Danfoss

Technical Information

MP1T 028/032
Axial Piston Tandem Pumps
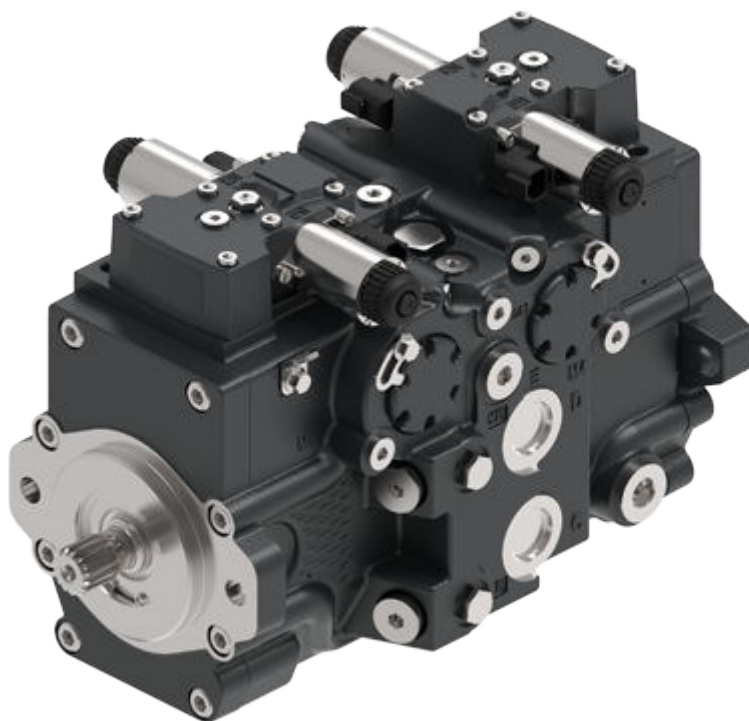
Revision history   *Table of revisions*

Date	Changed	Rev
August 2025	First Edition	0101

Contents

General description

Technical specifications

Operation

Contents

General description

MP1 Pump overview

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

MP1T Features

Designed for quality and reliability

- 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
- Standard connection interfaces

Greater total efficiency

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

Control options

- Electrical displacement control (EDC)
- Manual displacement control (MDC)
- Forward-neutral-reverse (FNR)
- Non-feedback proportional electric (NFPE)
- Non-feedback proportional hydraulic (NFPH)
- Common control across entire family

Expanded functionality

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

Modularity

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

General description

MP1T Schematic

The schematic below shows the function of MP1T axial piston displacement tandem pumps with electric displacement control (EDC), loop flushing valve, CCO valve and speed sensor.

P400907

Technical specifications

MP1T design specifications

Features	MP1
Design	Axial piston integrated tandem 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, NFPE, FNR and MDC control. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for non-conformance to these guidelines.
Filtration configuration	External charge filtration

MP1T technical data

Feature	28	32
Displacement (cm^3/rev [in^3/rev])	28.0 [1.71]	31.8 [1.94]
Flow at rated (continuous) speed (l/min [US gal/min])	95.3 [25.2]	108.1 [28.5]
Torque at maximum displacement (N•m/bar [lbf•in/1000psi])	0.45 [272.0]	0.51 [308.9]
Mass moment of inertia of rotating components (kg•m^2 [slug•ft^2])	0.0040 [0.0030]	
Mass (kg [lb])	58.5 [129.0]	
Oil volume (liter [US gal])	3.0 [0.80]	
Mounting flange	ISO 3019-1 flange 101-2 (SAE B)	
Input shaft outer diameter, splines and tapered shafts	ISO 3019-1, outer Ø25mm - 4 (SAE B-B, 15 teeth)	
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)	
Main port configuration **A, B, C, D**	ISO 11926-1 - 1 1/16 - 12 (Inch O-ring boss)	
Case drain ports **L1, L2**	ISO 11926-1, 1 1/16 -12 (Inch O-ring boss)	
Other ports	ISO 11926-1, (Inch O-ring boss)	
Customer interface threads	Metric fasteners	

MP1T operating parameters

Features		Units	28/32
Input speed	Minimum[1]	min^{-1} (rpm)	500
	Rated		3400
	Maximum		4000
System pressure	Maximum working pressure	bar [psi]	350 [5000]
	Maximum pressure		380 [5429]
	Minimum low loop (above case)		10 [143]
Charge pressure (minimum)		bar [psi]	16 [232]
Case pressure	Rated	bar [psi]	3 [43]
	Maximum		5 [71]

[1] No load condition. Full performance (pressure and displacement) possible at minimum charge and control pressure supply.

Technical specifications

MP1T fluid specifications

Features		Units	28/32
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	$\beta15\text{-}20=75(\beta10\geq10)$
	Efficiency (suction filtration)		$\beta35\text{-}45=75(\beta10\geq2)$
	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 MP1T 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

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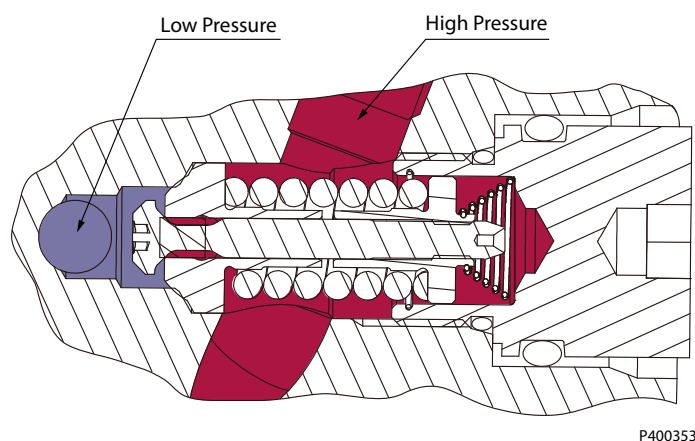
Bypass function

The bypass function allows a machine or load to be moved without rotating the pump shaft or prime mover. The pump HPRV also provides a loop bypass function. The bypass function is activated when each of the four HPRV HEX plug is turned out 3 full turns.

Engaging the bypass function mechanically connects each A & B sides, C & D sides of the working loop to the common charge gallery.

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

Operation

Charge pressure relief valve (CPRV) function

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

The charge pressure relief valve setting is specified within the model code of the pump. MP1T pumps have the CPRV set with 37.8 l/min [10.0 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].

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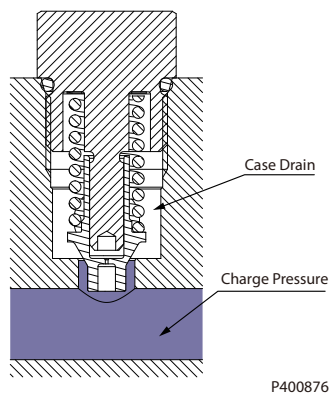
Operation

Loop flushing valve

MP1T tandem 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 MP1T loop flushing design is a simple spring centered shuttle spool with an orifice notch. 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 orifice notch.

Loop flush flow options of 6.0 l/min [1.6 gal/min] at 20 bar of delta charge pressure is standard. Please contact Danfoss representative if a loop flush option of 9.0 l/min [2.4 gal/min] is required.

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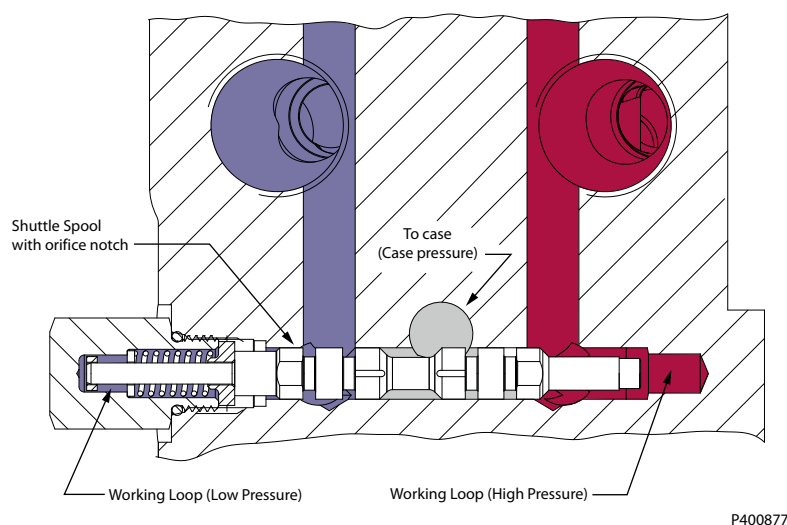
Loop flushing performance

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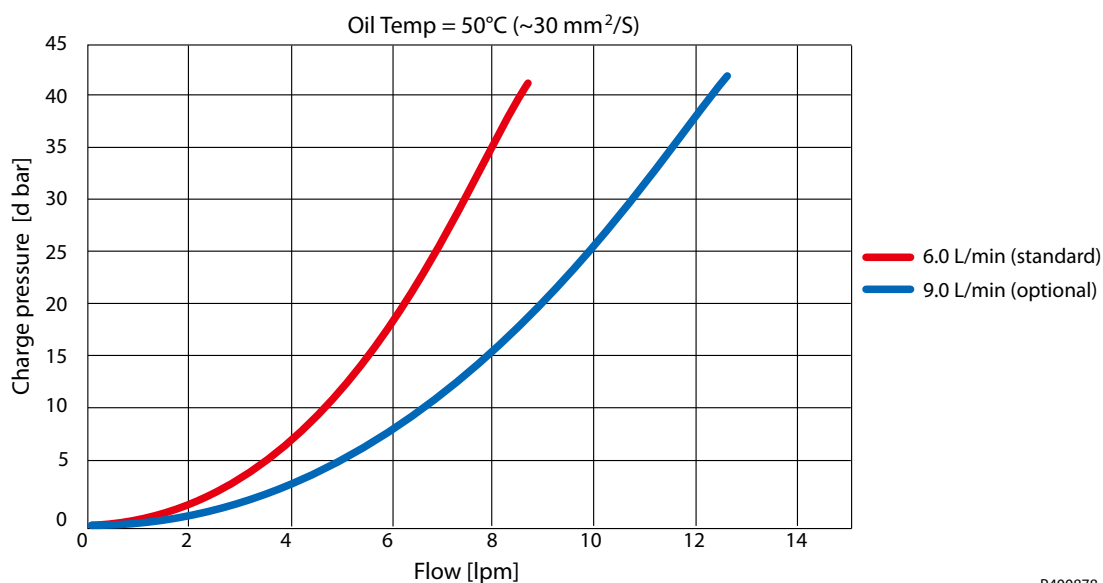
When a MP1 pump is used with an external loop flushing shuttle valve, ensure that the charge setting of the pump matches the setting of the loop flushing shuttle valve. Contact your Danfoss representative for the availability of additional charge relief settings.

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

EDC control

P003 191

EDC schematic

P003 478E
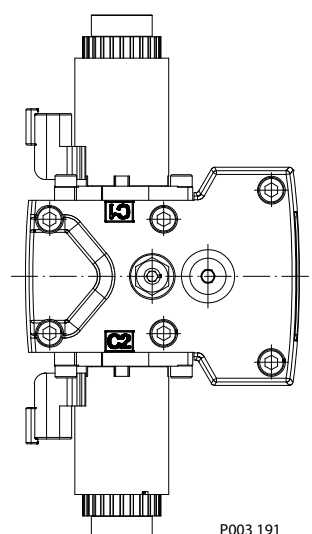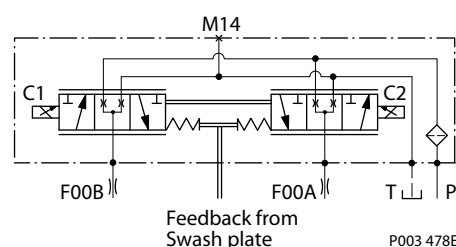
EDC operation

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.

Control signal requirements

Pump displacement vs. control current
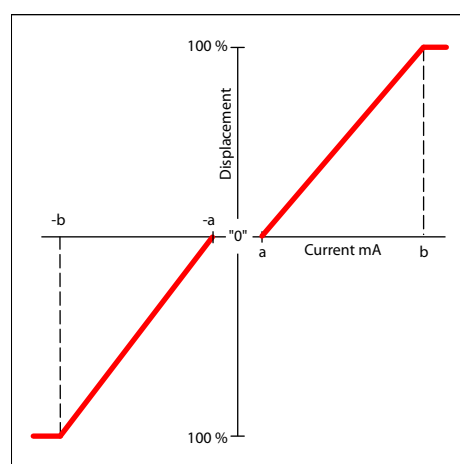
EDC control current

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

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

EDC solenoid data

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

* PWM signal required for optimum control performance.

Operation

Pump output flow direction vs. control signal

Shaft rotation EDC	CW				CCW			
Coil energized*	Front		Rear		Front		rear	
	C1	C2	C1	C2	C1	C2	C1	C2
Port A	out	in			in	out		
Port B	in	out			out	in		
Port C			in	out			out	in
Port D			out	in			in	out
Servo port pressurized	M4	M5	M4	M5	M4	M5	M4	M5

* For coil location see Installation drawings.

Control response

MP1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

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

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

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

EDC response time (28/32)

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
Neutral to full flow	1.3 s	0.9 s	0.6 s	0.4 s
Full flow to neutral	1.0 s	0.7 s	0.4 s	0.2 s

Manual override (MOR)

All controls are available with a manual override functionality, either as a standard or as an option for temporary actuation of the control to aid in diagnostics.

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

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

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

Operation

Control with manual override

P003 204
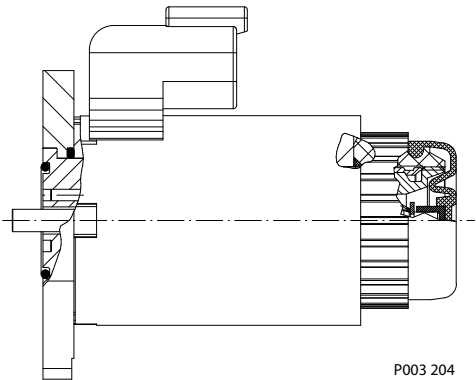
MOR schematic (EDC control shown)
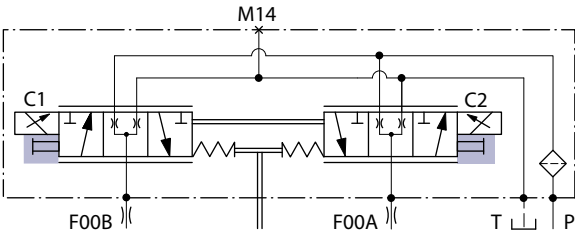
Operation

Swashplate angle sensor for EDC controls

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

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

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

Swashplate angle vs. output of supply voltage
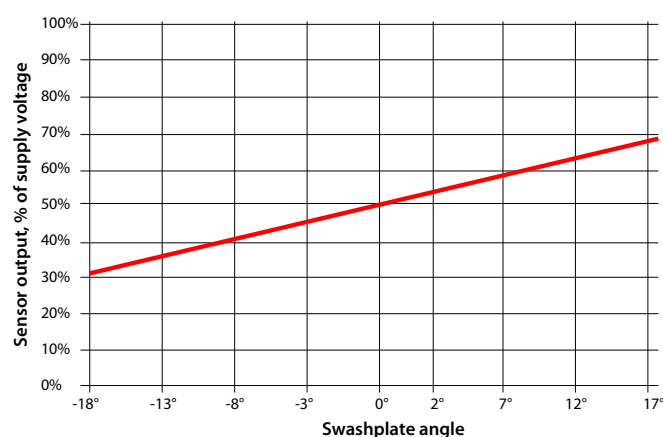
⚠ **Warning**

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

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

Swash plate angle sensor parameters (EDC)

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

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

Operation

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

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

Swash plate angle sensor connector

Connector DEUTSCH, 4-pin
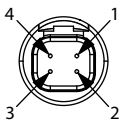
Pin assignment:

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

Connector order numbers

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

Interface with ECU (EDC)

Interface with ECU diagram
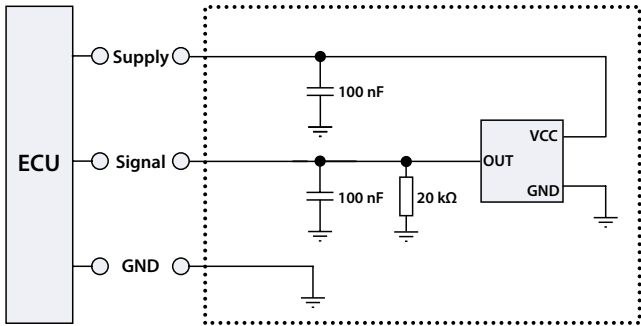
Operation

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

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

Manual Displacement Control

P301 749
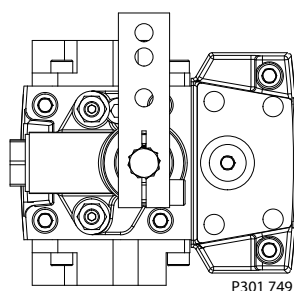
Pump displacement vs. control lever rotation

P301 752

Operation

MDC schematic diagram

P005 701
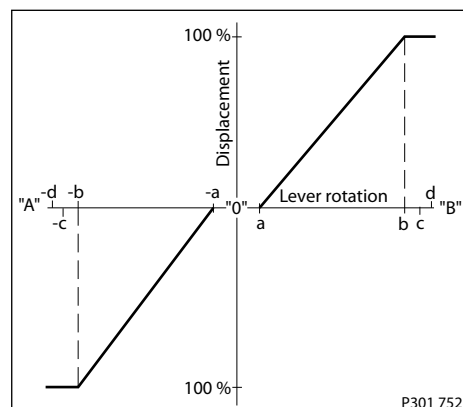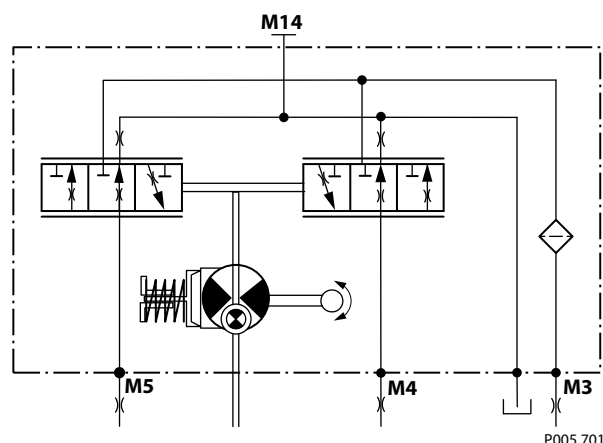
Where:

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°

MDC torque

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

MDC operation

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

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

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

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

⚠ **Caution**

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

Operation

MDC shaft rotation
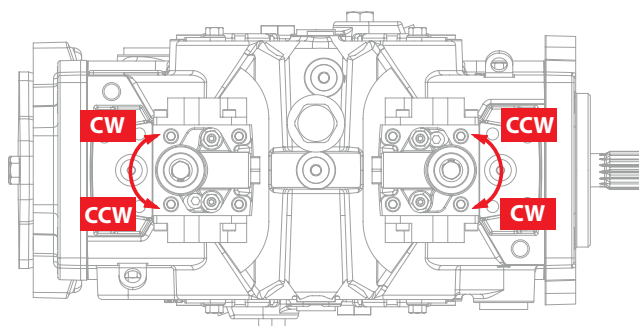
P400879

shaft rotation MDC	CW (right hand as seen from shaft)				CCW (left hand as seen from shaft)			
MDC shaft rotation	**Front**		**Rear**		**Front**		**Rear**	
	CW	**CCW**	**CW**	**CCW**	**CW**	**CCW**	**CW**	**CCW**
Port A	in	out			out	in		
Port B	out	in			in	out		
Port C			out	in			in	out
Port D			in	out			out	in
Servo gauge port pressurized	M5	M4	M5	M4	M5	M4	M5	M4

Control response

MP1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

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

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

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

MDC response time (28/32)

Code	Orifice description (mm)				Stroking direction (sec)	
	P	**A**	**B**	**Tank (A+B)**	**Neutral to full flow**	**Full flow to neutral**
C1	–	0.8	0.8	–	1.3	0.9
C2	–	1.3	1.3	–	0.5	0.4
C3	–	–	–	–	0.3	0.3
C4	–	1.0	1.0	–	0.8	0.6
C6	–	–	–	1.0	0.5	0.5
C7	–	–	–	1.3	0.4	0.5
C8	0.8	–	–	0.6	1.5	1.4
C9	1.0	–	–	0.6	1.3	1.1

Operation

Code	Orifice description (mm)				Stroking direction (sec)	
	P	**A**	**B**	**Tank (A+B)**	**Neutral to full flow**	**Full flow to neutral**
D1	1.0	–	–	0.8	0.9	0.8
D2	1.3	–	–	0.8	0.8	0.7
D3	1.3	–	–	1.0	0.6	0.6
D4	1.3	1.3	1.3	1.0	0.8	0.7
D5	0.6	0.8	0.8	0.6	3.2	2.0

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
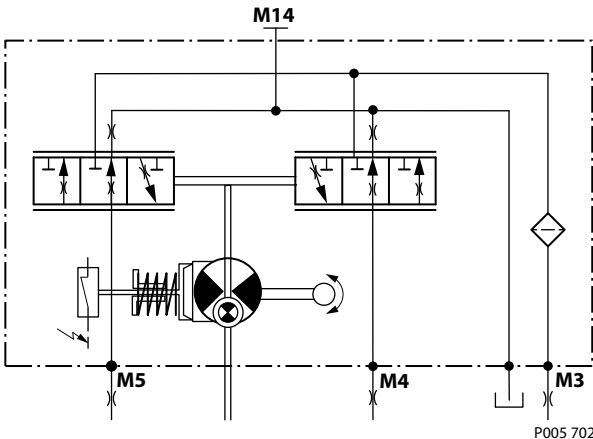
Neutral start switch data

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
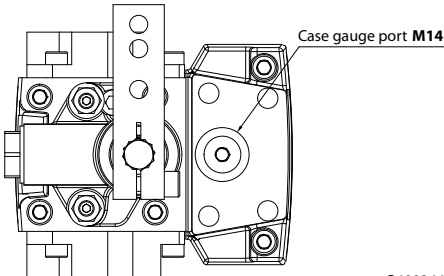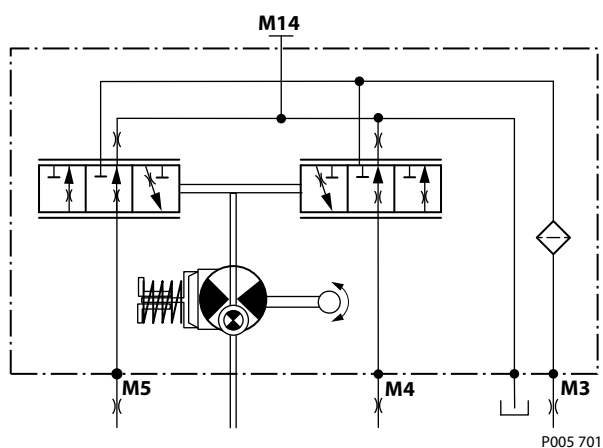
Lever

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

Standard orientation 90° from input shaft

P301 749
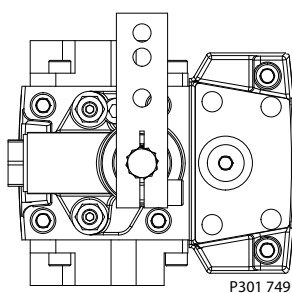
Operation

Forward-neutral-reverse electic control (FNR)

FNR principle

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

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

Forward-Neutral-Reverse electric control (FNR)

P003 193
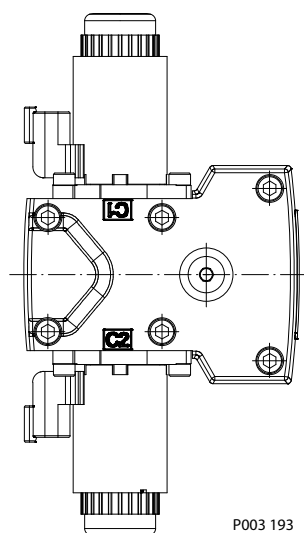
FNR hydraulic schematic

P003 189
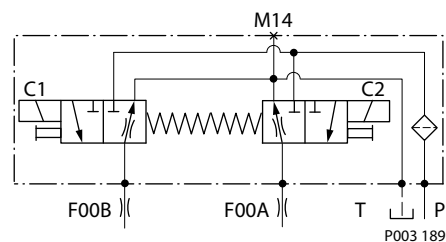
Operation

Pump displacement vs. electrical signal

P003 190E
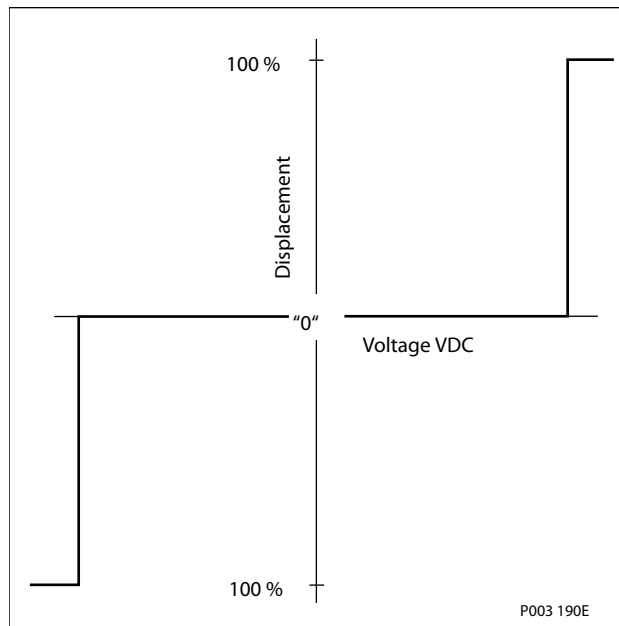
Control current

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

DEUTSCH connector, 2-pin
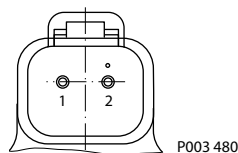
P003 480

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	

Operation

Solenoid data (continued)

Voltage	12 V	24 V
PWM Frequency (preferred)*	100 Hz	
IP Rating (IEC 60 529) + DIN 40 050, part 9	IP 67 / IP 69K (part 9 with mating connector)	
Bi-directional diode cut off voltage	28 V_{DC}	53 V_{DC}

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

Shaft rotation FNR	Clockwise (CW) seen from shaft				Counter Clockwise (CCW) seen from shaft			
Coil energized*	**Front**		**Rear**		**Front**		**Rear**	
	C1	**C2**	**C1**	**C2**	**C1**	**C2**	**C1**	**C2**
Port A	in	out			out	in		
Port B	out	in			in	out		
Port C			out	in			in	out
Port D			in	out			out	in
Servo gauge port pressurized	M5	M4	M5	M4	M5	M4	M5	M4

* For coil location see Installation Drawings.

Control response

MP1T controls are available with optional control passage orifices to assist in matching the rate of swash-plate response to the application requirements (e.g. in the event of electrical failure).

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

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

Δ p = 250 bar [3626 psi]
Charge pressure = 20 bar [290 psi]
Viscosity and temperature = 30 mm²/s [141 SUS] and 50 °C [122 °F]
Speed = 1800 min^{-1} (rpm)

FNR response time (28/32)

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
Neutral to full flow	2.1 s	1.1 s	0.8 s	0.7 s
Full flow to neutral	1.1 s	0.9 s	0.6 s	0.3 s

Operation

Non feedback proportional electric control (NFPE)

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

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

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

NFPE control

P003 192

NFPE schematic

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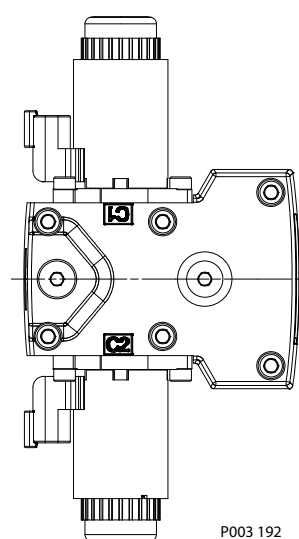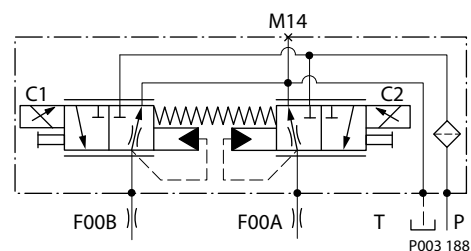
The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swashplate angle as system pressure increases. A typical response characteristic is shown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

NFPE pump displacement to input signal

P003 187E
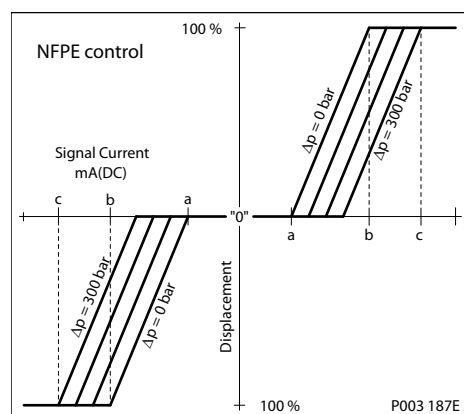
Operation

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.

DEUTSCH connector, 2-pin
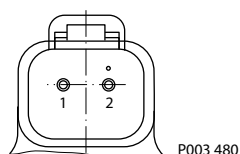
P003 480

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 EDC		Clockwise (CW) seen from shaft				Counter Clockwise (CCW) seen from shaft			
Coil energized*		**Front**		**Rear**		**Front**		**Rear**	
		C1	**C2**	**C1**	**C2**	**C1**	**C2**	**C1**	**C2**
Port A		in	out			out	in		
Port B		out	in			in	out		
Port C				out	in			in	out
Port D				in	out			out	in
Servo gauge port pressurized		M5	M4	M5	M4	M5	M4	M5	M4

* For coil location see Installation Drawings.

Operation

Control response

MP1T controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

Typical response times at the following conditions:

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

NFPE response time (28/32)

Stroking direction	0.8 mm [0.03 in] orifice	1.0 mm [0.04 in] orifice	1.3 mm [0.05 in] orifice
	28/32	28/45	28/45
Neutral to full flow	1.5 s	0.9 s	0.6 s
Full flow to neutral	0.9 s	0.6 s	0.4 s

Operation

Swash Plate Angle Sensor for NFPE controls

The angle sensor detects the swash plate angle position and direction of rotation from the zero position. The swash angle sensor works on the AMR sensing technology. Under the saturated magnetic field, the resistance of the element varies with the magnetic field direction.

The output signal give a linear output voltage for the various magnet positions in the sensing range.

P301 750
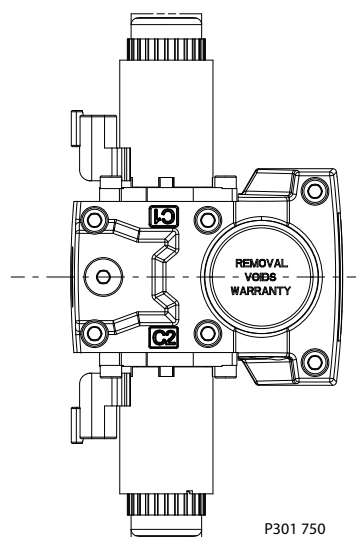
Swash Plate Angle Characteristic

The volumetric losses depend on pump max. displacement, actual displacement, speed, delta pressure, viscosity and temperature.

Swashplate angle vs. output voltage (calibrated at 50 ℃)
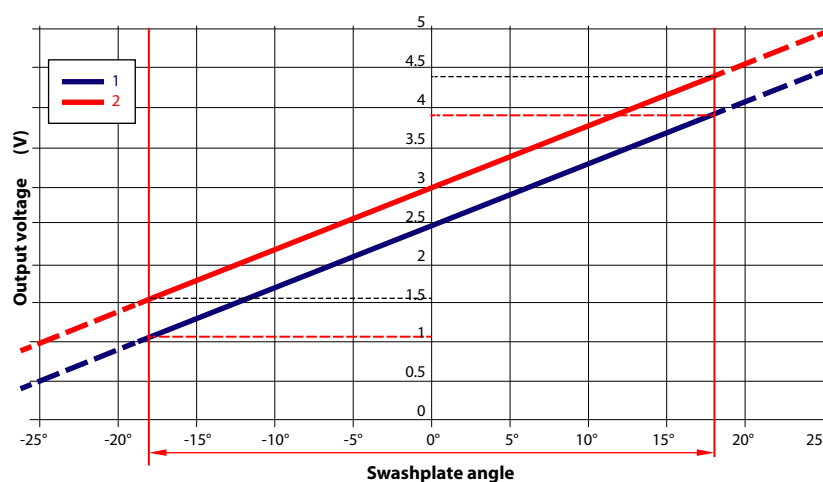
1. Signal 1 (nominal)

2. Signal 2 (redundant)

The displacement can be calculated by:

$$V = \frac{\tan \alpha \cdot V}{\tan 18°} \ (cm^3)$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \ (l/min)$$

Operation

Swash Plate Angle Sensor Parameters (NFPE)

Parameter	Minimum	Typical	Maximum
Supply voltage range	4.75 V	5 V	5.25 V
Supply protection	–	–	28 V
Supply current	–	22 mA	25 mA
Output current (Signal 1, 2)	–	0.1 mA	–
Short circuit output current to supply or GND[1)]	–	–	7.5 mA
Sensitivity	70.0 mV/deg	78.0 mV/deg	85.8 mV/deg
Working range (swash plate angle)	−18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

[1)] Up to duration of 2.5 seconds at 25°C

[2)] Signal 1 (nominal) is lower than signal 2 (redundant)

Swash Plate Angle Sensor Connector (NFPE)
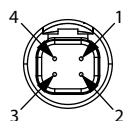
1   Ground (GND)

2   Output Signal 2 (SIG 2) – Secondary (redundant)

3   Output signal 1 (SIG 1)

4   Supply (V+)

Description	Quantity	Order number
Mating connector	1	DEUTSCH DTM06-4S-E004
Wedge lock	1	DEUTSCH WM-4S
Socket contact	4	DEUTSCH 0462-201-2031
Blind socket	1	DEUTSCH 0413-204-2005
Danfoss mating connector kit	1	11212713

Interface with ECU (NFPE)
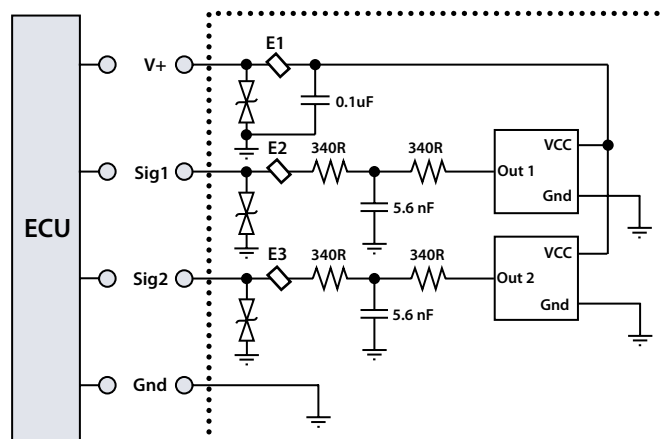
Minimum recommended load resistance is 100 kΩ.

Operation

Non-feedback, proportional hydraulic control (NFPH)

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

MP1T pumps with NFPH control have a special servo cylinder capable of providing proportional control with a hydraulic input.

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

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

Non-feedback proportional hydraulic control schematic
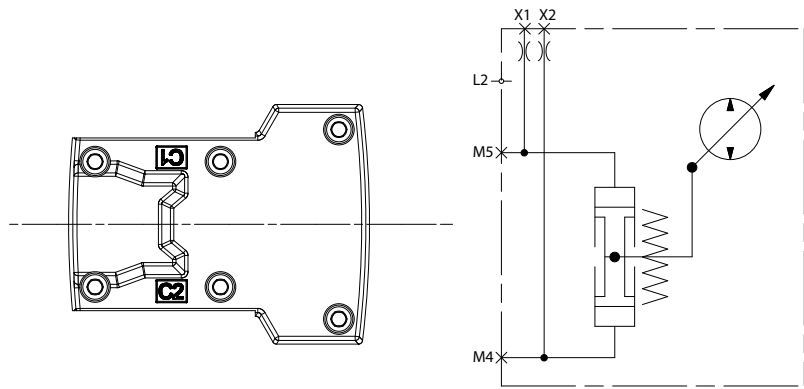
Pump flow direction with NFPH control

Shaft rotation NFPH	CW (right hand as seen from shaft)				CCW (left hand as seen from shaft)			
Control input port pressurized[*]	Front		Rear		Front		Rear	
	X1	X2	X1	X2	X1	X2	X1	X2
Port A	in	out			out	in		
Port B	out	in			in	out		
Port C			out	in			in	out
Port D			in	out			out	in
Servo gauge port pressurized	M5	M4	M5	M4	M5	M4	M5	M4

[*] For port location see Installation Drawings.

Operation

NFPH pump displacement to Input signal
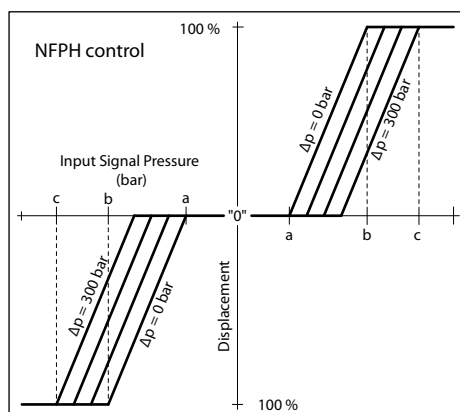
NFPH input signal pressure (bar)

Frame size	a	b	c
28/32	5.5	13.7	17

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

Control response

MP1T controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper orifice selection for the desired response.

Typical response times at the following conditions:

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

NFPH response time (28/32)

Stroking direction	0.8 mm [0.03] orifice	1.0 mm [0.04] orifice	1.3 mm [0.05] orifice
Neutral to full flow	1.5 s	0.9 s	0.6 s
Full flow to neutral	0.9 s	0.6 s	0.4 s

Operation

Control-Cut-Off (CCO) valve

The MP1T tandem pumps offer an optional **control-cut-off** valve integrated into housing. This valve will block charge pressure to the control, allowing the servo springs to de-stroke both pumps regardless of the pump´s primary control input. There is also a hydraulic logic port, X7, which can be used to control other machine functions, such as spring applied pressure release brakes. The pressure at X7 is controlled by the control cut off solenoid. The X7 port would remain plugged if not needed.

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

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

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

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

The CCO-valve is available with 12 V or 24 V solenoid.
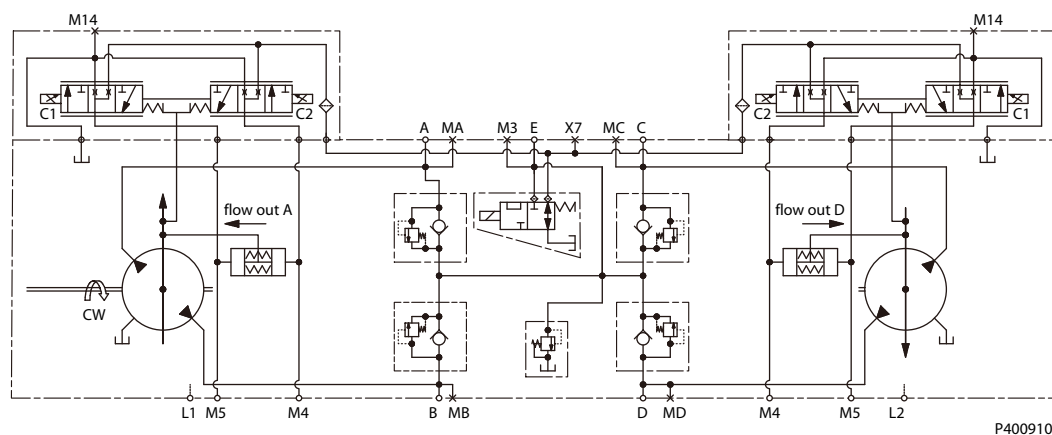
Control-Cut-Off Valve
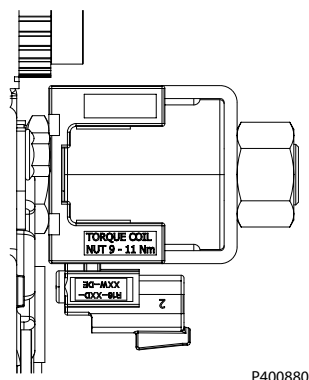
Operation

Solenoid data

Description		12 V	24 V
Minimum supply voltage		9 V_{DC}	18 V_{DC}
Maximum supply voltage (continuous)		16 V_{DC}	32 V_{DC}
IP Rating	**IEC 60 529**	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	
Pin connector		any order	

For additional information, please contact Danfoss.
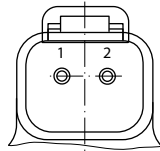
Operation

Displacement limiter

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

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

Displacement limiter
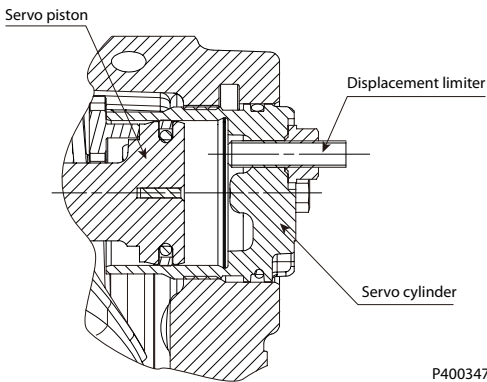
Displacement change (approximate)

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

Operation

Speed sensor

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

For more information, see *Speed and Temperature Sensor, Technical Information,* **BC152886482203**.

Temperature Range

Parameter	Minimum	Maximum
Operation temperature range	-40 °C	104 °C

115°C intermittent = short term; t < 1min per incident and not exceeding 2 % of duty cycle based load-life.

Output pulses

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

The number of output (speed) pulses

MP1P size	28/32
Pulses (per rev)	9

Mating connectors

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

Ordering number	
11033865	**11033863**
Assembly Bag, DEUTSCH DTM06-6S-E004; black, (24-20 AWG) 0.21 -0.52 mm²	Assembly Bag, DEUTSCH DTM06-6S, gray, (24-20 AWG) 0.21 -0.52 mm²

Speed sensor 4.5 – 8 V

Speed sensor connector, 6-pin

P006035
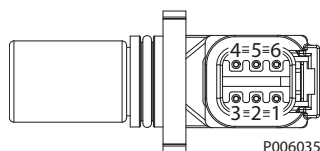
1. Speed signal 2
2. NC
3. Speed signal 1
4. Supply
5. Ground
6. Temperature

Technical data

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

Operation

Technical data (continued)

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

Temperature Signal

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

V_O – Measured output voltage (V)

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

T – Temperature (°C)

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

Output signal voltage vs. Temperature

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

* Accuracy: ±1. 5 to ± 4 °C

** Accuracy: ±2.5 to ± 5 °C

Response time in fluid

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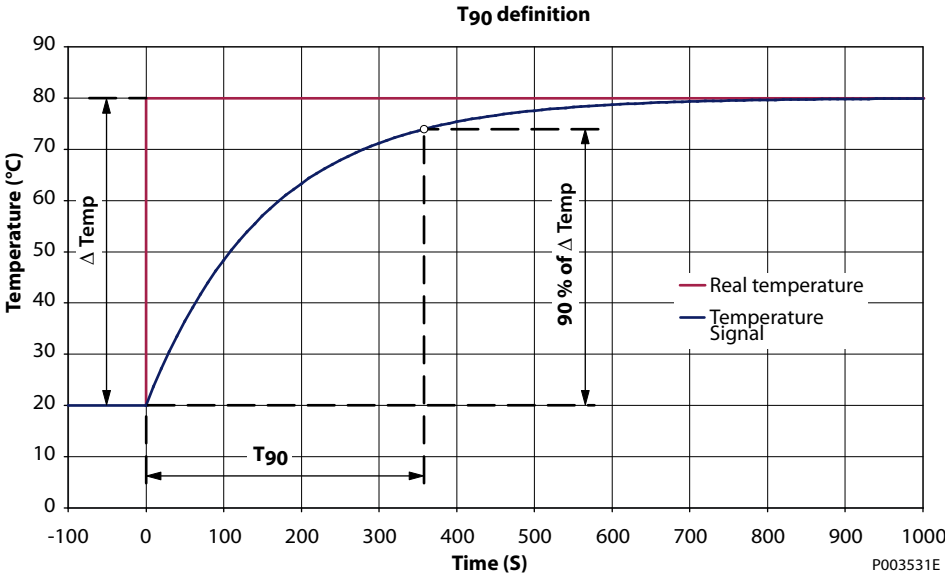
Response time in fluid (T_{90}) = 360 s

Operating parameters

Input speed

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

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

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

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

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

⚠ Warning

Unintended vehicle or machine movement hazard.

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

System Pressure

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

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

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

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

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

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

Operating parameters

Charge pressure

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

The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral with a charge flow of 37.8 l/min [10.0 US gal/min] and a fluid viscosity of 32 mm^2/s [150 SUS]. The charge pressure setting is referenced to case pressure.

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.

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,* **BC152886482150** for more information.

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

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

Filtration

Charge flow is required on MP1 tandem pumps. For pumps configured with no charge pump (external charge supply), filtered oil for charge must be delivered through E port. Charge inlet flow in excess of 80 L/min [21.1 US gal/min] must be avoided.

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.

System design parameters

Charge pressure filtration

P400031
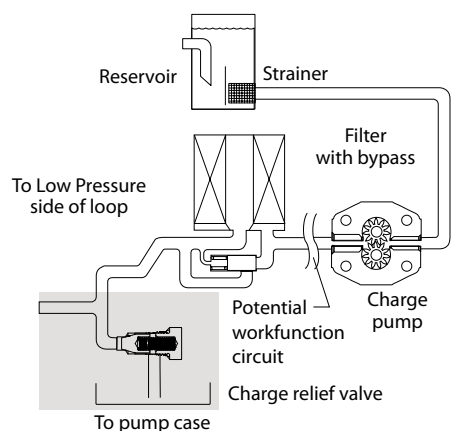
Independent braking system

⚠️ **Warning**

Unintended vehicle or machine movement hazard.

The loss of hydrostatic drive line power, in any mode of operation (forward, neutral, or reverse) may cause the system to lose hydrostatic braking capacity. You must provide a braking system, redundant to the hydrostatic transmission, sufficient to stop and hold the vehicle or machine in the event of hydrostatic drive power loss.

Fluid selection

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

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

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

🛑 **Caution**

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

Reservoir

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

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

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

System design parameters

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 front and rear pump cases are connected through cast passage in the housing. The charge relief valve discharges oil into both front and rear housings. The MP1 tandem pumps are 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

An external charge pump is required on the MP1 tandem pumps applied in closed circuit installation 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.

Charge pump sizing/selection

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

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

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

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

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.

System design parameters

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 tandem 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.

High capability bearing option is available on 28/32cc pump. High capability bearing is recommended for applications running at high speed and system pressure for a long time. Please refer to Model code/ J-input shaft section.

- In applications where the pump is operated such that nearly equal amounts of forward vs reverse swashplate operation is experienced; bearing life can be optimized by orientating the external side load to the 0 or 180 deg position (90 deg to rotating group load 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 orientating 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.

External radial shaft load
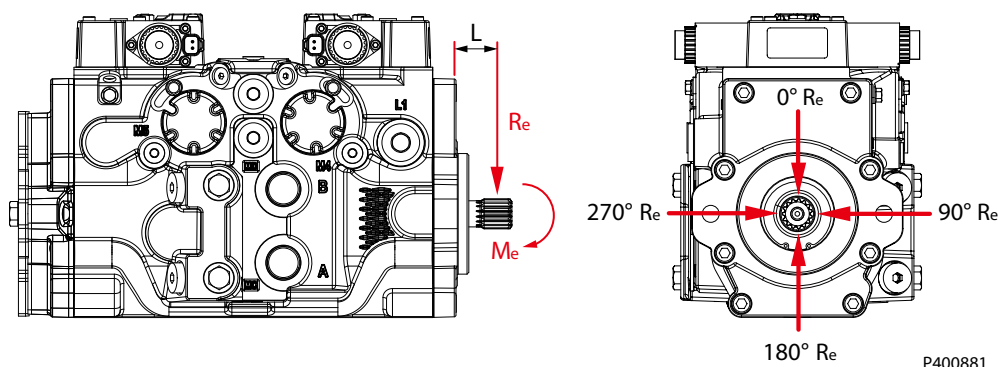
Shaft loading parameters:
M_e = shaft moment
L = flange distance
R_e = external force to the shaft

Thrust loads should be avoided. Contact factory in the event thrust loads are anticipated.

System design parameters

Hydraulic unit life

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

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

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

Mounting flange loads

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

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

$M_S = G_S (W_1L_1 + W_2L_2 + ... + W_nL_n)$

$M_C = G_C (W_1L_1 + W_2L_2 + ... + W_nL_n)$

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	1441 [12750]	3413 [30200]

System design parameters

Shaft loading parameters

P400882
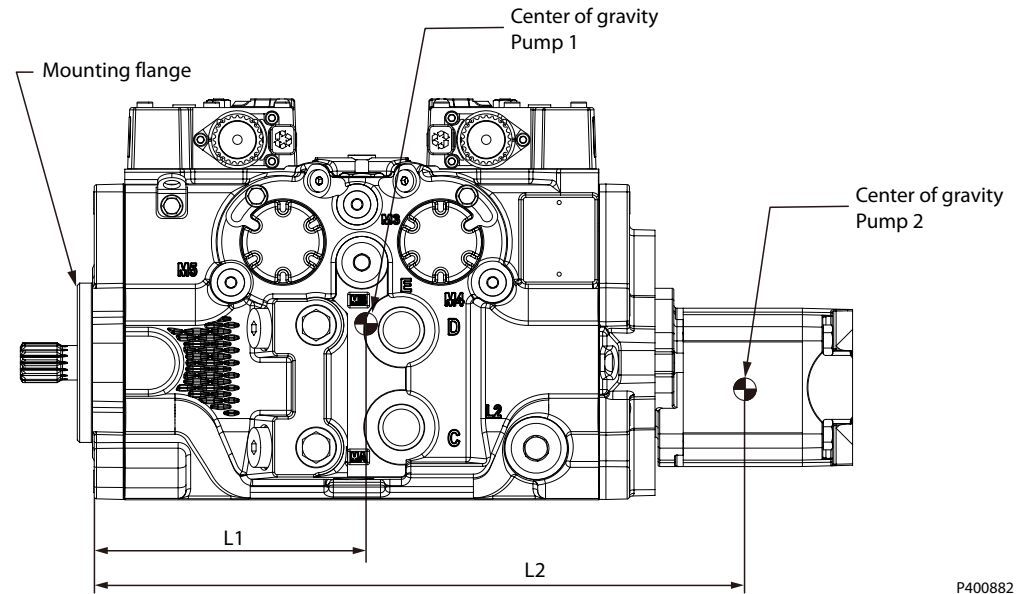
This illustration shows MP1 tandem pump with a gear pump.

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.

Typical G loads for sample applications

Application	Continuous (vibratory) acceleration (G_c)	Maximum (shock) acceleration (G_s)
Skid steer loader	4	10
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

Use these data for a rough estimation in the absence of specific data.

* 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.

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_{e2} for the second pump

M_{e3} for the next pump
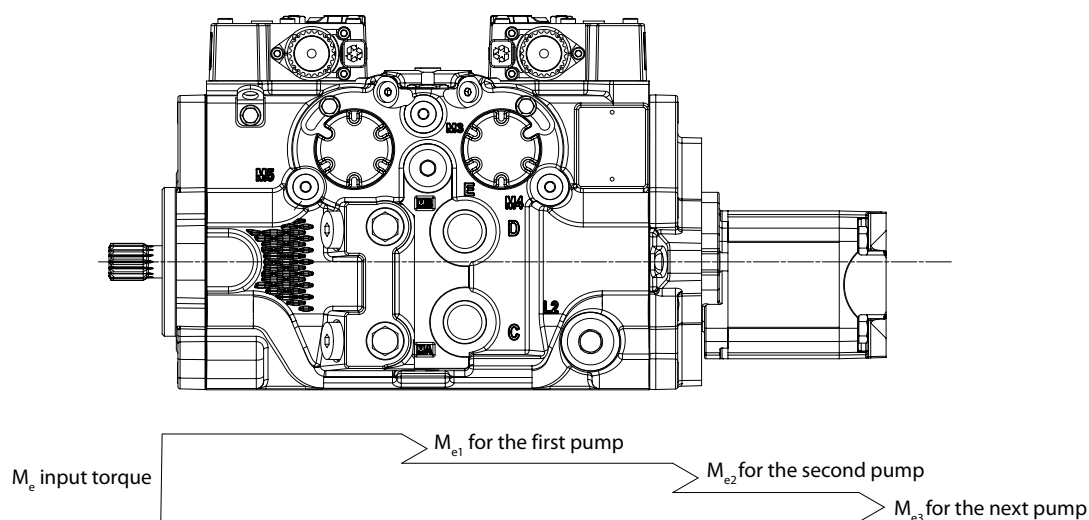
P400883

⚠️ **Attention**

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

System design parameters

Center section coupling, torque rating

Torque rating for center section coupling

Center coupling

P400884
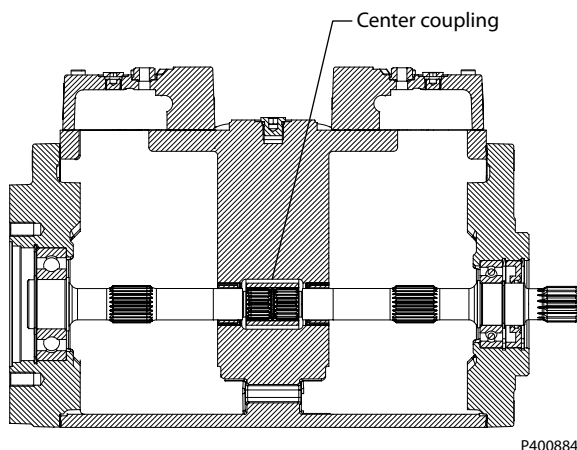
Maximum torque for center coupling

Model	Max. torque
028/032	265 N·m [2195 lbf·in]

Understanding and minimizing system noise

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

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

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

System lines and pump mounting can amplify pump noise.

Follow these suggestions to help minimize noise in your application:

• Use flexible hoses.

• Limit system line length.

• If possible, optimize system line position to minimize noise.

• 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*, **BC157786484430**, for a more complete description of hydrostatic drive line sizing.

Model code

Model code (A - B - C)

| Prod | A | B | C | D | F | E | H | J | K | M | N | P | R | U | L | S | T | V | G | W | X | Y |

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)

B - product version and unit

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

C - second pump kit size

Code	Description
N	Frame size of rear stage equal front stage (default)
A	Rear stage kit 28cc/rev (only use with 32cc/rev front stage)
B	Rear stage kit 32cc/rev (only use with 28cc/rev front stage)

Model code

Model code (D)

| Prod | A | B | C | D | F | E | H | J | K | M | N | P | R | U | L | S | T | V | G | W | X | Y |

MP1 T ☐☐☐☐ ▨▨ ☐☐ ☐☐ ☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐ ☐☐ ☐ ☐ ☐ ☐ ☐☐ ☐☐☐ ☐☐

D - controls

Code	Control type	Voltage	Options	Port	Connector
SA2	**EDC** Electric displacement control	12V	—	Inch	DEUTSCH
SA3		24V	—	Inch	DEUTSCH
SA4		12V	Manual override	Inch	DEUTSCH
SA5		24V	Manual override	Inch	DEUTSCH
SH2		12V	Angle Sensor	Inch	DEUTSCH
SH3		24V	Angle Sensor	Inch	DEUTSCH
SH6		12V	Angle Sensor, Manual override	Inch	DEUTSCH
SH7		24V	Angle Sensor, Manual override	Inch	DEUTSCH
SM1	**MDC** Manual displacement control	-	Standard	Inch	—
SD9		-	Neutral Start Switch (front unit only)	Inch	DEUTSCH
SA9	**FNR** Forward-neutral-reverse	12V	Manual override	Inch	DEUTSCH
SB1		24V	Manual override	Inch	DEUTSCH
SN1	**NFPE** Non-feedback proportional electric	12V	Manual override	Inch	DEUTSCH
SN2		24V	Manual override	Inch	DEUTSCH
NN5		12V	Angle Sensor, Manual override	Inch	DEUTSCH
NN6		24V	Angle Sensor, Manual override	Inch	DEUTSCH
SNN	**NFPH** Non-feedback proportional hydraulic	—	—	Inch	—

Model code

Model code (F - E)

| Prod | A | B | C | D | F | E | H | J | K | M | N | P | R | U | L | S | T | V | G | W | X | Y |

F - orifices

Code	Orifice			Controls: (X marks compatible use)			
	Tank (A+B)	P	A / B	EDC, FNR	MDC	NFPE	NFPH
C3	No orifice			X	X		
C1			0.8 mm	X	X	X	X
C2			1.3 mm	X	X	X	X
C4			1.0 mm	X	X	X	X
C6	1.0 mm				X		
C7	1.3 mm				X		
C8	0.6 mm	0.8 mm			X		
C9	0.6 mm	1.0 mm			X		
D1	0.8 mm	1.0 mm			X		
D2	0.8 mm	1.3 mm			X		
D3	1.0 mm	1.3 mm			X		
D4	1.0 mm	1.3 mm	1.3 mm		X		
D5	0.6 mm	0.6 mm	0.8 mm		X		

E - displacement limiter

Code	Description
N	No limiters
B	Adjustable externally
C	No limiters, required for FNR, NFPE, NFPH (align with option D: control)
D	Adjustable externally, required for FNR, NFPE, NFPH (align with option D: control)

Model code

Model code (H - J - K)

Prod	A	B	C	D	F	E	H	J	K	M	N	P	R	U	L	S	T	V	G	W	X	Y
MP1T																						

H - mounting flange

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

J - input shaft

Code	Description
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)

K - Auxiliary pad

Code	Description
E16	SAE A 9 tooth (w/shipping cover), inch
E19	SAE A 11 tooth (w/shipping cover), inch
E22	SAE B 13 tooth (w/shipping cover), inch
E17	SAE A 9 tooth (w/ running cover), inch

Model code

Model code (M - N - P - R)

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

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]

P - high pressure relief setting side "C" & *R* - high pressure relief setting side "D"

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]

Model code

Model code (U - L - S - T)

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

U - control cut off (CCO)

Code	Description
N	None
A	Control Cut Off, 12 V
B	Control Cut Off, 24 V

L - loop flushing

Code	Description
N	No loop flushing valve
B	Loop flushing setting 1 (6 lpm @ 20bar)

S - charge pump

Code	Description
N	No charge pump

T - filtration

Code	Description
E	External charge flow filtration

Model code

Model code (V - G - W)

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

V – charge pressure relief setting

Code	Description	
20	20 bar [290 psi]	Not to be used for NFPE or NFPH controls.
22	22 bar [319 psi]	NFPE is 24 bar or higher; NFPH is 26 bar or higher
24	24 bar [348 psi]	
26	26 bar [377 psi]	
28	28 bar [406 psi]	
30	30 bar [435 psi]	

G - system port type

Code	Description
A1	Inch O-ring boss per ISO 11926-1
A3	Inch O-ring boss per ISO 11926-1 with integral loop flush valve
A4	Inch O-ring boss per ISO 11926-1 with speed sensor
A5	Inch O-ring boss per ISO 11926-1 with integral loop flush and speed sensor
AA	Inch O-ring boss per ISO 11926-1 with control cut off valve
AC	Inch O-ring boss per ISO 11926-1 with integral loop flush and control cut off valve
AD	Inch O-ring boss per ISO 11926-1 with speed sensor and control cut off valve
AE	Inch O-ring boss per ISO 11926-1 with integral loop flush, speed sensor and control cut off valve

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
RBC	NFPE/NFPH valve plate, CW, 28cm^3
LBC	NFPE/NFPH valve plate, CCW, 28cm^3
RBD	NFPE/NFPH valve plate, CW, 32cm^3
LBD	NFPE/NFPH valve plate, CCW, 32cm^3

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

Model code

Model code (X - Y)

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

X - paint and name tag

Code	Description
NNN	Black paint, standard name tag
C08	None paint, standard name tag

Y - settings

Code	Description
NNNN	None
ENNN	Displacement limitation side A full, side B full
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%
M00A	MDC control handle, standard orientation
MNNN	Displacement limitation side A full, side B full, MDC handle, standard orientation
M095	Displacement limitation side A 95%, side B 95%, MDC handle, standard orientation
M090	Displacement limitation side A 90%, side B 90%, MDC handle, standard orientation
M085	Displacement limitation side A 85%, side B 85%, MDC handle, standard orientation (28cc only)

Installation drawings

28/32 ports
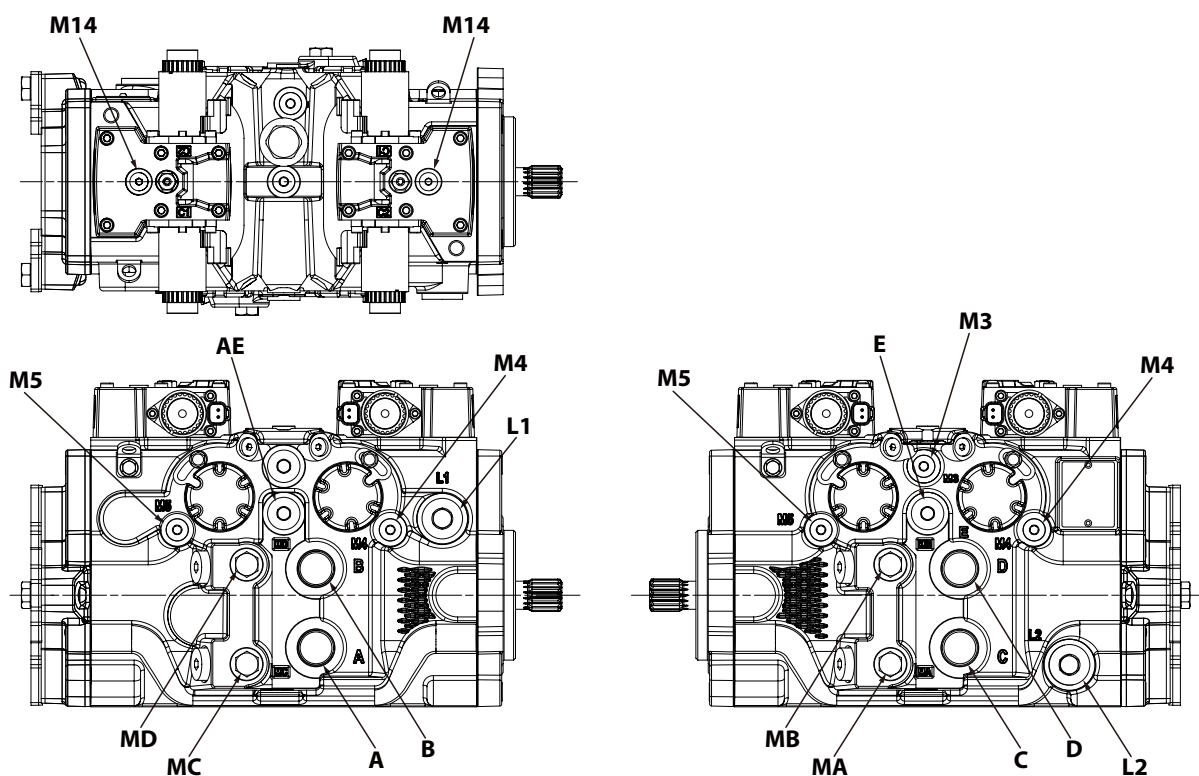
P400885

(NFPH Control)
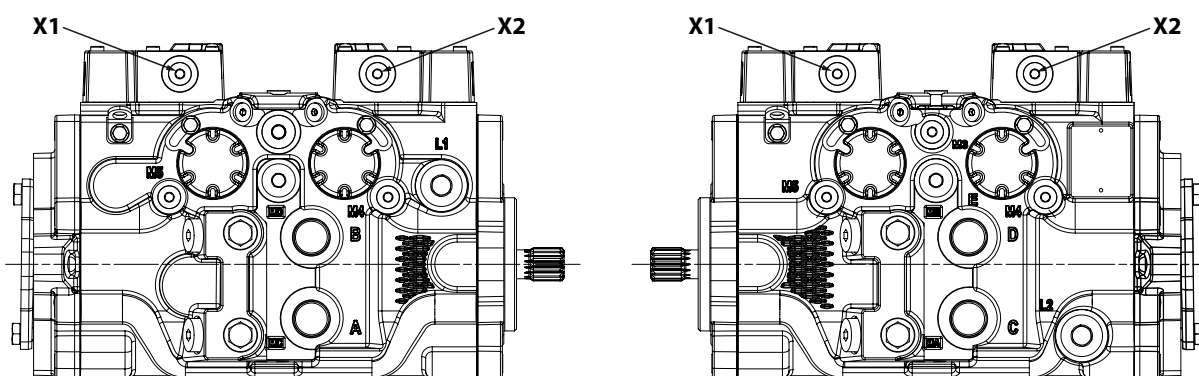
P400886

Installation drawings

Port description

Port	Description	Size	Code
A, B, C, D	System ports	1 1/16-12	
MA, MB, MC, MD	System gauge port	9/16-18	
E	Charge filtration inlet port from filter	7/8-14	
AE	Alternative filtration inlet port	7/8-14	
L1, L2	Case drain ports	1 1/16-12	Inch ISO 11926-1
M3	Charge gauge port	9/16-18	
M4, M5	Servo gauge ports	9/16-18	
M14	Case gauge ports (Air bleed)	7/16-20	
X1, X2 (NFPH control only)	Hydraulic control input	9/16-18	

Installation drawings

28/32 dimensions

P400887

Please contact Danfoss representative for specific installation drawings.

Installation drawings
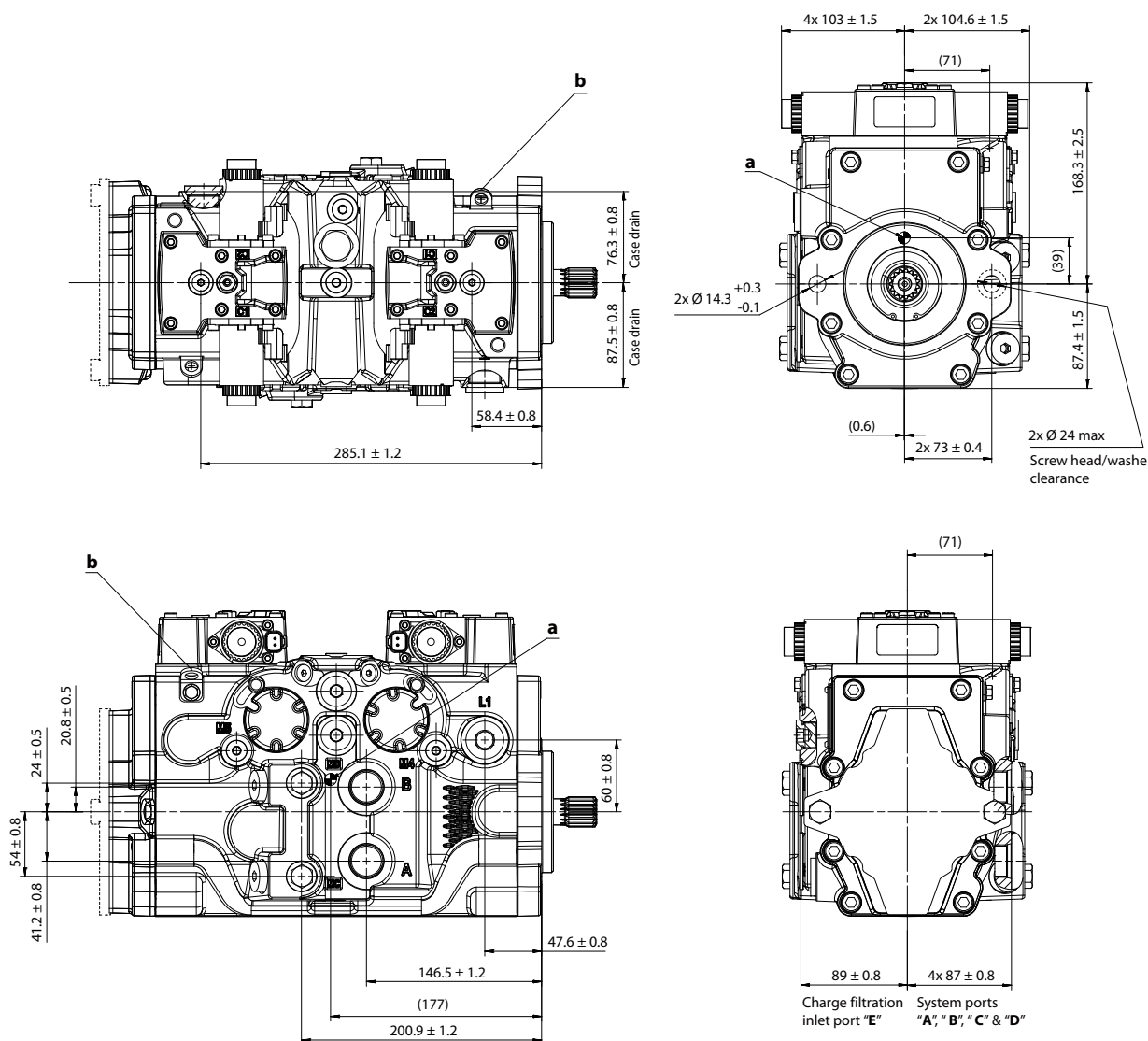
P400888

Notes in the drawing:

a - Approximate center of gravity

b - Lifting bracket holes

Please contact Danfoss representative for specific installation drawings.

Installation drawings

28/32 dimensions with speed sensor

88 ± 0.8
112 ± 1.5
36 ± 0.8
280 ± 1.5

Speed sensor connector
DEUTSCH DTM4-6P
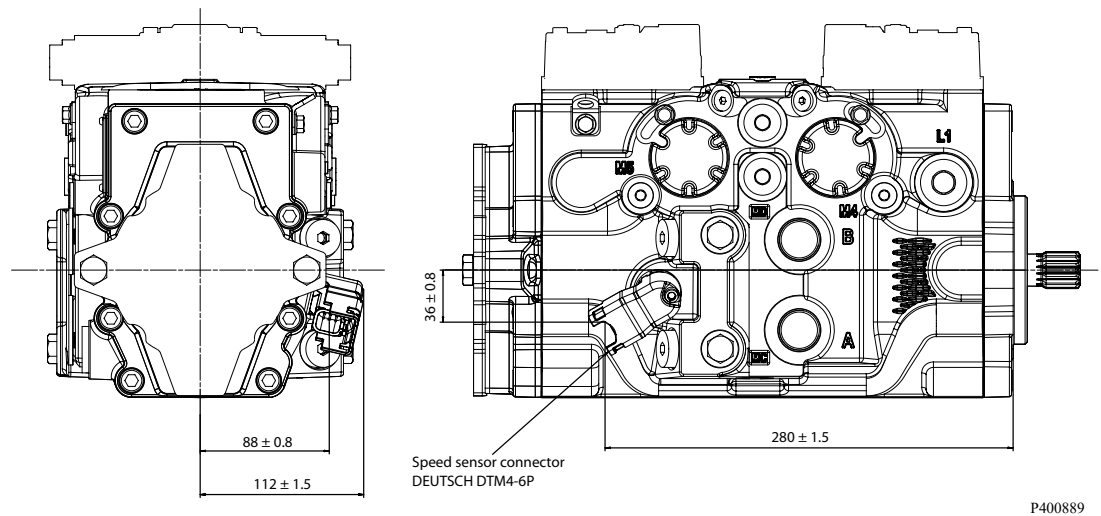
P400889

Please contact Danfoss representative for specific installation drawings.

Speed sensor connector

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

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: 28/32: ANSI B92.1-1970 Class 5

Ø62
Ø22 ± 0.13
Ø25.34 ± 0.06
Paint free
39.25
Mounting flange
Flange 101-2
Per ISO 3019-1 (SAE B)
6.75 ± 1
Mating coupling must not protrude beyond this point
" A "
P400890
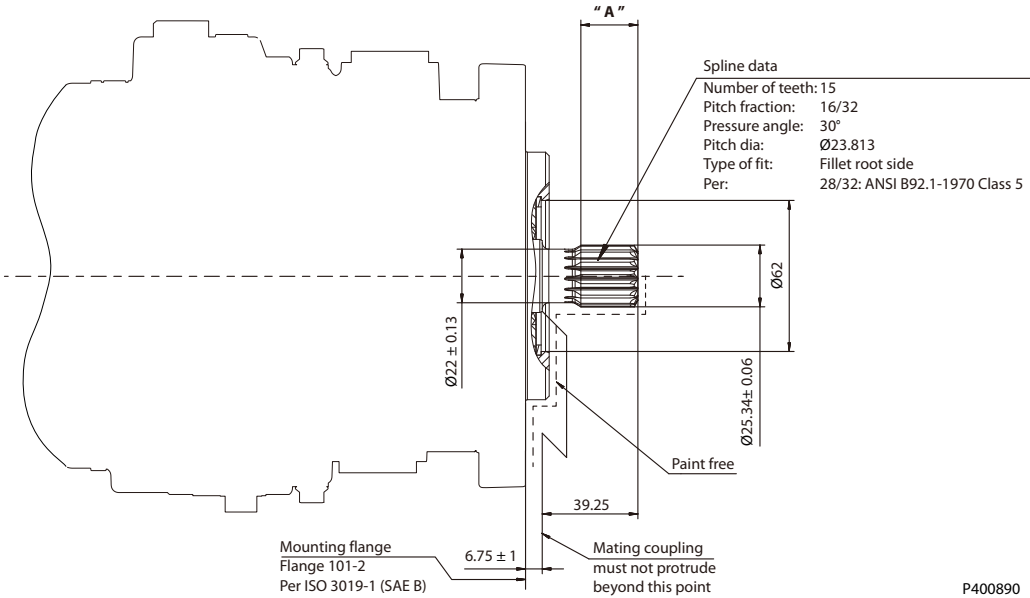
Min. active spline length[1]	28/32
A	23.4 ± 0.5

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

Specifications

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

Please contact Danfoss representative for specific installation drawings.

Installation drawings

Auxiliary mounting: option E16, E17 (SAE A, 9 teeth)

Option E16, ISO 3019-1, flange 82-2 (SAE A, 9 teeth)
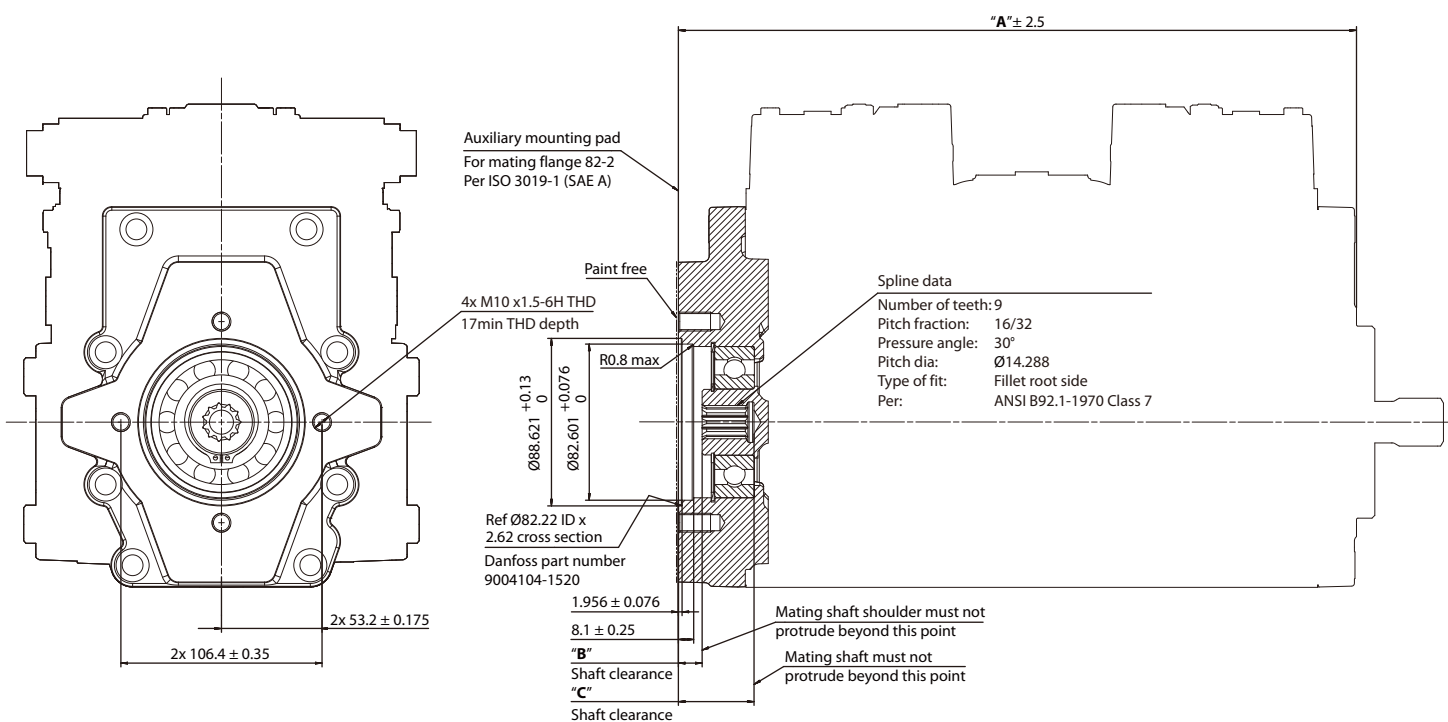
P400891

Location	28/32
A	358.7
B	11.8 min shaft clearance
C	39.0 min shaft clearance

Specifications

Option	E16, E17
Spline	9 teeth, 16/32 pitch
Maximum torque	107 N•m

Installation drawings

Auxiliary mounting: option E19 (SAE A, 11 teeth)

Option E19, ISO 3019-1, flange 82-2 (SAE A, 11 teeth)
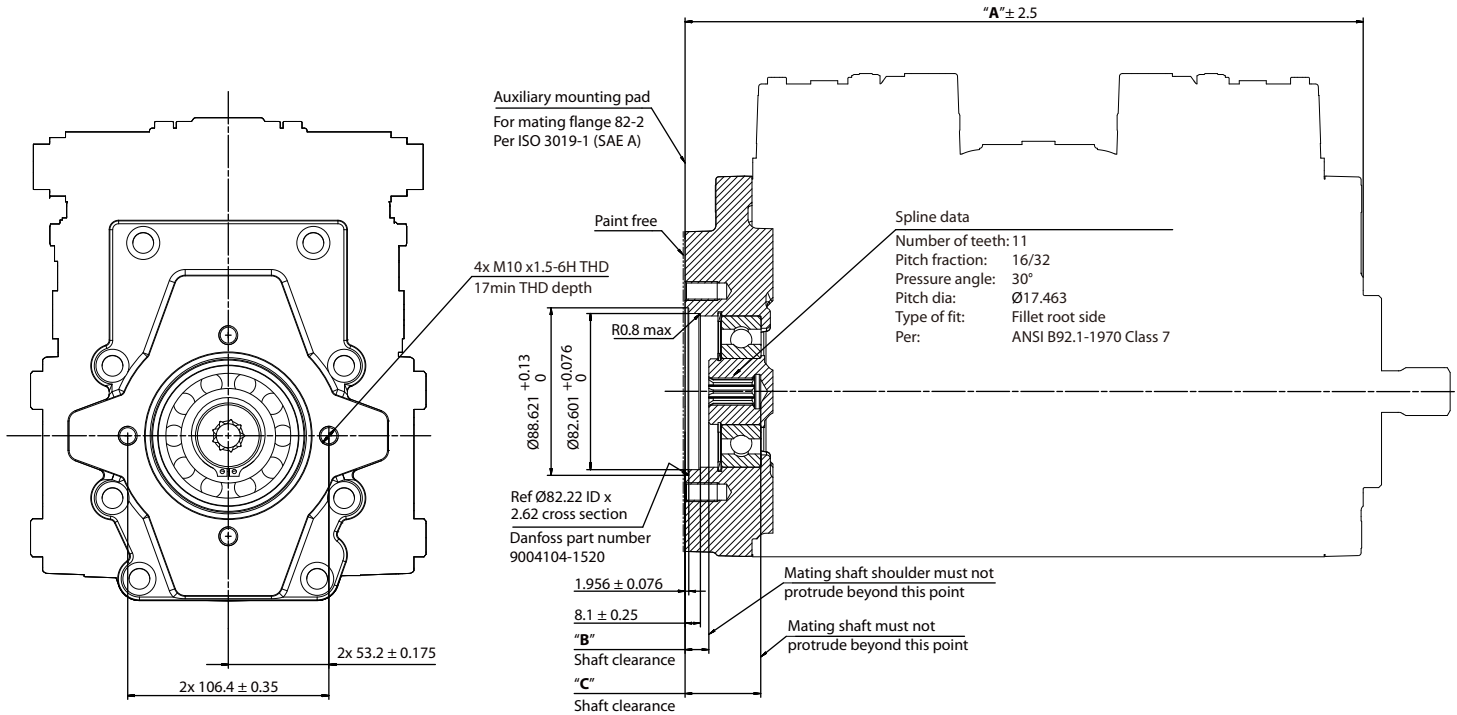
P400892

Location	28/32
A	358.7
B	11.8 min shaft clearance
C	39.0 min shaft clearance

Specifications

Option	E19
Spline	11 teeth, 16/32 pitch
Maximum torque	147 N•m

Installation drawings

Auxiliary mounting: option E22 (SAE B, 13 teeth)

Option E22 ISO 3019-1, flange 101-2 (SAE B, 13 teeth)

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

Paint free

4x M12 x1.75-6H THD
22min THD depth

R0.8 max

$\varnothing 107.823 \,^{+0.13}_{0}$
$\varnothing 101.651 \,^{+0.076}_{0}$

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

Ref Ø94.92 ID x
2.62 cross section
Danfoss part number
9004104-1540

Mating shaft shoulder must not
protrude beyond this point

Mating shaft must not
protrude beyond this point

1.956 ± 0.076
11.4 ± 0.25
"**B**"
Shaft clearance
"**C**"
Shaft clearance

2x 73 ± 0.175
2x 146 ± 0.35

"**A**" ± 2.5

P400893

Location	28/32
A	361.7
B	14.8 min shaft clearance
C	42.0 min shaft clearance

Specifications

Option	E22
Spline	13 teeth, 16/32 pitch
Maximum torque	248 N•m

Controls

Electric displacement control (EDC)
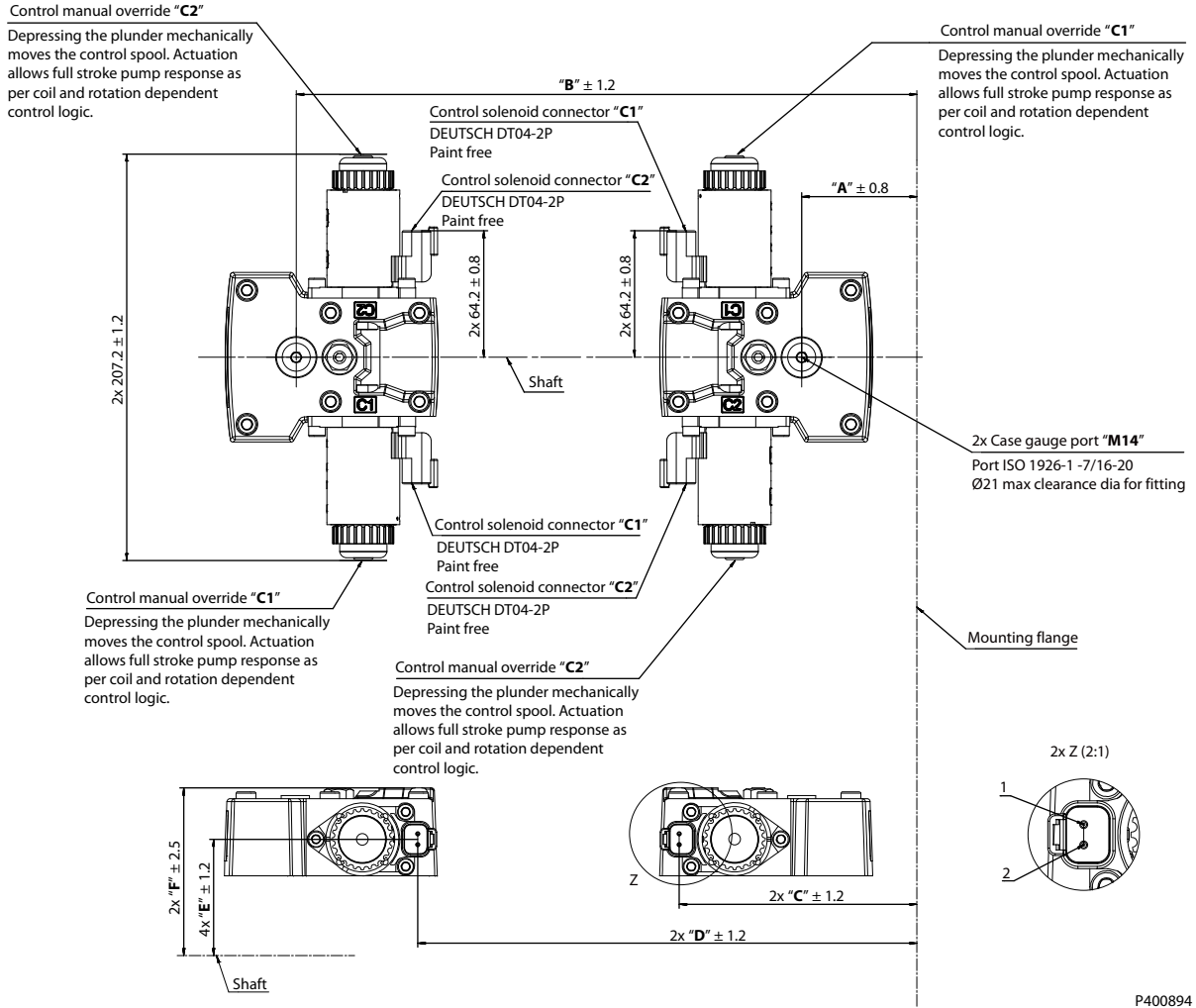
P400894

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

Location	28/32
A	58.4
B	285.1
C	120.5
D	223
E	142.3
F	168.3

Please contact Danfoss representative for specific installation drawings.

Controls

EDC with Angle sensor
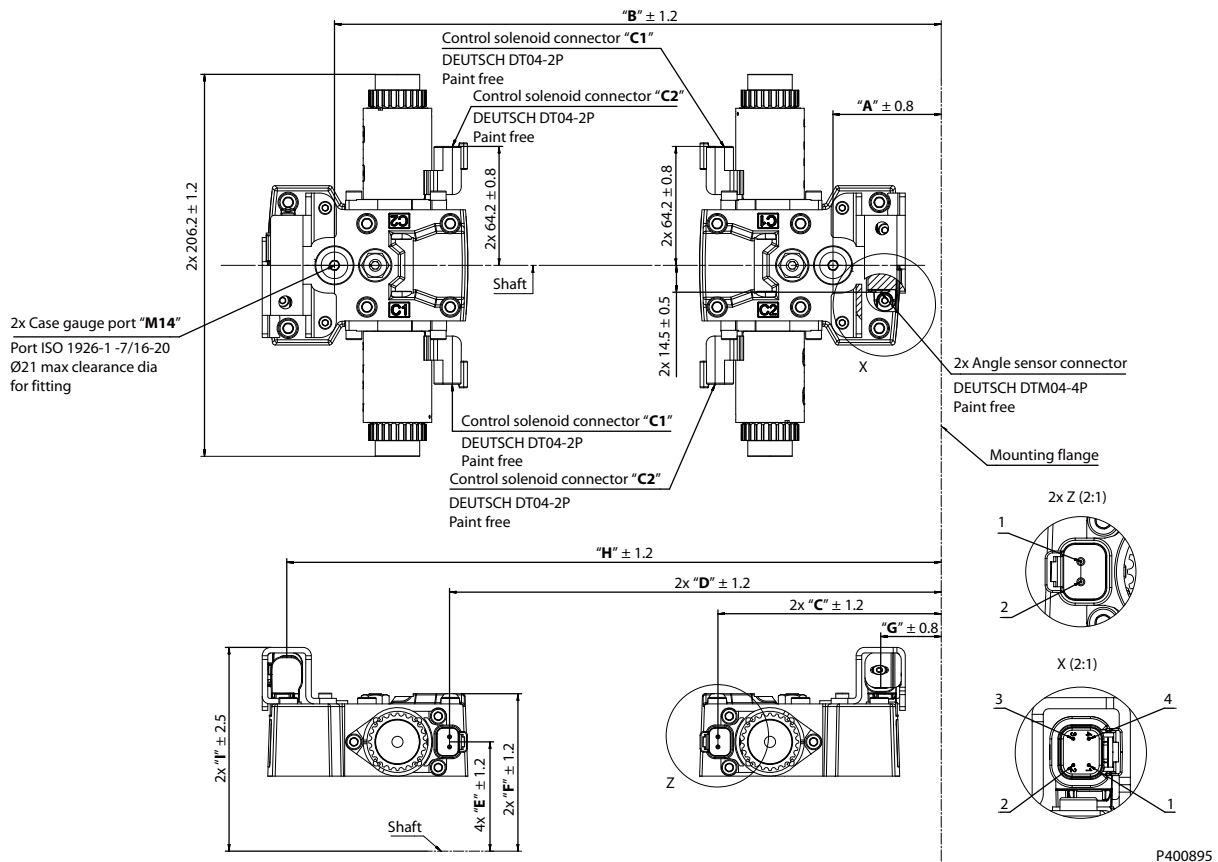
Control solenoid connector "C1" & "C2"				
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Angle sensor connector pinout

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

Dimensions

Reference	28/32	Reference	28/32	Reference	28/32
A	58.4	D	223	G	32.7
B	285.1	E	142.3	H	310.8
C	120.5	F	168.3	I	193.3

Please contact Danfoss representative for specific installation drawings.

Controls

Manual displacement control (MDC)
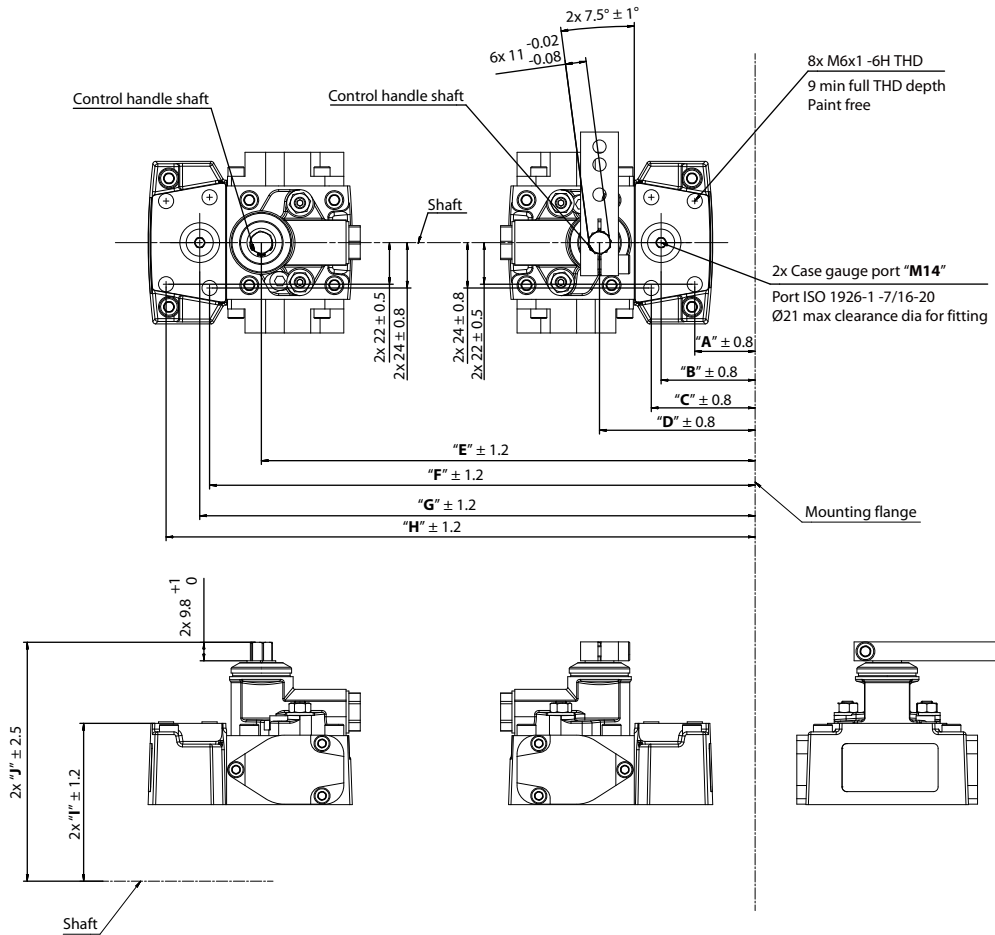
P400896

Location	28/32
A	31.9
B	49.7
C	54.9
D	82.3
E	261.2
F	288.6
G	293.6
H	311.6
I	166.8
J	209.7

Please contact Danfoss representative for specific installation drawings.

Controls

MDC with neutral start switch option: SD9

P400897
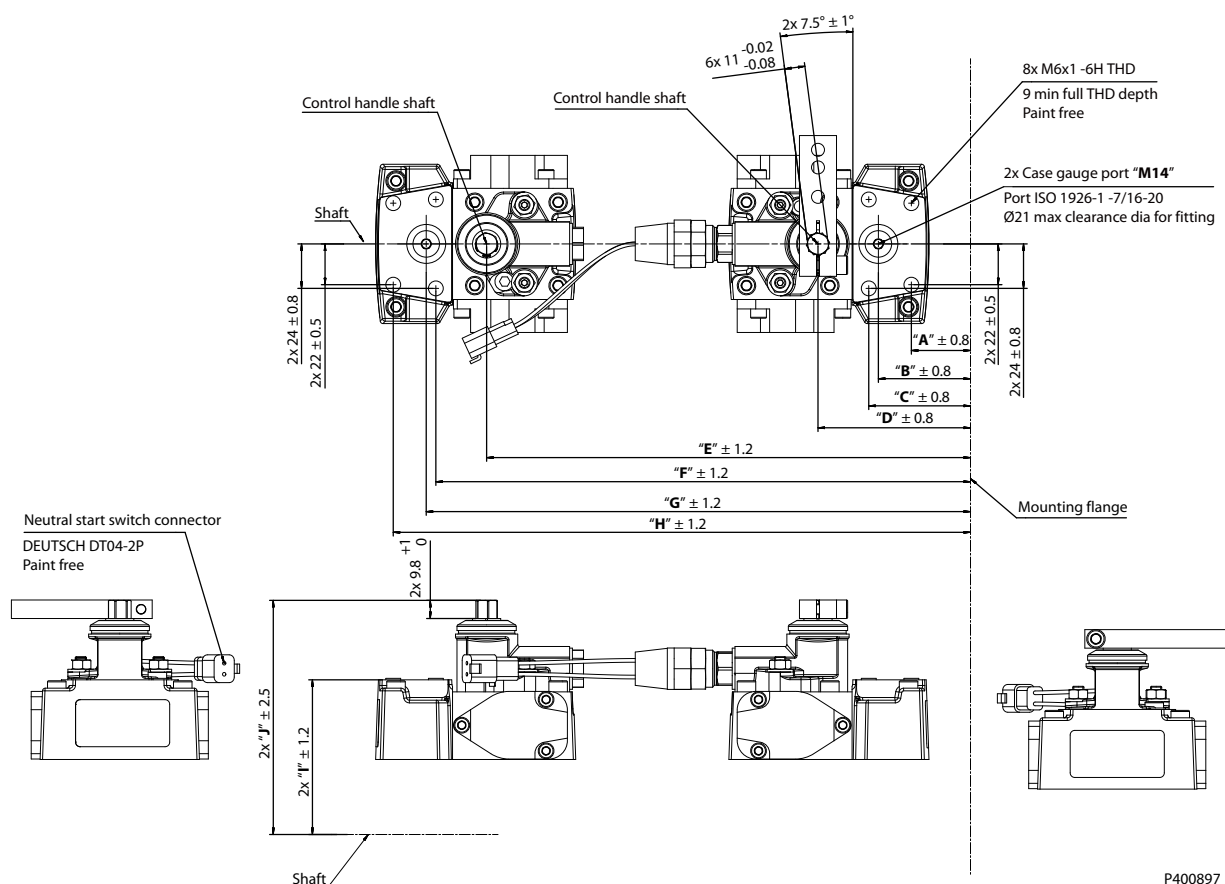
Neutral start switch connector

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

Dimension	28/32
A	31.9
B	49.7
C	54.9
D	82.3
E	261.2
F	288.6
G	293.8
H	311.6
I	166.8
J	209.7

Please contact Danfoss representative for specific installation drawings.

Controls

Forward-neutral-reverse (FNR)

Control Manual Override "**C2**"

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

Control Solenoid Connector "**C1**"

Deutsch DT04-2P
Paint free

Control Solenoid Connector "**C2**"

Deutsch DT04-2P
Paint free

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.

"**B**" ± 1.2

"**A**" ± 0.8

Shaft

2x 207.2 ± 1.2

2x 64.2 ± 0.8

2x 64.2 ± 0.8

2x Case gauge port "**M14**"

Port ISO 1926-1 -7/16-20
Ø21 max clearance dia for fitting

Mounting flange

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.

Control Solenoid Connector "**C2**"

Deutsch DT04-2P
Paint free

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.

2x "**D**" ± 1.2

2x "**C**" ± 1.2

Shaft

4x "**E**" ± 1.2

2x "**F**" ± 2.5

Z

Z (2:1)
2x

1

2

P400898

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

Dimension	28/32
A	58.4
B	285.1
C	120.5
D	223
E	142.3
F	168.3

Please contact Danfoss representative for specific installation drawings.

Controls

Non-feedback proportional electric (NFPE)

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

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

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.

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

2x Case gauge port "**M14**"
Port ISO 1926-1 -7/16-20
Ø21 max clearance dia for fitting

Mounting flange

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

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.

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 respose as per coil and rotation dependent control logic.

Shaft

Shaft

P400899

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

Dimension	28/32
A	58.4
B	285.1
C	120.5
D	223
E	142.3
F	168.3

Please contact Danfoss representative for specific installation drawings.

Controls

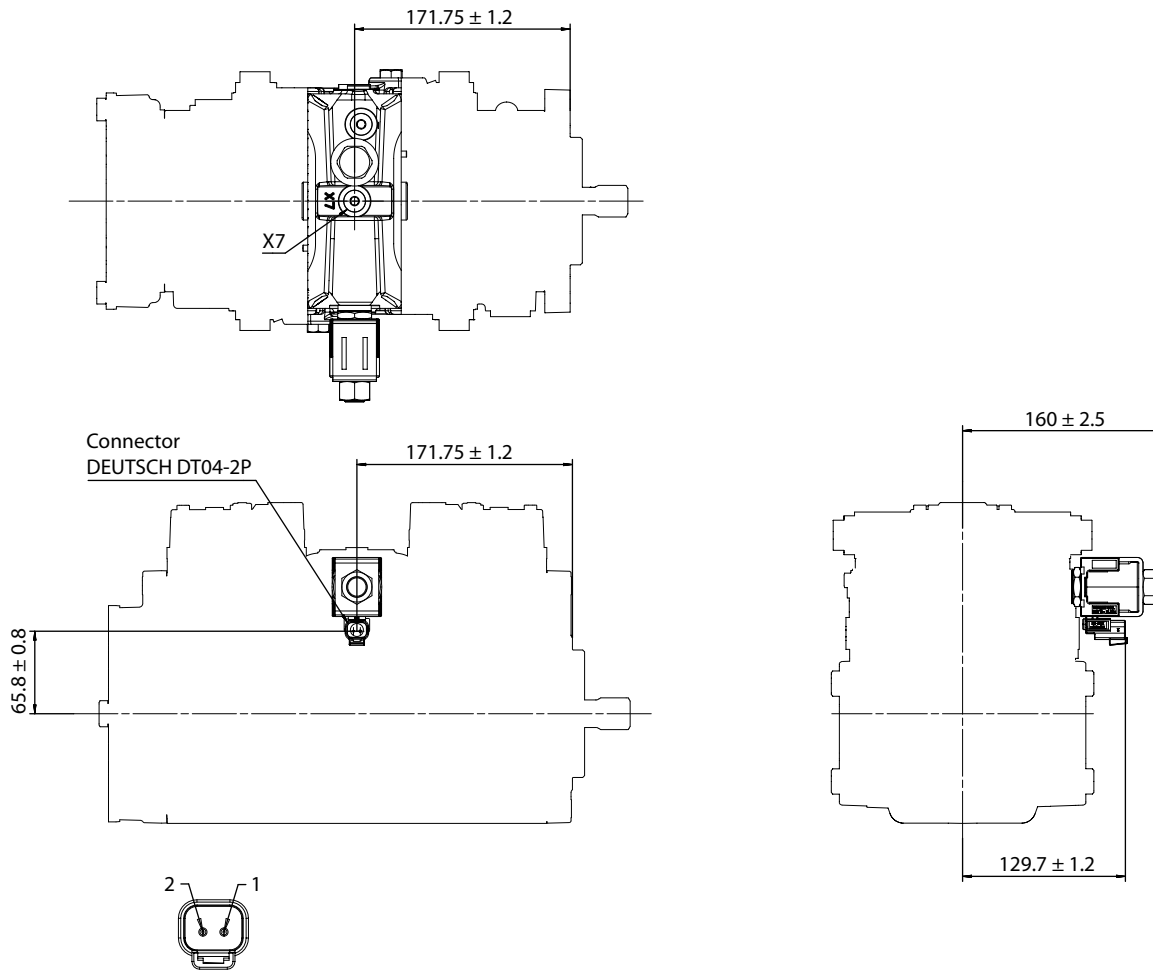### MP1T Non-feedback proportional hydraulic (NFPH)
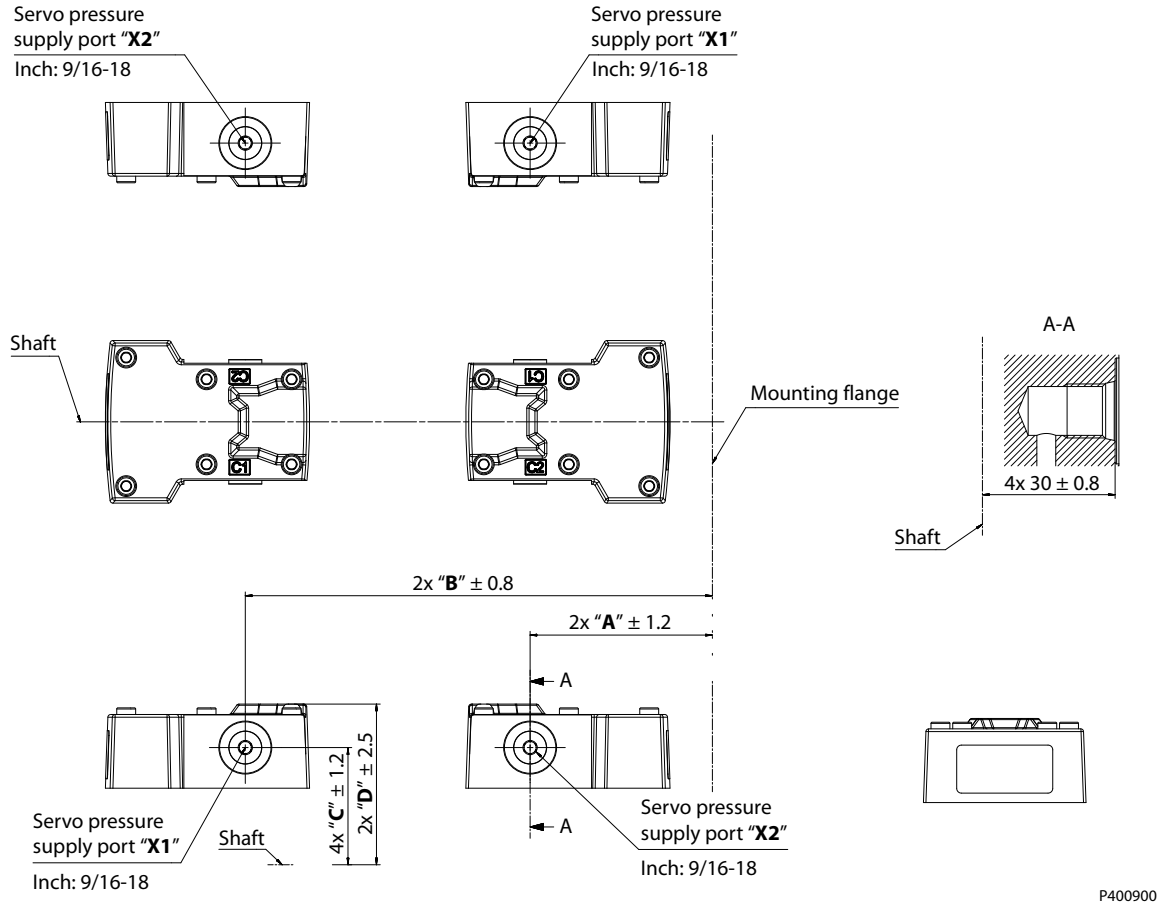
P400900

Dimension	28/32
A	96.4
B	247.1
C	145.3
D	168.3

Controls

Control-cut-off valve (CCO)

P400901

Control Cut off connector					
Pin	Assignment	OR	Pin	Assignment
1	Supply		1	Ground
2	Ground		2	Supply

Port description

Ports	Description	Size	Code
X7	Brake release port	9/16-18	Inch ISO 11926-1

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