, SAE Cover, Inch	●	●	●	●
BNN	9 cm³/rev Charge Pump, None, SAE Cover, Metric	●	●	●	●
C16	12 cm³/rev Charge Pump, SAE A 9 tooth (w/Shipping Cover), Inch	●	●	●	●
D16	12 cm³/rev Charge Pump, SAE A 9 tooth (w/Shipping Cover), Metric	●	●	●	●
C19	12 cm³/rev Charge Pump, SAE A 11 tooth (w/Shipping Cover), Inch	●	●	●	●
D19	12 cm³/rev Charge Pump, SAE A 11 tooth (w/Shipping Cover), Metric	●	●	●	●
C22	12 cm³/rev Charge Pump, SAE B 13 tooth (w/Shipping Cover), Inch	●	●	●	●
D22	12 cm³/rev Charge Pump, SAE B 13 tooth (w/Shipping Cover), Metric	●	●	●	●
C25	12 cm³/rev Charge Pump, SAE B-B 15 tooth (w/Shipping Cover), Inch			●	●
D25	12 cm³/rev Charge Pump, SAE B-B 15 tooth (w/Shipping Cover), Metric			●	●
CNN	12 cm³/rev Charge Pump, None, SAE Cover, Inch	●	●	●	●
DNN	12 cm³/rev Charge Pump, None, SAE Cover, Metric	●	●	●	●
E16	No Charge Pump, SAE A 9 tooth (w/Shipping Cover), Inch	●	●	●	●
F16	No Charge Pump, SAE A 9 tooth (w/Shipping Cover), Metric	●	●	●	●
E19	No Charge Pump, SAE A 11 tooth (w/Shipping Cover), Inch	●	●	●	●
F19	No Charge Pump, SAE A 11 tooth (w/Shipping Cover), Metric	●	●	●	●
E22	No Charge Pump, SAE B 13 tooth (w/Shipping Cover), Inch	●	●	●	●
F22	No Charge Pump, SAE B 13 tooth (w/Shipping Cover), Metric	●	●	●	●
E25	No Charge Pump, SAE B-B 15 tooth (w/Shipping Cover), Inch			●	●
F25	No Charge Pump, SAE B-B 15 tooth (w/Shipping Cover), Metric			●	●
ENN	No Charge Pump, None, SAE cover, Inch	●	●	●	●
FNN	No Charge Pump, None, SAE cover, Metric	●	●	●	●

Align with option **B** (Product version and unit)

"Inch" : Option B="AS", inch O-ring boss port.

"Metric" : Option B="AM", metric O-ring boss port.

Model Code

Model Code (E - M - N - Z - L)

Prod	A	B	C	D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y
MP1 P				NN		F							NN						

E - Displacement limiter

Code	Description
N	No Limiters
B	Adjustable Externally
C	No Limiters, required for FNR, NFPE (Align with option D: Control)
D	Adjustable Externally, required for FNR, NFPE (Align with option D: Control)

Align with **Y**: Settings if applicable

M - High Pressure Relief Setting Side "A" & N - High Pressure Relief Setting Side "B"

Code	Pressure Setting
140	140 bar [2030 psi]
175	175 bar [2538 psi]
190	190 bar [2755 psi]
210	210 bar [3045 psi]
230	230 bar [3336 psi]
250	250 bar [3630 psi]
260	260 bar [3770 psi]
280	280 bar [4061 psi]
300	300 bar [4350 psi]
325	325 bar [4713 psi]
345	345 bar [5000 psi]

Please contact Danfoss Power Solutions for pressures not shown or for applied pressures above max. working pressure (see *Operating Parameters* on page 9).

Z - POR Setting

Code	Description
NN	No Pressure Over Ride

L - Loop Flushing

Code	Description	28	32	38	45
N	No LF valve	●	●	●	●
A	Defeated	●	●		
B	Loop Flushing; 1.6 mm orifice	●	●		
C	Loop Flushing; 1.9 mm orifice	●	●		

Align with **G**: System Port Type (28/32 only)

Model Code

Model Code (V - G - W)

Prod	A	B	C		D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y
MP1 P			N N N				F							N N							

V – Charge pressure relief setting

Code	Description	
20	20 bar [290 psi]	Not to be used for **NFPE** controls.
22	22 bar [319 psi]	
24	24 bar [348 psi]	
26	26 bar [377 psi]	
28	28 bar [406 psi]	

G - System Port Type

Code	Description	28	32	38	45
A1	Inch O-ring Boss per ISO 11926-1	●	●	●	●
A3	Inch O-ring Boss per ISO 11926-1, with integral loop flush valve	●	●		
B1	Split Flange per ISO 6162-2, (all other O-ring boss, inch per ISO 11926-1)			●	●
C1	Metric O-ring Boss per ISO 6149-1	●	●	●	●
C3	Metric O-ring boss per ISO 6149-1, with integral loop flush valve	●	●		
D1	Split Flange per ISO 6162-2, (all other O-ring boss, metric per ISO 6149-1)			●	●

Align with **B**: Product Version and Unit, and **L**: Loop Flushing

W - Special Hardware Features

Code	Description
RAC	Standard valve plate, CW, 28 cm^3
LAC	Standard valve plate, CCW, 28 cm^3
RAD	Standard valve plate, CW, 32 cm^3
LAD	Standard valve plate, CCW, 32 cm^3
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 valve plate, CW, 28cm^3
LBC	NFPE valve plate, CCW, 28cm^3
RBD	NFPE valve plate, CW, 32cm^3
LBD	NFPE valve plate, CCW, 32cm^3
RBE	NFPE valve plate, CW, 38cm^3
LBE	NFPE valve plate, CCW, 38cm^3
RBF	NFPE valve plate, CW, 45cm^3
LBF	NFPE valve plate, CCW, 45cm^3

Align with **A**: Displacement and Rotation : and **D**: controls

Model Code

Model Code (X - Y)

Prod	A	B	C	D	F	H	J	T	K	E	M	N	Z	L	V	G	W	X	Y

X - *Paint and Nametag*

Code	Description
NNN	Black Paint, Standard Nametag

Y - *Settings*

Code	Description
NNNN	None
E095	Displacement limitation Side A 95%, Side B 95%
E090	Displacement limitation Side A 90%, Side B 90%
E085	Displacement limitation Side A 85%, Side B 85%
E080	Displacement limitation Side A 80%, Side B 80%
M00A	MDC Control Handle, Standard Orientation
M095	Displacement limitation Side A 95%, Side B 95%, MDC Handle, Std Orientation
M090	Displacement limitation Side A 90%, Side B 90%, MDC Handle, Std Orientation
M085	Displacement limitation Side A 85%, Side B 85%, MDC Handle, Std Orientation
M080	Displacement limitation Side A 80%, Side B 80%, MDC Handle, Std Orientation

Installation Drawings

28/32 Ports
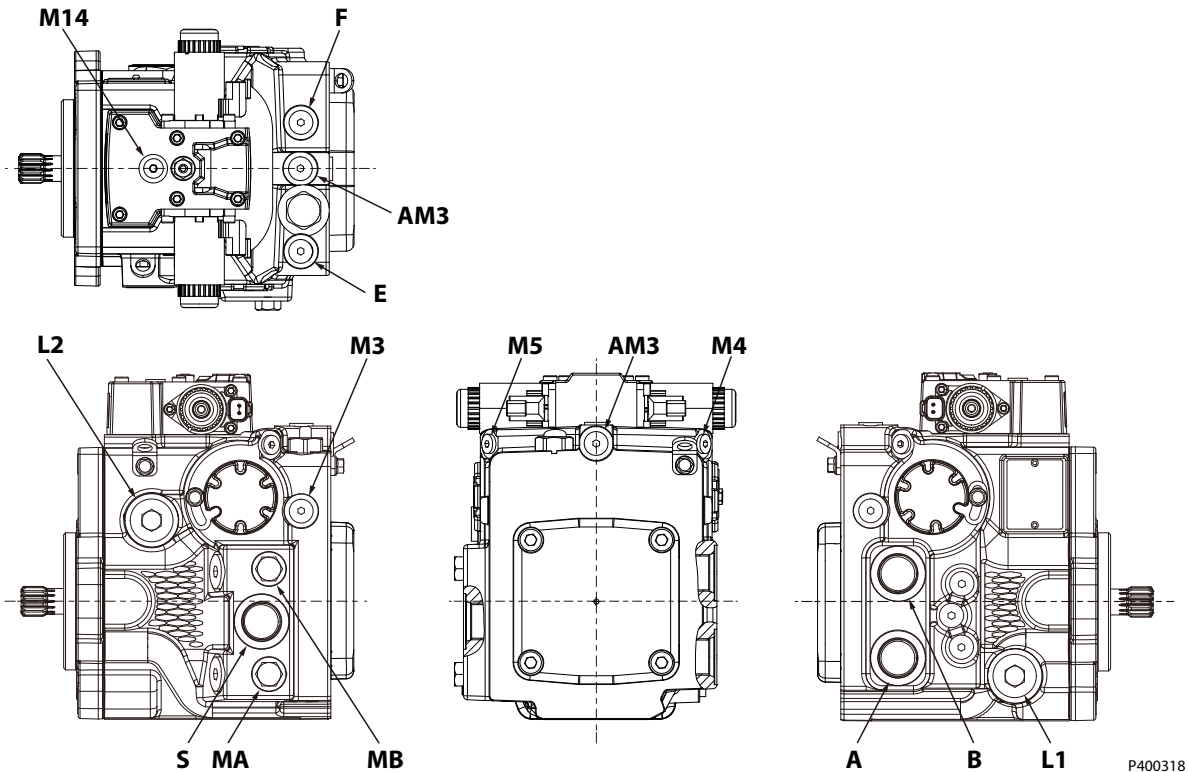
P400318

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 Guage 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

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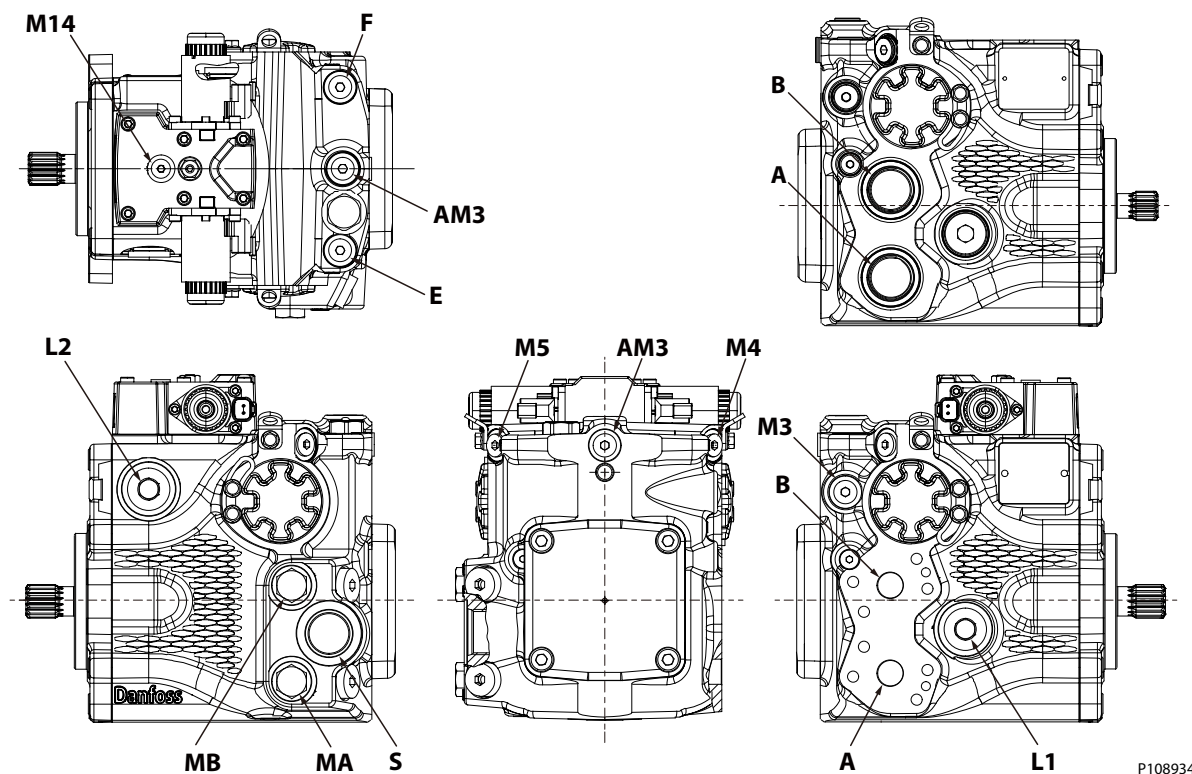
Port description

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

Approximate center of gravity

Approximate center of gravity

Mounting flange
Flange 101-2
Per ISO 3019-1 (SAE J744 B)

R 0.8 max

Paint free
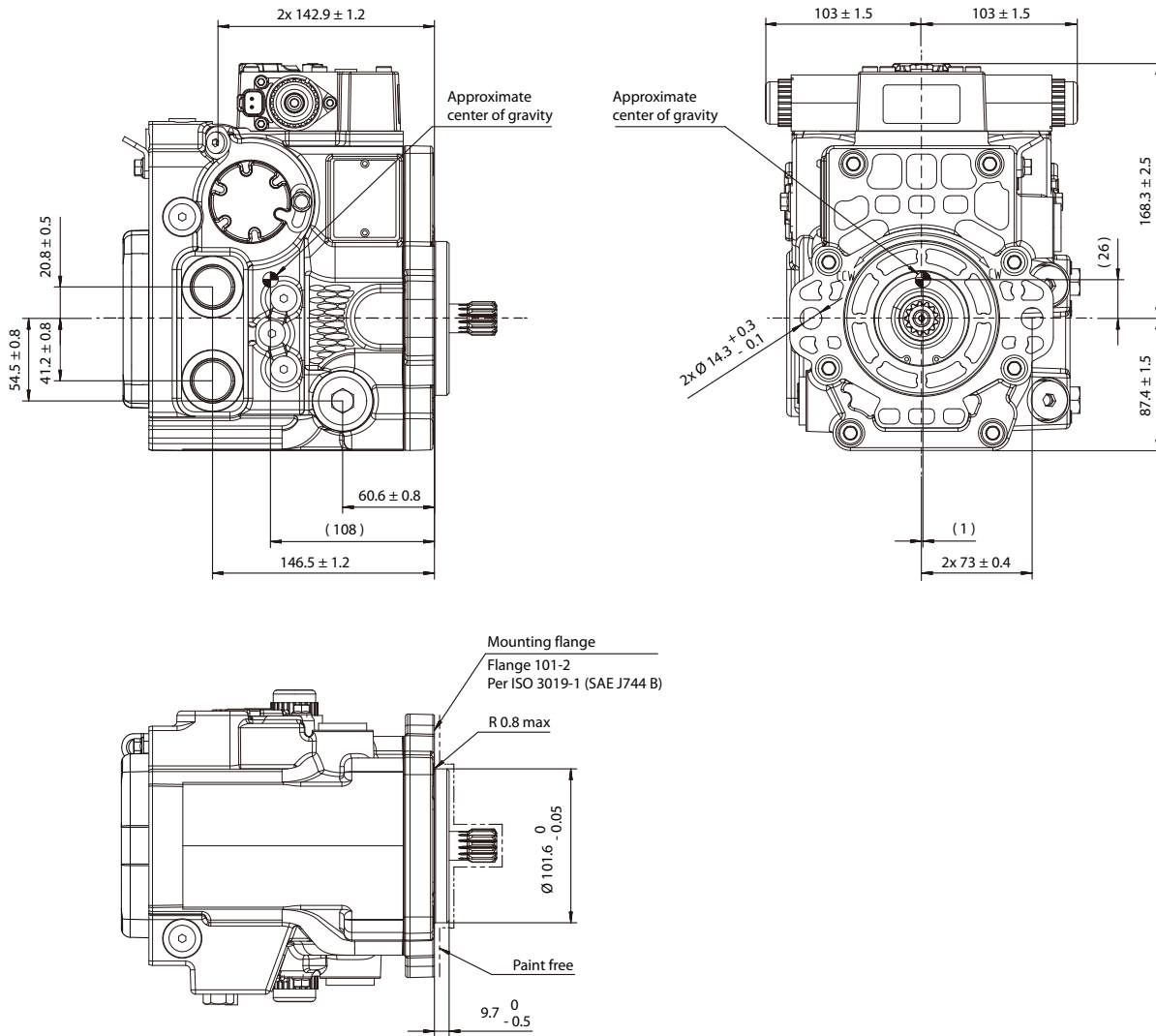
P400312

Please contact Danfoss representative for specific installation drawings.

Installation Drawings

28/32 Dimentions (continued)
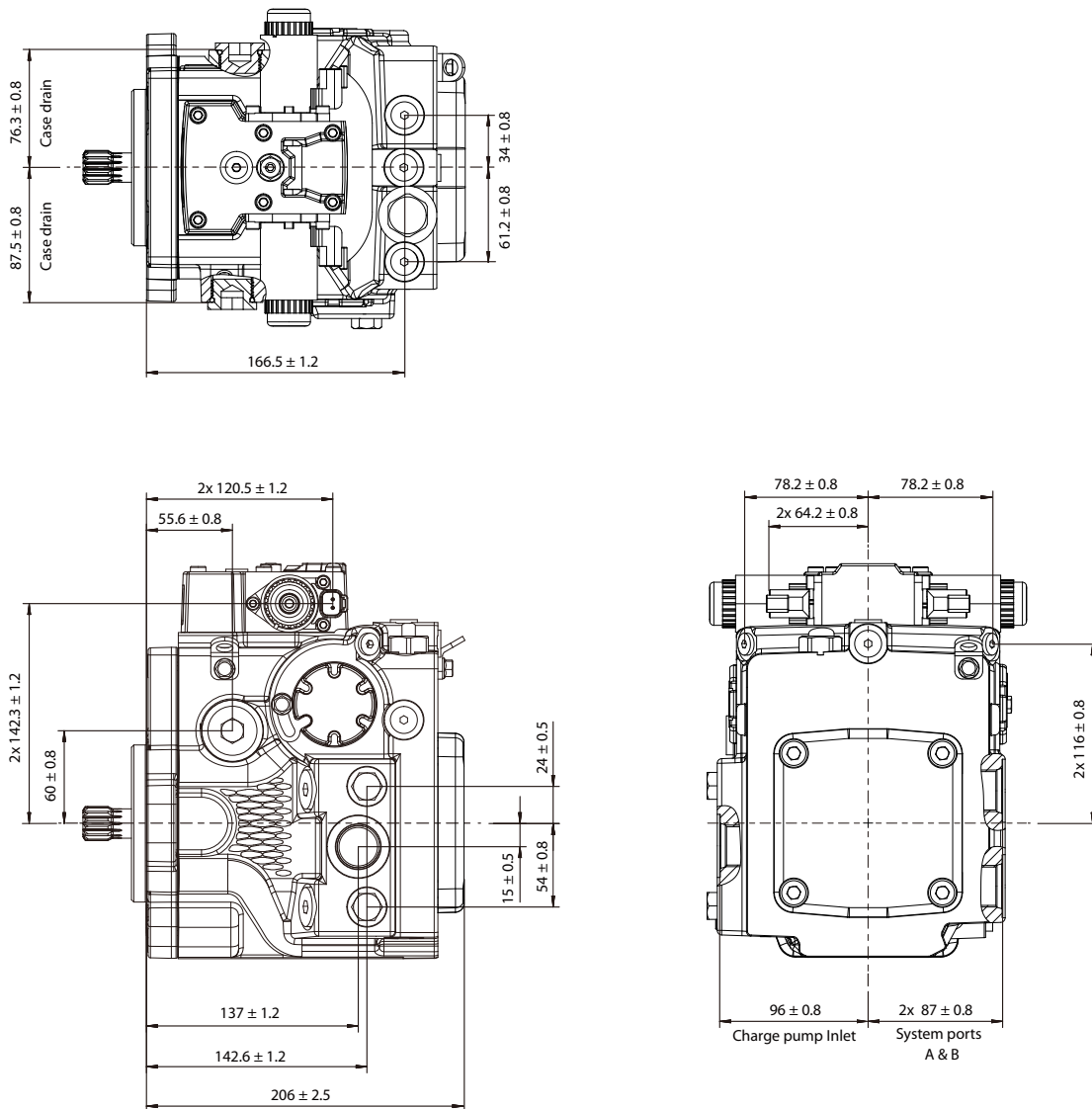
P400313

Please contact Danfoss representative for specific installation drawings.

Installation Drawings

38/45 Dimensions

Split flange type

2x 162.6 ± 2.5
(116)
(27)
12 ± 1
54 ± 1.5
21 ± 1
Approximate center of gravity
104 ± 1.5
160.4 ± 2.5

103 ± 1.5
113.2 ± 1.5
Approximate center of gravity
169.8 ± 2.5
90.7 ± 1.5
2x Ø14.3 +0.3 -0.1
CCW
CW
(2)
2x 73 ± 0.4

Mounting flange
Flange 101-2
per ISO 3019-1 (SAE J744 B)
Ø 101.6 0 -0.05
Paint free
9.7 0 -0.5

2x (20°)
4x 11.9 ± 0.25
4x 25.4 ± 0.25
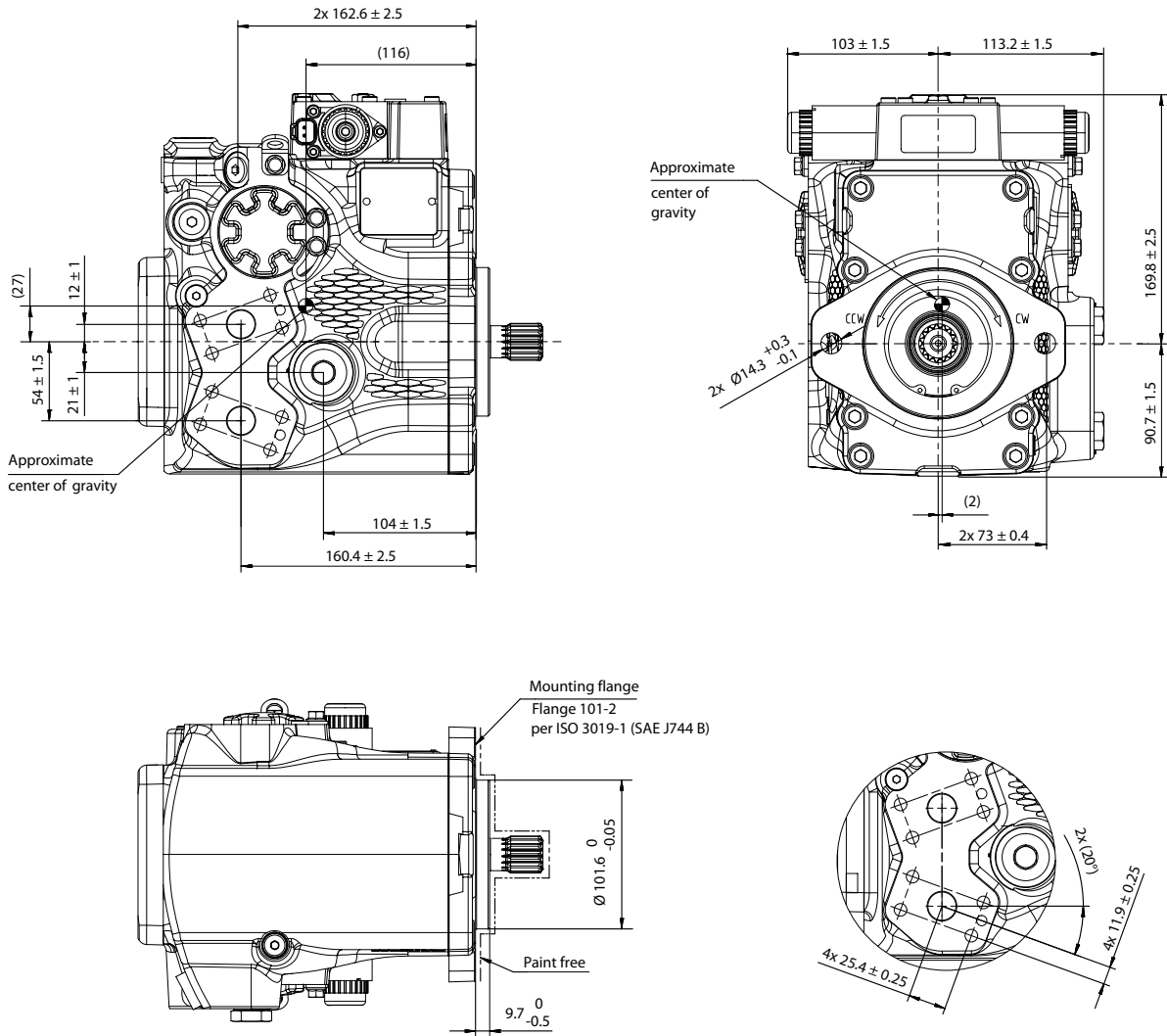
P108935

Please contact Danfoss representative for specific installation drawings.

Installation Drawings

38/45 Dimensions (continued)
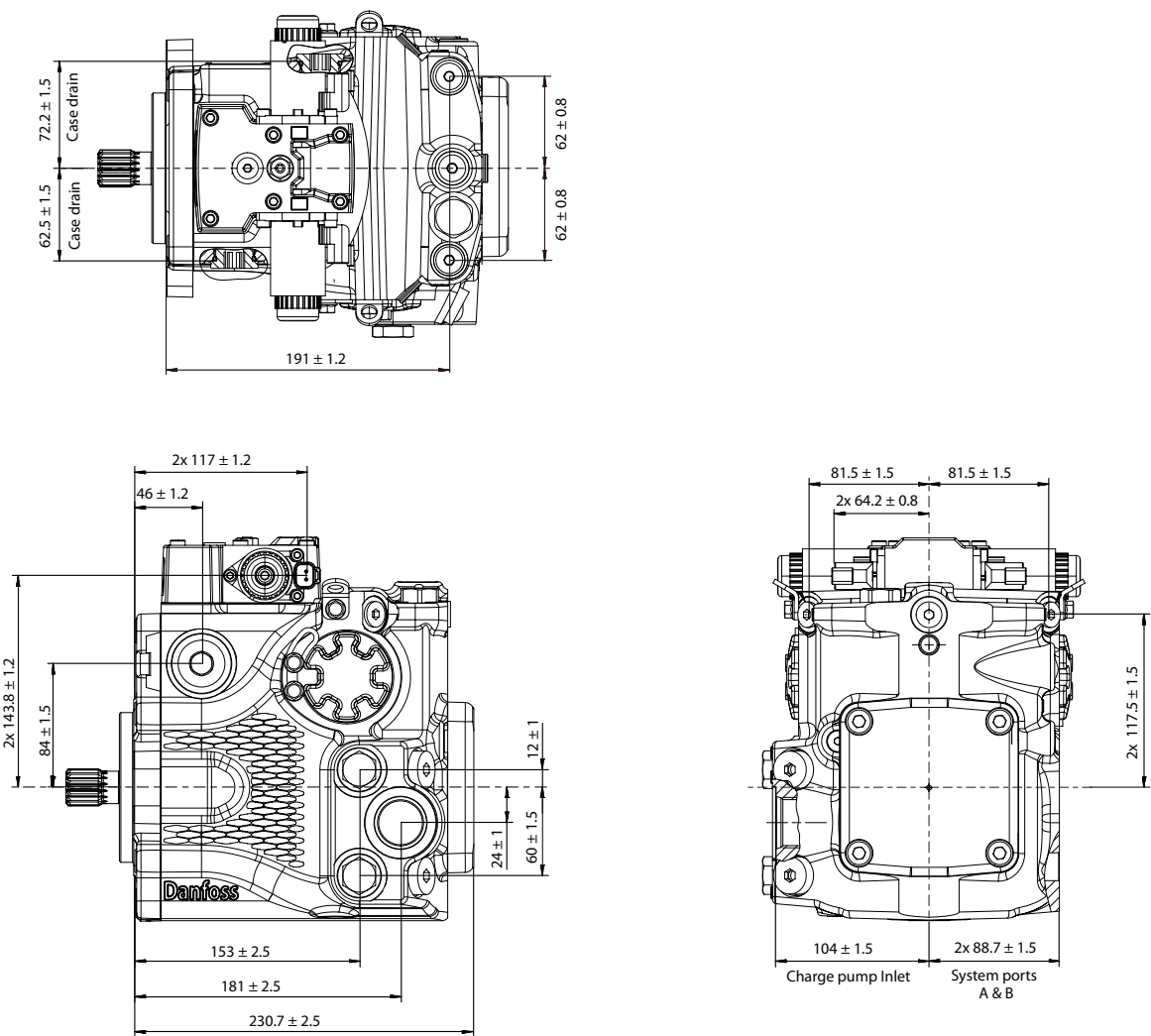
P108957

Please contact Danfoss representative for specific installation drawings.

Installation Drawings

38/45 Dimensions (continued)

O-ring boss type

2x 162.6 ± 2.5
(116)
X
(27)
12 ± 1
54 ± 1.5
21 ± 1
Approximate center of gravity
104 ± 1.5
160.4 ± 2.5

103 ± 1.5   113.2 ± 1.5
Approximate center of gravity
169.8 ± 2.5
90.7 ± 1.5
2x Ø14.3 +0.3 -0.1
CCW   CW
(2)
2x 73 ± 0.4

Mounting flange
Flange 101-2
per ISO 3019-1 (SAE J744 B)
Ø 101.6 0 -0.05
Paint free
9.7 0 -0.5

View X
81.5 ± 1.5   81.5 ± 1.5
2x 64.2 ± 0.8
2x 117.5 ± 1.5
104 ± 1.5   2x 88.2 ± 1.5
Charge pump Inlet   System ports A & B
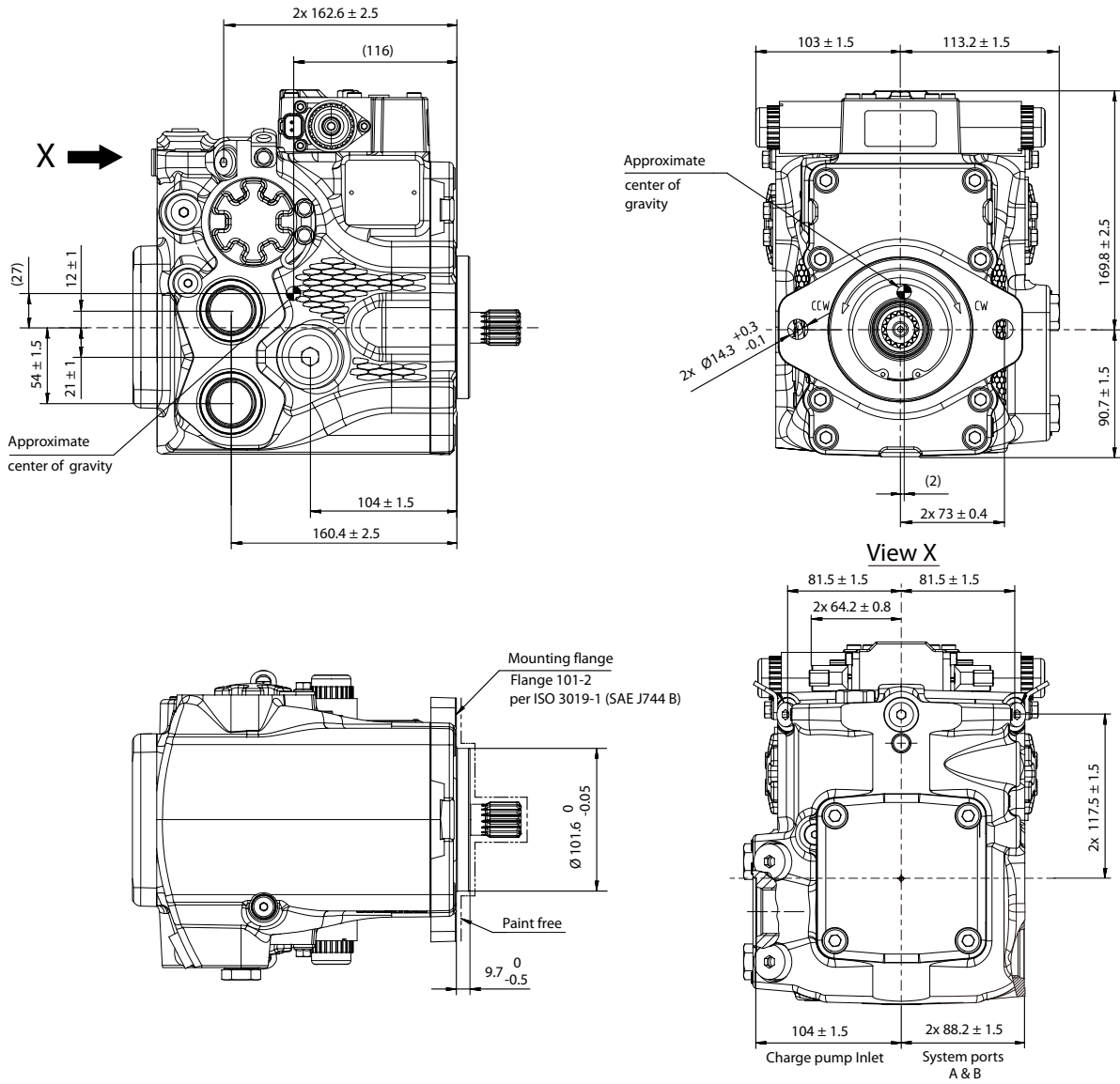
P400351

Please contact Danfoss representative for specific installation drawings.

Installation Drawings

Input Shafts: Option G4, F6 (SAE B, 13 teeth)

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

Spline data
Number of teeth: 13
Pitch fraction: 16/32
Pressure angle: 30°
Pitch dia: Ø20.6375
Type of fit: Fillet root side
Per: 28/32: ANSI B92.1-1970 Class 5
38/45: ANSI B92.1-1970 Class 6e

P400321

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
Torque rating	Maximum	226 N•m

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

Spline data
Number of teeth: 15
Pitch fraction: 16/32
Pressure angle: 30°
Pitch dia: Ø23.813
Type of fit: Fillet root side
Per: ANSI B92.1-1970 Class 5

Paint free

Mating coupling
must not protrude
beyond this point

Mounting flange
Flange 101-2
Per ISO 3019-1 (SAE B)

P400322
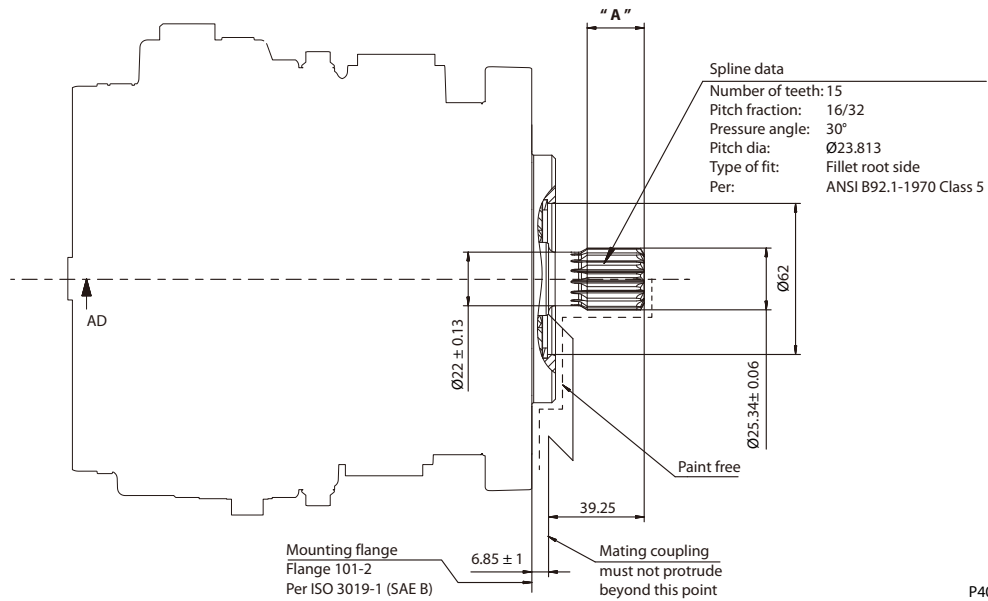
Min. active spline length[1]	28/32	38/45
"A"	23.4 ± 0.5	22.0 ± 0.15

[1] Minimum active spline length for the specified torque ratings.

Specifications

Option		G5, F5
Spline		15 teeth, 16/32 pitch
Torque rating	Maximum	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)

P400323
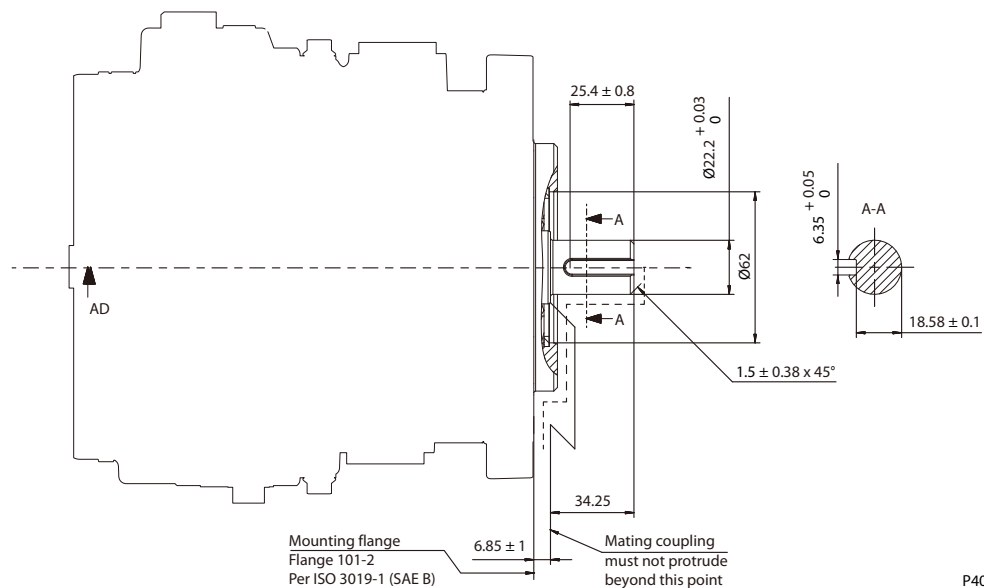
Specifications

Option		A7, A9
Torque rating	Maximum	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)

Spline data
Number of teeth: 19
Pitch fraction: 16/32
Pressure angle: 30°
Pitch dia: Ø30.163
Type of fit: Fillet root side
Per: ANSI B92.1-1970 Class 5

Ø72.3
AD
33.8 ± 0.5
Paint free
Ø 31.24 ± 0.09
63.5 ± 1.5
27.7 ± 0.12
6.85 ± 1
Mating coupling must not protrude beyond this point
Mounting flange
Flange 101-2
Per ISO 3019-1 (SAE B)
AD
P400334

Specifications

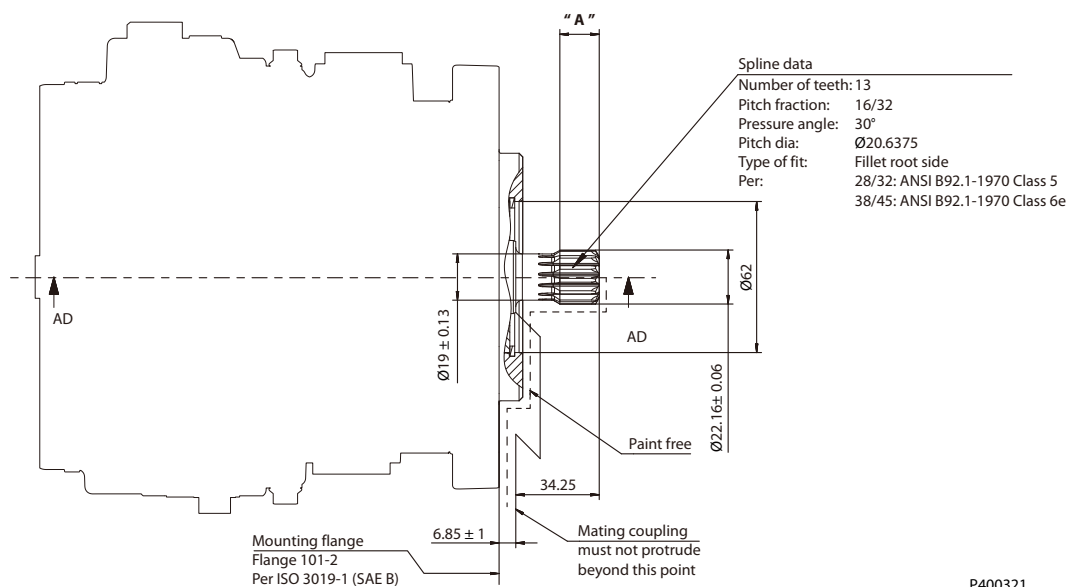| Option		G6, G7
Spline		19 teeth, 16/32 pitch
Min. active spline length[1]		33.8 ± 0.5
Torque rating	Maximum	734 N•m

[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)

P400335
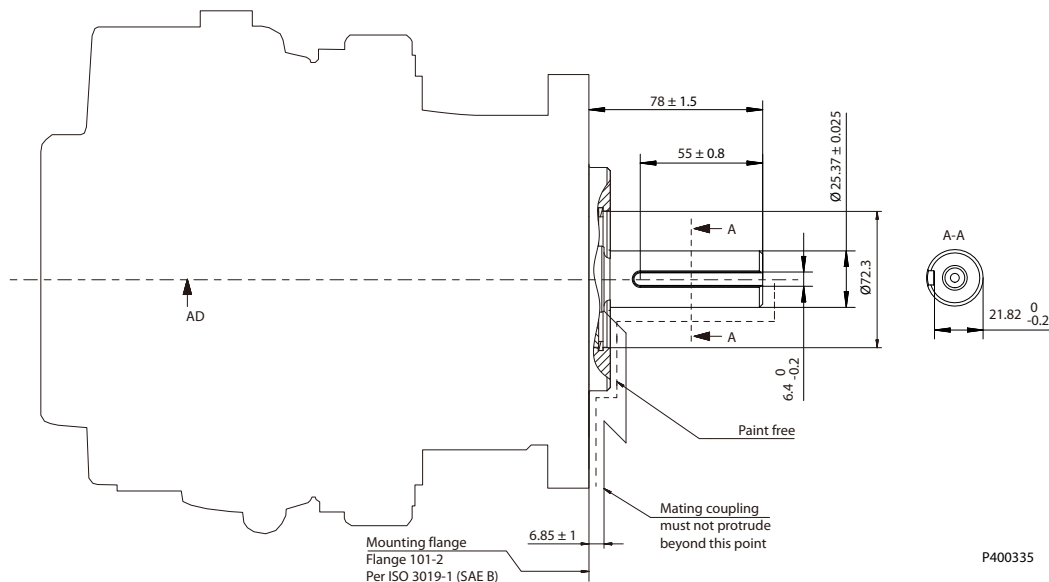
Specifications

Option		A6, A8
Torque rating	Maximum	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)
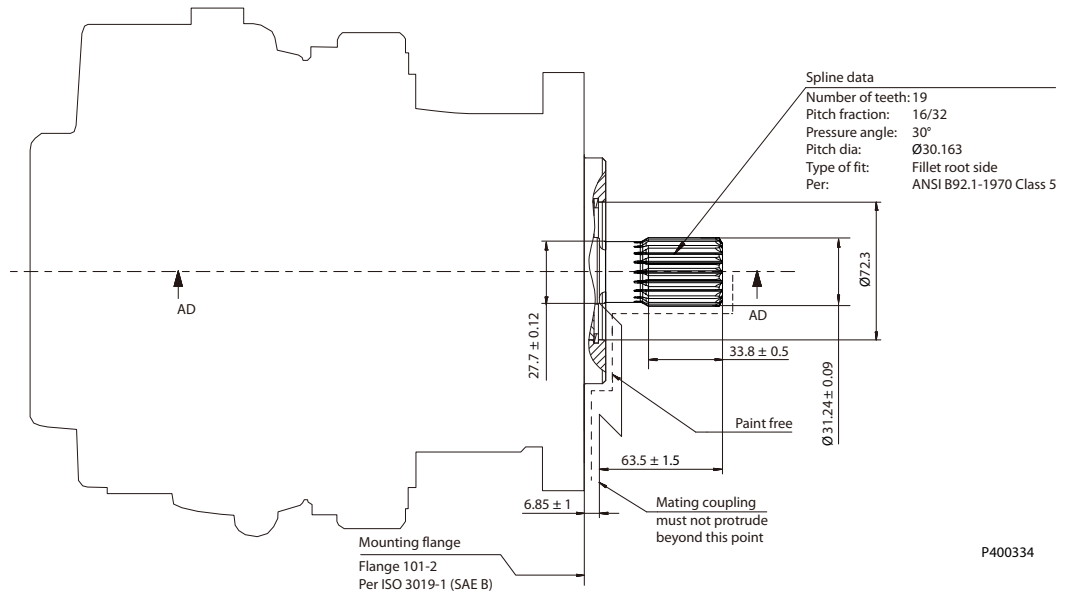

P400336
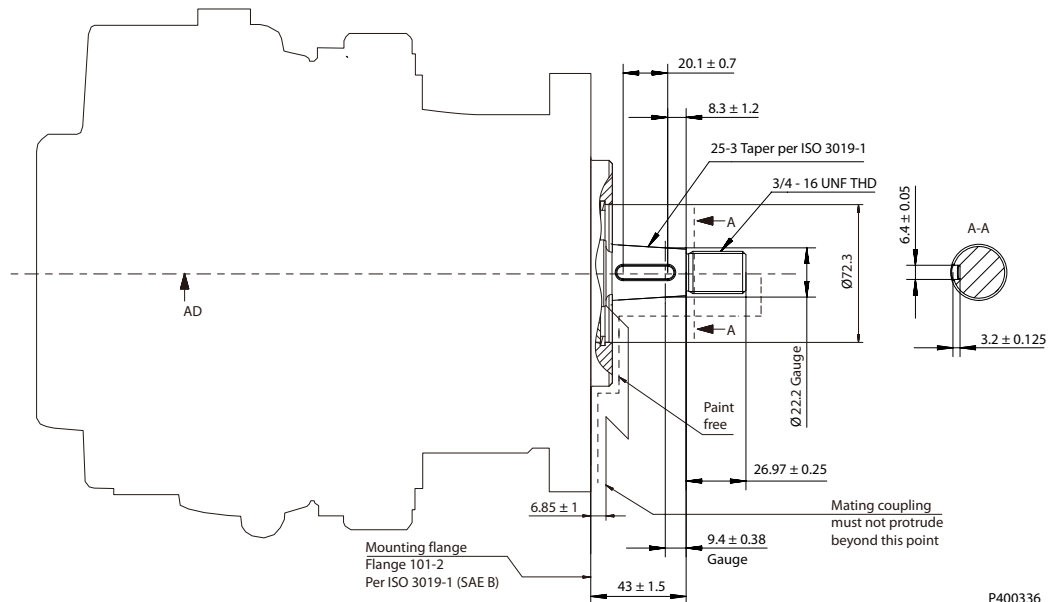
Specifications

Option		F2, F3
Torque rating	Maximum	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 it's 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)

Auxiliary mounting pad
For mating flange 82-2
Per ISO 3019-1 (SAE A)

Paint free

4x M10 x1.5-6H THD
15min THD depth

Ref Ø82.22 ID x
2.62 cross section

"A" ± 2.5

Spline data
Number of teeth: 9
Pitch fraction: 16/32
Pressure angle: 30°
Pitch dia: Ø14.288
Type of fit: Fillet root side
Per: ANSI B92.1-1970 Class 7

R0.8 max

$\varnothing 88.621 \, {}^{+0.13}_{0}$
$\varnothing 82.601 \, {}^{+0.076}_{0}$

Mating shaft shoulder must not
protrude beyond this poit

Mating shaft must not
protrude beyond this poit

1.956 ± 0.076
8.1 ± 0.25

"B"
Shaft clearance

"C"
Shaft clearance

2x 53.2 ± 0.175
2x 106.4 ± 0.35

P400324

	28/32	38/45
"A"	210	234.5
"B"	11.8 Min Shaft Clearance	12.0 Min Shaft Clearance
"C"	38.3 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)
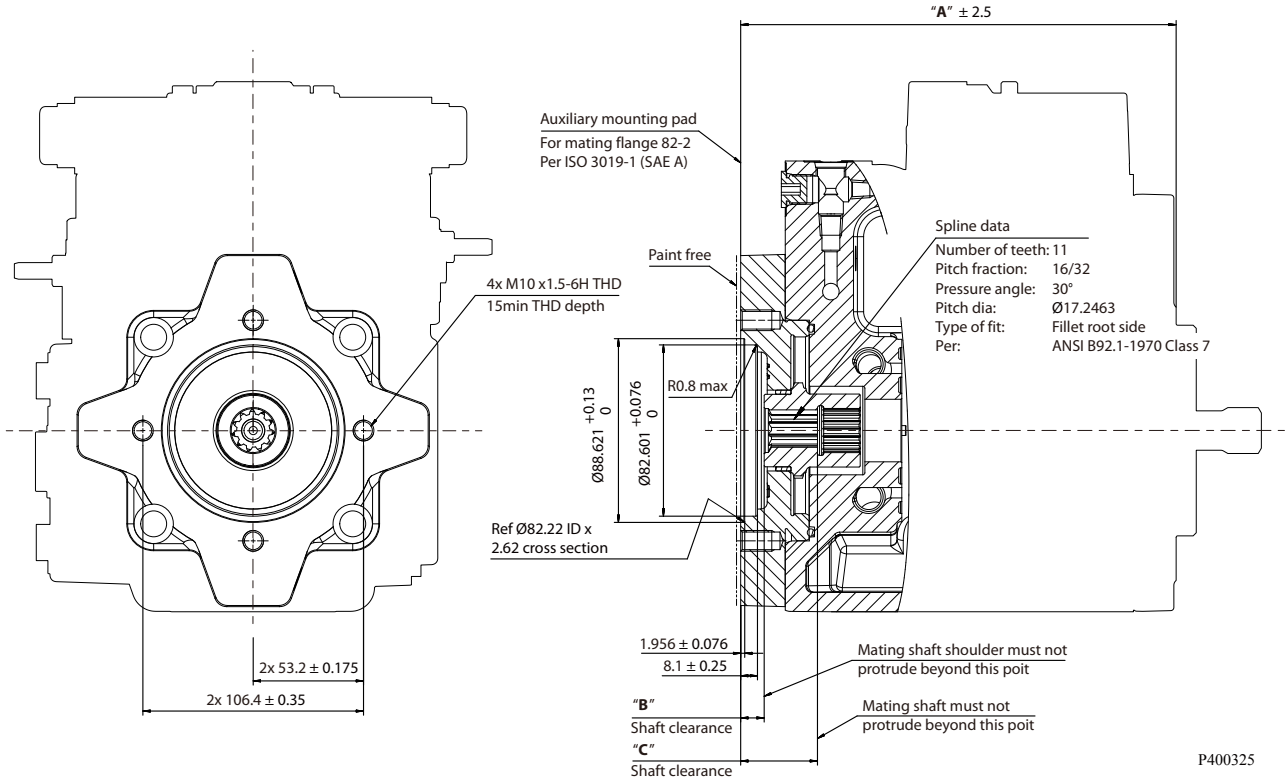
P400325

	28/32	38/45
"A"	210	234.5
"B"	11.8 Min Shaft Clearance	12.0 Min Shaft Clearance
"C"	38.3 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)

"A" ± 2.5

Auxiliary mounting pad
For mating flange 101-2
Per ISO 3019-1 (SAE B)

Paint free

4x M12 x1.75-6H THD
21.4 min THD depth

R0.8 max

Ø107.823 +0.13 / 0

Ø101.651 +0.076 / 0

Spline data
Number of teeth: 13
Pitch fraction: 16/32
Pressure angle: 30°
Pitch dia: Ø20.638
Type of fit: Fillet root side
Per: ANSI B92.1-1970 Class 7

Ref Ø94.92 ID x
2.62 cross section

2x73 ± 0.175

2x 146 ± 0.35

1.956 ± 0.076
11.4 ± 0.25

"B"
Shaft clearance

"C"
Shaft clearance

Mating shaft shoulder must not
protrude beyond this poit

Mating shaft must not
protrude beyond this poit

P400326

	28/32	38/45
"A"	213	234.5
"B"	14.8 Min Shaft Clearance	12.0 Min Shaft Clearance
"C"	41.3 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)

"A" ± 2.5

Auxiliary mounting pad
For mating flange 101-2
Per ISO 3019-1 (SAE B-B)

Paint free

4x M12 x1.75-6H THD
21.4 min THD depth

R0.8 max

Spline data
Number of teeth: 15
Pitch fraction: 16/32
Pressure angle: 30°
Pitch dia: Ø23.813
Type of fit: Fillet root side
Per: ANSI B92.1b-1996 Class 7e

Ø107.823 $^{+0.13}_{0}$

Ø101.651 $^{+0.076}_{0}$

Ref Ø94.92 ID x
2.62 cross section

Mating shaft shoulder must not
protrude beyond this poit

1.96 ± 0.08
11.4 ± 0.25

Mating shaft shoulder must not
protrude beyond this poit

"B"
Shaft clearance

"C"
Shaft clearance

2x73 ± 0.175

2x 146 ± 0.35

P400337

	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)

Control Manual Override "**C1**"
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump respose as per coil and rotation dependent control logic.

Case Gauge Port "**M14**"
Ø21 max clearance dia for fitting

Control Solenoid Connector "**C1**"
Deutsch DT04-2P
Paint free

Control Solenoid Connector "**C2**"
Deutsch DT04-2P
Paint free

Shaft

Mounting Flange

"**D**" ±0.8

2x 64.2±0.8

206±2.5

Z (2:1) 2x
1
2

Control Manual Override "**C2**"
Depressing the plunger mechanically moves the control spool. Actucation allows full stroke pump respose as per coil and rotation dependent control logic.

"**C**" ±2.5
"**A**" ±1.2
"**B**" ±1.2

Mounting Flange

Shaft

Z

P400314

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

	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)

Control Manual Override " **C1** "
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Control Solenoid Connector " **C1** "
Deutsch DT04-2P Paint free

Control Cut-Off Connector " **C4** "
Deutsch DT04-2PC Paint free

Control Solenoid Connector " **C2** "
Deutsch DT04-2P Paint free

Control Manual Override " **C2** "
Depressing the plunger mechanically moves the control spool. Actuation allows full stroke pump response as per coil and rotation dependent control logic.

Case Gauge Port " **M14** "
Ø21 max clearance dia for fitting

Shaft

Hydraulic logic Port" **X7** "

Mounting flange

Z (2:1) 2x

Y (2:1)

Mounting flange

Shaft

P400331

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

	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.
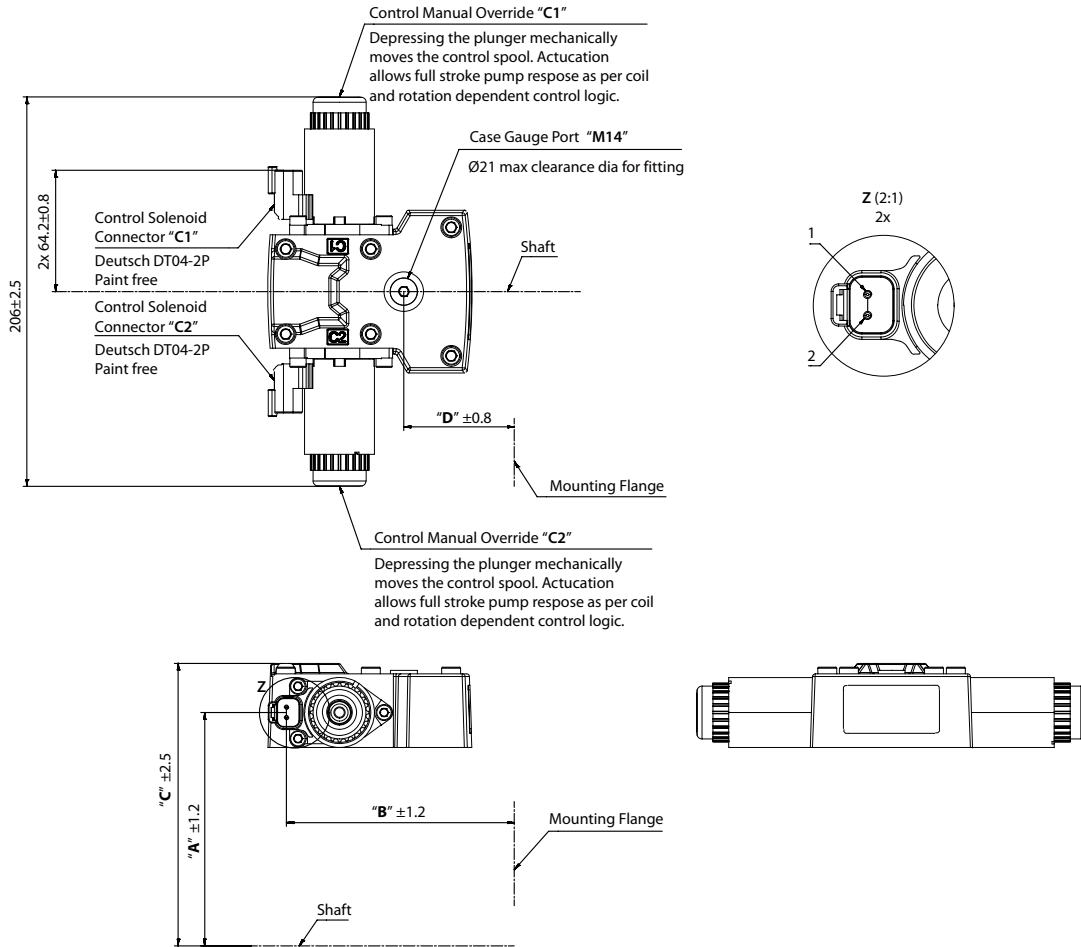
Controls

Manual Displacement Control (MDC)
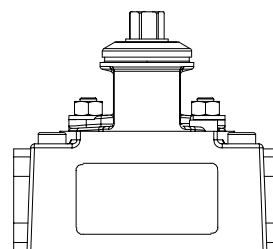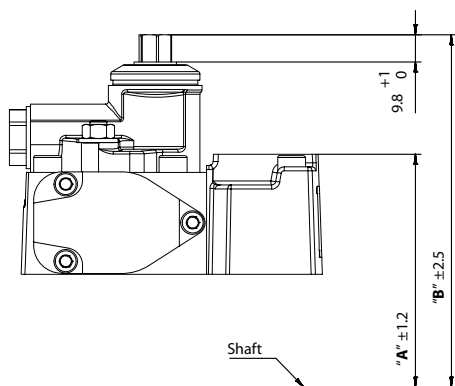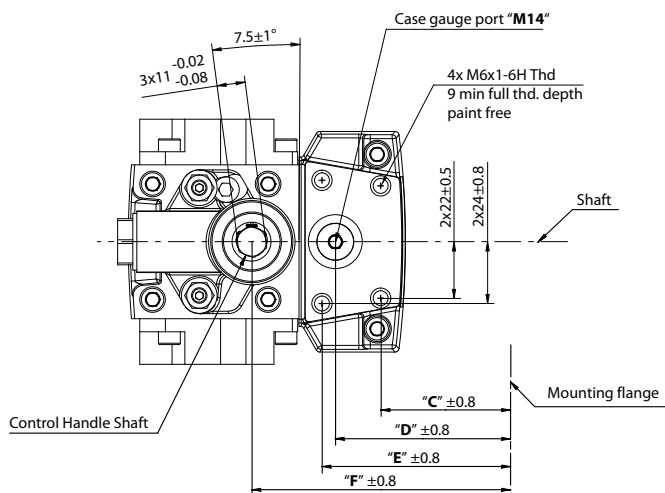
P400315

	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.
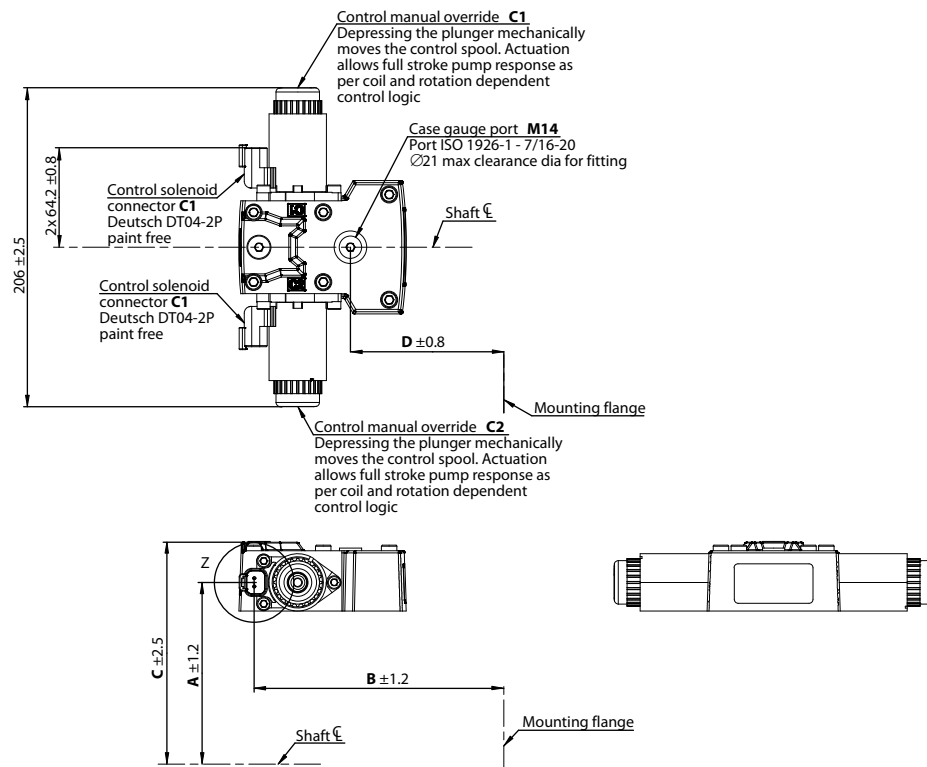
Controls

Forward-Neutral-Reverse (FNR)

Control Manual Override "**C1**"

Depressing the plunger mechanically moves the control spool. Actucation allows full stroke pump respose as per coil and rotation dependent control logic.

Case Gauge Port "**M14**"

Ø21 max clearance dia for fitting

Control Solenoid Connector "**C1**"

Deutsch DT04-2P Paint free

Shaft

Control Solenoid Connector "**C2**"

Deutsch DT04-2P Paint free

Z (2:1) 2x

"**D**" ±0.8

Mounting Flange

Control Manual Override "**C2**"

Depressing the plunger mechanically moves the control spool. Actucation allows full stroke pump respose as per coil and rotation dependent control logic.

Mounting Flange

Shaft

P400316

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

	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	

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

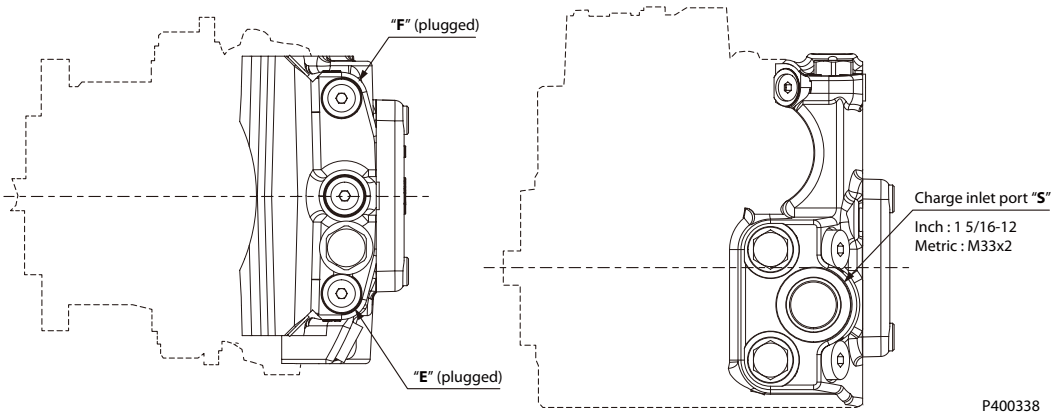Please contact Danfoss representative for specific installation drawings.

Filtration

Suction Filtration: Option S

28/32
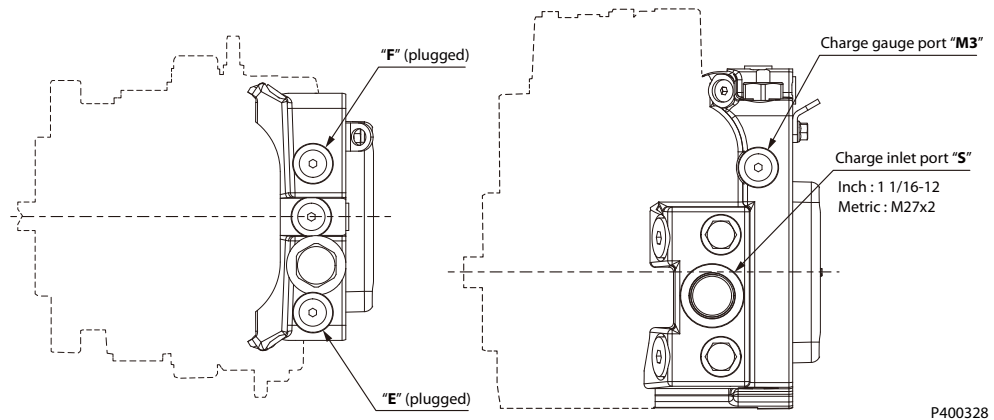
"**F**" (plugged)

Charge gauge port "**M3**"

Charge inlet port "**S**"
Inch : 1 1/16-12
Metric : M27x2

"**E**" (plugged)

P400328

Please contact Danfoss representative for specific installation drawings.

38/45

"**F**" (plugged)

Charge inlet port "**S**"
Inch : 1 5/16-12
Metric : M33x2

"**E**" (plugged)

P400338

Please contact Danfoss representative for specific installation drawings.

Filtration

Remote Full Flow Charge Pressure Filtration: Option R

28/32
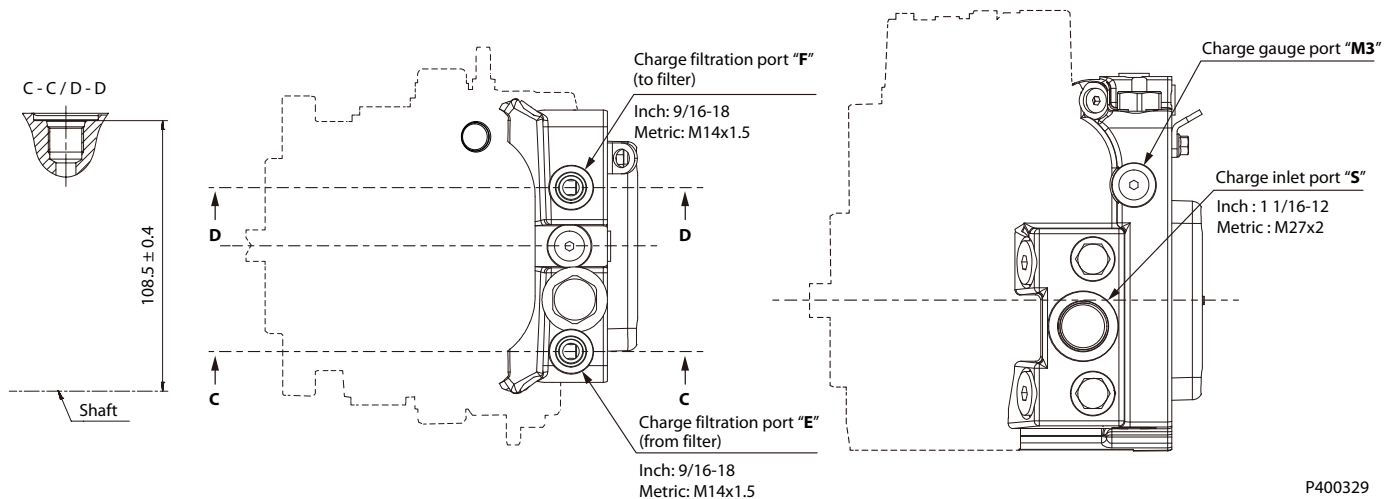
Charge filtration port "**F**"
(to filter)

Inch: 9/16-18
Metric: M14x1.5

Charge gauge port "**M3**"

Charge inlet port "**S**"

Inch : 1 1/16-12
Metric : M27x2

C - C / D - D

108.5 ± 0.4

Shaft

Charge filtration port "**E**"
(from filter)

Inch: 9/16-18
Metric: M14x1.5

P400329

Please contact Danfoss representative for specific installation drawings.

38/45

Charge filtration port "**F**"
(to filter)

Inch: 9/16-18
Metric: M14x1.5

Charge inlet port "**S**"

Inch: 1 5/16-12
Metric: M33x2

C - C / D - D

122.6 ± 0.4

Shaft

Charge filtration port "**E**"
(from filter)

Inch: 9/16-18
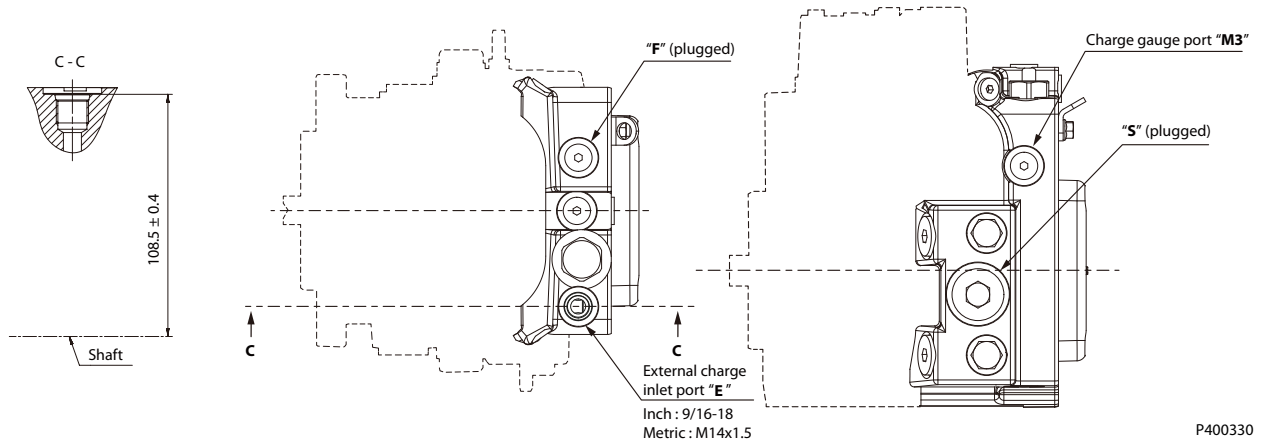Metric: M14x1.5

P400339
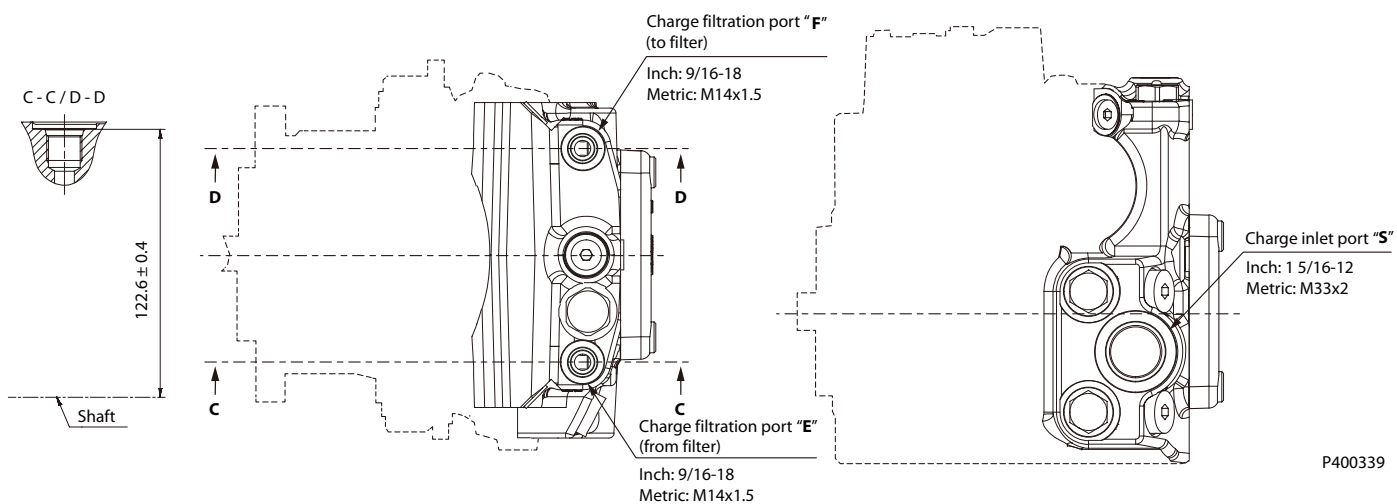
Please contact Danfoss representative for specific installation drawings.

Filtration

External Full Flow Charge Pressure Filtration: Option E

28/32

C - C

108.5 ± 0.4

Shaft

C

C

"**F**" (plugged)

External charge
inlet port "**E**"

Inch : 9/16-18
Metric : M14x1.5

Charge gauge port "**M3**"

"**S**" (plugged)

P400330

Please contact Danfoss representative for specific installation drawings.

38/45

C - C

122.6 ± 0.4

Shaft

C

C

"**F**" (plugged)

External charge
inlet port "**E**"

Inch : 9/16-18
Metric : M14x1.5

"**S**" (plugged)

P400340
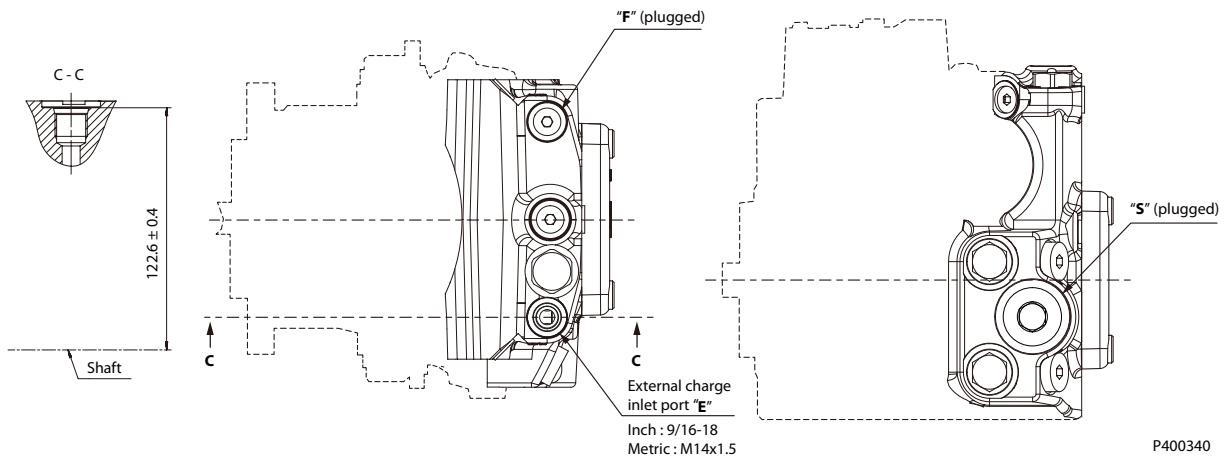
Please contact Danfoss representative for specific installation drawings.

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- Closed Circuit Axial Piston Pumps and Motors
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- Microcontrollers and Software
- Open Circuit Axial Piston Pumps
- Orbital Motors
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- Proportional Valves
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- Steering
- Transit Mixer Drives

Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electronic components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market. Building on our extensive applications expertise, we work closely with our customers to ensure exceptional performance for a broad range of off-highway vehicles.

We help OEMs around the world speed up system development, reduce costs and bring vehicles to market faster.

Danfoss – Your Strongest Partner in Mobile Hydraulics.

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

Wherever off-highway vehicles are at work, so is Danfoss. We offer expert worldwide support for our customers, ensuring the best possible solutions for outstanding performance. And with an extensive network of Global Service Partners, we also provide comprehensive global service for all of our components.

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