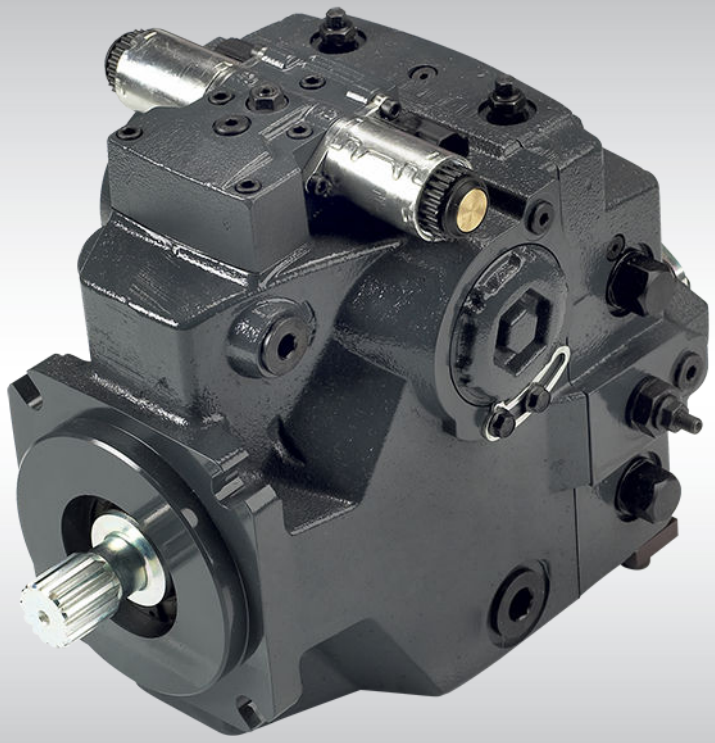
MAKING MODERN LIVING POSSIBLE

Technical Information

H1 Axial Piston Single Pumps

Size 069/078



Revision history

Table of revisions

Date	Changed	Rev
September 2014	MDC, CCO, and Swash Angle Sensor options added	GA
March 2014	Converted to Danfoss layout - DITA CMS	FA
April 2013	FDC option added	EA
Feb 2013	AC section added	DA
Dec 2012	Size 69 added	CA
Jun 2010	New EC directive	BA
Jul 2009	First edition	AA

Contents

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Technical specifications

For definitions of the following specifications, see *Basic Information* **11062168**, *Operating parameters*.

H1P general specifications

Design	Axial piston pump of cradle swashplate design with variable displacement
Direction of rotation	Clockwise, counterclockwise
Pipe connections	*Main pressure ports:* ISO split flange boss *Remaining ports:* SAE straight thread O-ring boss
Recommended installation position	Pump installation position is discretionary, however the recommended control position is on the top or at the side with the top position preferred. If the pump is installed with the control at the bottom, flushing flow must be provided through port M14 located on the EDC, FNR and NFPE control. Vertical input shaft installation is acceptable. If input shaft is at the top 1 bar case pressure must be maintained during operation. The housing must always be filled with hydraulic fluid. Recommended mounting for a multiple pump stack is to arrange the highest power flow towards the input source. Consult Danfoss for nonconformance to these guidelines.
Auxiliary cavity pressure	Will be inlet pressure with internal charge pump. For reference see operating parameters on next page. Will be case pressure with external charge supply. Please verify mating pump shaft seal capability.

Technical data H1P 069/078

Feature	Size 069	Size 078
Displacement	69.2 cm^3 [4.22 in^3]	78.1 cm^3 [4.77 in^3]
Flow at rated (continuous) speed	243 l/min [53.5 US gal/min]	273 l/min [72 US gal/min]
Torque at maximum displacement (theoretical)	1.1 N•m/bar [672 lbf•in/1000 psi]	1.24 N•m/bar [758 lbf•in/1000 psi]
Mass moment of inertia of rotating components	0.0077 kg•m^2 [0.0057 slug•ft^2]	0.0094 kg•m^2 [0.00693 slug•ft^2]
Mass [weight] dry	56 kg [123 lb] (without charge pump or auxiliary mounting flange)	
Oil volume	2 l [0.5 US gal]	
Mounting flange	ISO 3019-1 flange 127-4 (SAE C)	
Input shaft outer diameter, splines and tapered shafts	ISO 3019-1, outer Ø 32 mm - 4 (SAE C, 14 teeth) ISO 3019-1, outer Ø 35 mm - 4 (SAE C, 21 teeth) ISO 3019-1, outer Ø 38 mm - 4 (SAE C-C, 23 teeth) Conical keyed shaft end similar to ISO 3019-1 code 38-3, taper 1:8	
Auxiliary mounting flange with metric fasteners, Shaft outer diameter and splines	ISO 3019-1, flange 82 - 2, outer Ø 16 mm - 4 (SAE A, 9 teeth) ISO 3019-1, flange 82 - 2, outer Ø 19 mm - 4 (SAE A, 11 teeth) ISO 3019-1, flange 101 - 2, outer Ø 22 mm - 4 (SAE B, 13 teeth) ISO 3019-1, flange 101 - 2, outer Ø 25 mm - 4 (SAE B-B, 15 teeth) ISO 3019-1, flange 127 - 4, outer Ø 32 mm - 4 (SAE C, 14 teeth)	
Suction port	Port ISO 11926-1 – 1 $^5/_8$ -12 (SAE O-ring boss)	
Main port configuration	Ø25.4 - 450 bar split flange boss per ISO 6162, M12x1.75	
Case drain ports L2, L4	Port ISO 11926-1 – 1 $^1/_{16}$ -12 (SAE O-ring boss)	
Other ports	SAE O-ring boss	
Customer interface threads	Metric fasteners	

Technical specifications

Operating parameters H1P 069/078

Feature		Size 069/078
Input speed (at minimum charge/ control pressure)	**Minimum for internal charge supply.[1)]**	500 min^{-1} (rpm)
	Minimum for external charge supply.[2)]	500 min^{-1} (rpm)
	Minimum for full performance for internal charge supply.	1200 min^{-1} (rpm)
	Rated	3500 min^{-1} (rpm)
	Maximum	4000 min^{-1} (rpm)
System pressure	**Maximum working pressure**	450 bar [6528 psi]
	Maximum pressure	480 bar [6960 psi]
	Maximum low loop	45 bar [650 psi]
	Minimum low loop pressure	10 bar [145 psi]
Charge pressure	**Minimum**	16 bar [232 psi]
	Maximum	35 bar [508 psi]
Control pressure	**Minimum (at corner power for EDC, MDC and FNR)**	14 bar [203 psi]
	Minimum (at corner power for NFPE)	22 bar [319 psi]
	Maximum	40 bar [580 psi]
Charge pump inlet pressure	**Rated**	0.7 bar (absolute) [9 in Hg vacuum]
	Minimum (cold start)	0.2 bar (absolute) [24 in Hg vacuum]
	Maximum	4 bar [58 psi]
Case pressure	**Rated**	3 bar [44 psi]
	Maximum	5 bar [73 psi]
Lip seal external maximum pressure		0.4 [5.8 psi]

[1)] Performance (pressure and displacement) may be limited due to limited control pressure.

[2)] Full performance (pressure and displacement) possible at minimum charge and control pressure supply.

Fluid specifications H1P

Viscosity	Intermittent[1)]	5 mm^2/s [42 SUS]
	Minimum	7 mm^2/s [49 SUS]
	Recommended range	12-80 mm^2/s [66-370 SUS]
	Maximum	1600 mm^2/s [7500 SUS]
Temperature range (At the hottest point, normally case drain port)	Minimum[2)] (cold start)	-40°C [-40]
	Recommended range	60-85°C [140-185°F]
	Rated	104°C [220°F]
	Maximum intermittent[1)]	115°C [240°F]
Filtration (recommended minimum)	Cleanliness per ISO 4406	22/18/13
	Efficiency (charge pressure filtration)	$\beta_{15-20} = 75$ ($\beta_{10} \geq 10$)
	Efficiency (suction and return line filtration)	$\beta_{35-45} = 75$ ($\beta_{10} \geq 2$)
	Recommended inlet screen mesh size	100 – 125 µm

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

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

Technical specifications

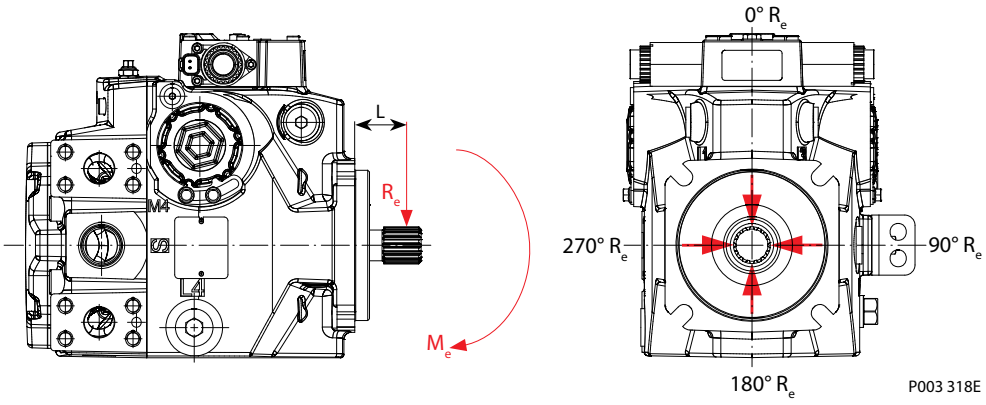
External radial shaft loads

H1 pumps are designed with bearings that can accept some external radial loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit. External radial shaft loads impact lifetime. For lifetime calculations please contact Danfoss representative.

The **maximum allowable radial load (R_e)** is based on the maximum external moment (M_e) and the distance (L) from the mounting flange to the load.

It may be determined using the following formula: $$R_e = \frac{M_e}{L}$$

Radial load position



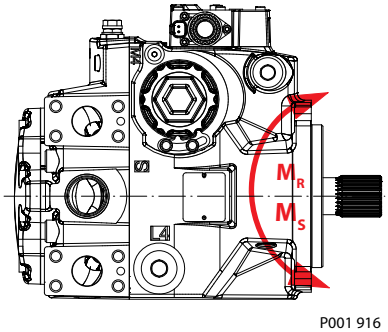
M_e = shaft moment
L = flange distance
R_e = external force to the shaft

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

Mounting flange loads H1P 069/078

The moments shown below apply for top or side control orientation.

Mounting flange loads, Size 069/078



Rated moment:

M_R = 3700 N•m [32 750 lbf•in]

Shock load moment:

M_S = 7900 N•m [69 920 lbf•in]

For calculation details refer to *H1 Axial Piston Pumps, Basic Information* **11062168**, chapter *Mounting flange loads*.

Technical specifications

Bearing life H1P 069/078

Maximum external shaft moment based on shaft deflection (both sizes 069/078):

M_e = 109 N•m [965 lbf•in]

All external shaft loads affect bearing life. In applications with external shaft loads, minimize the impact by positioning the load at 0° or 180° as shown in the figure. Danfoss recommends clamp-type couplings for applications with radial shaft loads.

Contact your Danfoss representative for an evaluation of unit bearing life if you have continuously applied external loads exceeding 25 % of the maximum allowable radial load (R_e) or the pump swashplate is positioned on one side of center all or most of the time.

Charge pump

Charge pump sizing/selection

In most applications a general guideline is that the charge pump displacement should be at least 10 % of the total displacement of all components in the system. Unusual application conditions may require a more detailed review of charge flow requirements. Please refer to *Selection of Drive line Components*, **BLN-9885** for a detailed procedure.

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

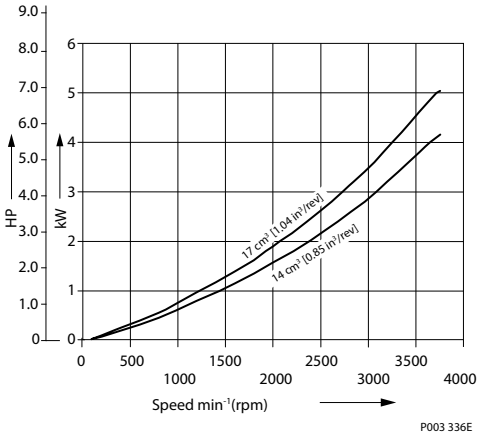
- Continuous operation at low input speeds (< 1500 min^{-1} (rpm))
- High shock loading and/or long loop lines
- High flushing flow requirements
- Multiple low speed high torque motors
- High input shaft speeds

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

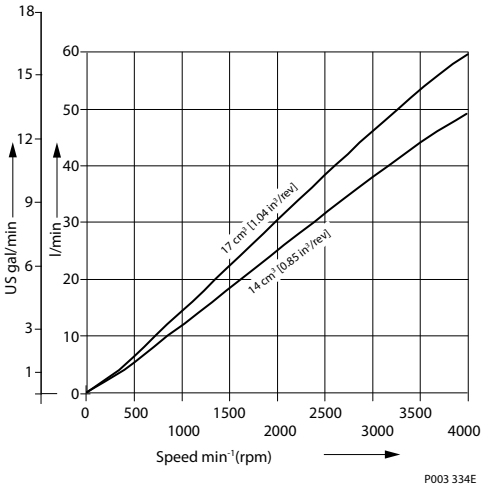
Charge pump flow and power curves, 14/17 cm^3

Charge pressure: 20 bar [290 psi] / *Viscosity:* 11 mm^2/s [63 SUS] / *Temperature:* 80°C [176°F]

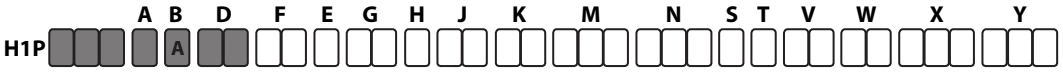
Charge pump power requirements



Charge pump flow



Model code H1P 069/078



Displacement

069	69.2 cm^3 [4.22 in^3]
078	78.1 cm^3 [4.77 in^3]

A – Rotation

L	Left hand (counter clockwise)
R	Right hand (clockwise)

B – Product version A - Revision code

D – Control

A2	Electric Displacement Control **(EDC)** 12V, Deutsch connector
A3	Electric Displacement Control **(EDC)** 24V, Deutsch connector
A4	Electric Displacement Control **(EDC)** 12V, Deutsch connector, Manual override
A5	Electric Displacement Control **(EDC)** 24V, Deutsch connector, Manual override
A9	Forward-Neutral-Reverse **(FNR)** 12V, Deutsch connector, Manual override
B1	Forward-Neutral-Reverse **(FNR)** 24V, Deutsch connector, Manual override
A8	Non Feedback Proportional Electric **(NFPE)** 12V, Deutsch connector, Manual override[1)]
B8	Non Feedback Proportional Electric **(NFPE)** 24V, Deutsch connector, Manual override[1)]
B5	Non Feedback Proportional Electric **(NFPE)** 12V, Deutsch connector, Swash Plate Angle Sensor[1)]
B9	Non Feedback Proportional Electric **(NFPE)** 24V, Deutsch connector, Swash Plate Angle Sensor[1)]
A7	Automotive **(AC-1)**, 12V, Manual Override[2)]
C2	Automotive **(AC-1)**, 24V, Manual Override[2)]
B7	Automotive **(AC-2)**, 12V, with Swash Plate Angle Sensor and Manual Override[2)]
C3	Automotive **(AC-2)**, with Swash Plate Angle Sensor and Manual Override[2)]
F1	Fan Drive Control **(FDC)**, 12V, Deutsch connector[3)]
F2	Fan Drive Control **(FDC)**, 24V, Deutsch connector[3)]
M1	Manual Displacement Control **(MDC)**[4)]
M2	Manual Displacement Control **(MDC)** with Neutral Start Switch, Deutsch Connector[4)]
M3	Manual Displacement Control **(MDC)** with 12V CCO, Deutsch Connector[4)]
M4	Manual Displacement Control **(MDC)** with 24V CCO, Deutsch Connector[4)]
M5	Manual Displacement Control **(MDC)** with 12V CCO and Neutral Start Switch, Deutsch Connector[4)]
M6	Manual Displacement Control **(MDC)** with 24V CCO and Neutral Start Switch, Deutsch Connector[4)]

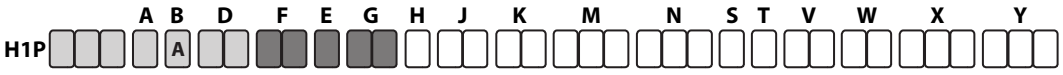
[1)] Align with options: **F:** Displacement Limiters and **W:** Special Hardware.

[2)] Align with options: **F:** Displacement Limiters, **W:** Special Hardware, **Y:** Special settings.

[3)] Align with options: **F:** Orifices, **E:** Displacement Limiters, **N+M:** Overpressure protection type and setting **W:** Special Hardware.

[4)] Align with option: **F:** Orifices.

Model code H1P 069/078



F – Orifices (mm)

Code	Tank (A+B)	P	A	B
C1	–	–	0.8	0.8
C2	–	–	1.3	1.3
D5*	0.6	0.6	0.8	0.8
C8*	0.6	0.8	–	–
C9*	0.6	1	–	–
D1*	0.8	1	–	–
D2*	0.8	1.3	–	–
D3*	1	1.3	–	–
D4*	1	1.3	1.3	1.3
C6*	1	–	–	–
C7*	1.3	–	–	–
C3	No orifice, Not recommended for mobile applications			

* to be used with **MDC** controls only.

E – Displacement limiters

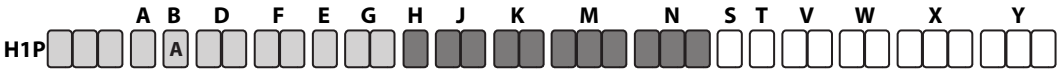
N	None
C	No limiters, with nested springs, required for NFPE[1)]
B	Adjustable externally
D	Adjustable externally with nested springs, required for NFPE[1)]

1) Align with option **Y:** Settings for adjustment (if applicable).

G – Endcap options (Twin port, ISO 6162 Split flange ports)

Match with options: *T: Filtration (below):* and *K: Auxiliary mounting pads:* • **ISO 3019-1, flange 82 - 2 (SAE A, 9 and 11 teeth)** • **ISO 3019-1, flange 101 - 2 (SAE B, 13 teeth)** • **ISO 3019-1, flange 101 - 2 (SAE B-B, 15 teeth) or None**			
Code	Suction filtration	Integral full charge flow filtration	Remote or external charge supply for full charge flow filtration
D3	–	●	–
D6	●	–	–
D8	–	–	●
Match with option *K: Auxiliary mounting pad:* ISO 3019-1, flange 127 - 4 (SAE C, 14 teeth)			
F4	–	●	–
F5	–	–	●
F6	●	–	–

Model code H1P 069/078



H – Mounting

H	ISO 3019-1, flange 127 - 4 (SAE C)
K	ISO 3019-1, flange 127 - 4 (SAE C), 4-bolt and speed sensor

J – Input shaft

G1	ISO 3019-1, outer Ø32 mm - 4 (SAE C, 14 teeth splined shaft 12/24 pitch)
F1	ISO 3019-1, outer Ø35 mm - 4 (SAE C, 21 teeth splined shaft 16/32 pitch)
G9	ISO 3019-1, outer Ø38 mm - 4 (SAE C-C, 23 teeth splined shaft 16/32 pitch
F4	Conical keyed shaft end similar to ISO 3019-1 code 38-3, taper 1:8 (key not supplied with pump)

K – Auxiliary mounting pad (align with option G: Endcap selection)

NN	None	
H2	ISO 3019-1, flange 82 - 2, outer Ø16 mm - 4 (SAE A, 9 teeth 16/32 coupling)	Shipping cover
H1	ISO 3019-1, flange 82 - 2, outer Ø19 mm - 4 (SAE A, 11 teeth 16/32 coupling)	
H3	ISO 3019-1, flange 101 - 2, outer Ø22 mm - 4 (SAE B, 13 teeth 16/32 coupling)	
H5	ISO 3019-1, flange 101 - 2, outer Ø25 mm - 4 (SAE B-B, 15 teeth 16/32 coupling)	
H6	ISO 3019-1, flange 127 - 4, outer Ø32 mm - 4 (SAE C, 14 teeth 12/24 coupling)	

M – Overpressure protection type, side "A" / N – Overpressure protection, side "B"

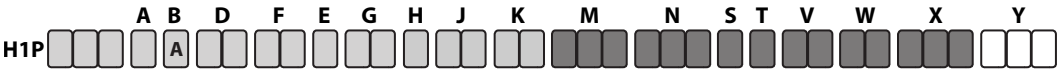
High pressure relief valve with bypass, pressure protection type must be the same for side "A" and "B"		
L[1)]	**K[2)]**	**Pressure setting[3)]**
L15	**K15**	150 bar [2175 psi]
L18	**K18**	180 bar [2610 psi]
L20	**K20**	200 bar [2900 psi]
L23	**K23**	230 bar [3336 psi]
L25	**K25**	250 bar [3630 psi]
L28	**K28**	280 bar [4061 psi]
L30	**K30**	300 bar [4350 psi]
L33	**K33**	330 bar [4786 psi]
L35	**K35**	350 bar [5080 psi]
L38	**K38**	380 bar [5510 psi]
L40	**K40**	400 bar [5800 psi]
L42	**K42**	420 bar [6090 psi]
L45	**K45**	450 bar [6960 psi]

[1)] With pressure limiters

[2)] Without pressure limiters

[3)] Please contact Danfoss for pressures not shown or for applied pressure above max. working pressure (see System pressure in *Operating parameters H1P 069/078* on page 6).

Model code H1P 069/078



M – Overpressure protection type, side "A" / N – Overpressure protection, side "B"

Code	Overpressure protection type and setting for FDC
F01	Pressure setting for FDC, PL: 150 bar [2175 psi]; HPRV: 250 bar [3630 psi]
F02	Pressure setting for FDC, PL: 150 bar [2175 psi]; HPRV: 300 bar [4350 psi]
F03	Pressure setting for FDC, PL: 150 bar [2175 psi]; HPRV: 350 bar [5080 psi]
F04	Pressure setting for FDC, PL: 150 bar [2175 psi]; HPRV: 400 bar [5800 psi]

S – Charge pump

F	14 cm^3/rev [0.85 in^3/rev]
C	17 cm^3/rev [1.03 in^3/rev]
N	No charge pump, external charge supply*

* Align with options: **E** and **T**

T – Filtration (align with option G: Endcap selection)

L	Suction filtration (see *H1P 069/078, suction filtration, option L* on page 64)
M	Integral full charge flow filtration with bypass, bypass sensor, medium filter length, **11004918**
P	Remote full charge flow filtration
E	External charge flow filtration*

* Align with options: **N** and **S**

V – Charge pressure relief setting

20	20 bar [290 psi]
24	24 bar [348 psi]
30	30 bar [435 psi]

W – Special hardware features

PN	None
P1	NFPE valve plate (align with options: **D:** Control selection and **E:** Displacement limiters)

X – Paint and nametag

NNN	Black paint and Danfoss nametag

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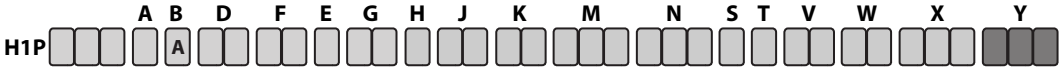


Y – Special settings

Code	Description	Functional option	Control	AC type
D3E	ECO Fuel Saving Mode, CAN J1939 in/out*	E	A7 (12 V_{DC})	AC1
D3F	CAN J1939 in/out*	F		
D3H	SIL2 certifiable, CAN J1939 in/out*	H		
D4E	ECO Fuel Saving Mode, CAN J1939 in/out*	E	C2 (24 V_{DC})	
D4F	CAN J1939 in/out*	F		
D4H	SIL2 certifiable, CAN J1939 in/out*	H		
D5F	CAN J1939 in/out*	F	B7 (12 V_{DC})	AC2 with Swash Plate Angle Sensor
D5H	CAN J1939 out, SIL2 certificable*	H		
D5J	Cruise Control, ECO Fuel Saving Mode, (reduced) CAN J1939 in/out*	J		
D6F	CAN J1939 in/out*	F	C3 (24 V_{DC})	
D6H	CAN J1939 out, SIL2 certifiable*	H		
D6J	Cruise Control, ECO Fuel Saving Mode, (reduced) CAN J1939 in/out*	J		
NNN	None			

* without Customer files

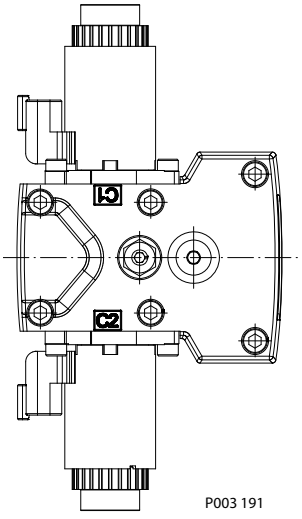
Control options

Electrical Displacement Control (EDC), options: A2 (12 V) / A3 (24 V)

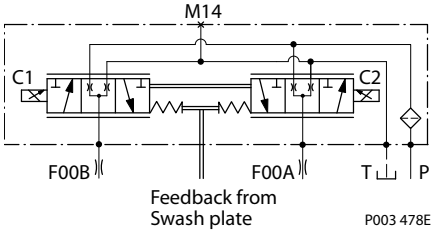
The **E**lectrical **D**isplacement **C**ontrol (EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. Differential pressure across the servo piston rotates the swashplate, changing the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement. A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

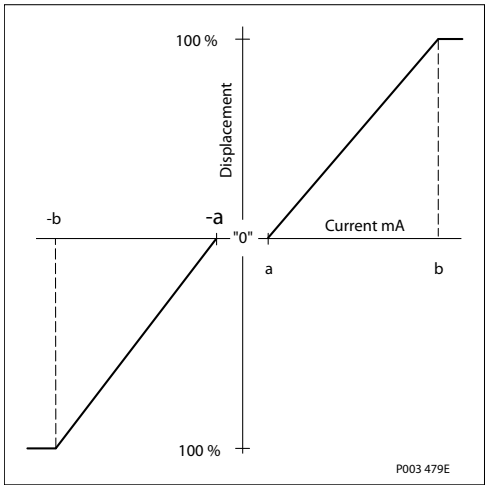
Electrical Displacement Control



EDC schematic



Pump displacement vs. control current



EDC control signal requirements

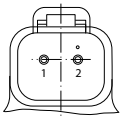
Control minimum current to stroke pump

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

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

Control options

Connector



Connector ordering data

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

EDC solenoid data

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	**Range**	70-200 Hz	
	Frequency (preferred)*	100 Hz	
IP Rating	**IEC 60 529**	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

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

* For coil location see *Installation drawings* on page 48.

Control response

H1 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.

H1 pumps are limited in mechanical orificing combinations. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.

Control options

Typical response times shown below 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	20 bar [290 psi]
Speed	1800 min^{-1} (rpm)

Response time EDC 069/078

Stroking direction	0.8 mm [0.03 in] Orifice	1.3 mm [0.05 in] Orifice	No orifice
Neutral to full flow	1.9 s	0.9 s	0.6 s
Full flow to neutral	1.6 s	0.9 s	0.5 s

Control options

Manual Displacement Control (MDC)

MDC principle

An MDC is a **M**anual proportional **D**isplacement **C**ontrol (MDC). The MDC consists of a handle on top of a rotary input shaft. The shaft provides an eccentric connection to a feedback link. This link is connected on its one end with a porting spool. On its other end the link is connected the pumps swashplate.

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

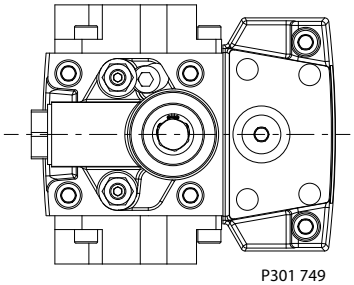
Differential pressure across the servo piston rotates the swash plate, changing the pump's displacement. Simultaneously the swashplate movement is fed back to the control spool providing proportionality between shaft rotation on the control and swashplate rotation.

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

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

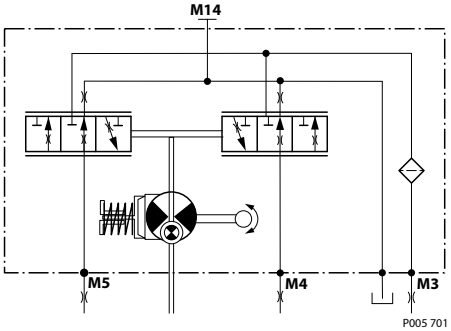
The MDC is sealed by means of a static O-ring between the actuation system and the control block. Its shaft is sealed by means of a special O-ring which is applied for low friction. The special O-ring is protected from dust, water and aggressive liquids or gases by means of a special lip seal.

Manual Displacement Control on H1 pump



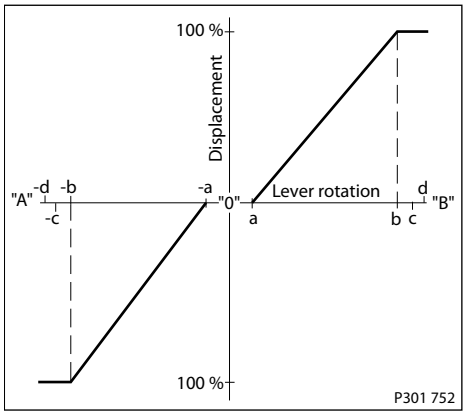
P301 749

MDC schematic diagram



P005 701

Pump displacement vs. control lever rotation



P301 752

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]

Control options

MDC torque (continued)

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]

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

MDC general information

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

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

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

For the MDC with CCO option the brake port (X7) provides charge pressure when the coil is energized to activate static function such as a brake release. The X7 port must not be used for any continuous oil consumption.

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 such way the actuation force will be transferred from the pilot control to the second control but the kinematic of the linkages must ensure that either control shaft is protected from torque overload.

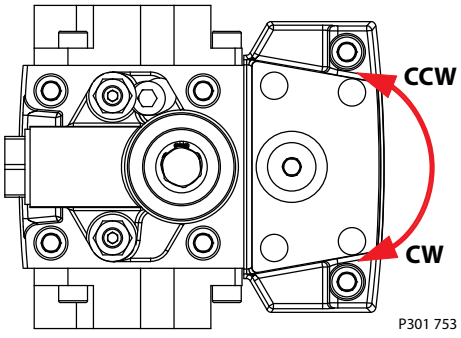
To avoid an overload of the MDC customers must install any support to limit the setting range of the Bowden cable.

Caution

The internal spring force on the input shaft is not appropriate to return any customer connection linkage to neutral.

Shaft rotation MDC

Shaft rotation MDC



Control options

MDC shaft rotation data

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

* as seen from shaft side

Control response

H1 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.

H1 pumps are limited in mechanical orificing combinations. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.

Typical response times shown below at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm^2/s [141 SUS] and 50 °C [122 °F]
Charge pressure	20 bar [290 psi]
Speed	1800 min^{-1} (rpm)

Response time, MDC 069/078

Response time for MDC 069/078 (sec)

Code	Orifice description (mm)				Stroking direction	
	P	**A**	**B**	**Tank (A +B)**	**Neutral to full flow (sec)**	**Full flow to neutral (sec)**
C3	–	–	–	–	0.4	0.5
D5	0.6	0.8	0.8	0.6	7.5	4.4
C8	0.8	–	–	0.6	4.2	3.1
C9	1	–	–	0.6	3.9	2.9
D1	1	–	–	0.8	2.5	1.9
D2	1.3	–	–	0.8	2.2	1.7
D3	1.3	–	–	1	1.6	1.2
D4	1.3	1.3	1.3	1	1.9	1.5
C6	–	–	–	1	1.4	1.1
C7	–	–	–	1.3	0.9	0.8

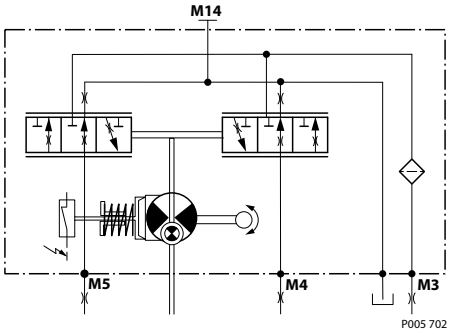
Control options

Neutral Start Switch (NSS)

The **N**eutral **S**tart **S**witch (NSS) contains an electrical switch that provides a signal of whether the control is in neutral.

The signal in neutral is normally closed **(NC)**.

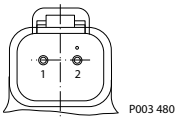
Neutral Start Switch schematic



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

Connector



Connector ordering data

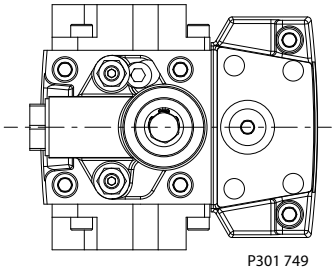
Description	Quantity	Ordering number
Mating connector	1	Deutsch® DT06-2S
Wedge lock	1	Deutsch® W2S
Socket contact (16 and 18 AWG)	2	Deutsch® 0462-201-16141
Danfoss mating connector kit	1	K29657

Case gauge port M14

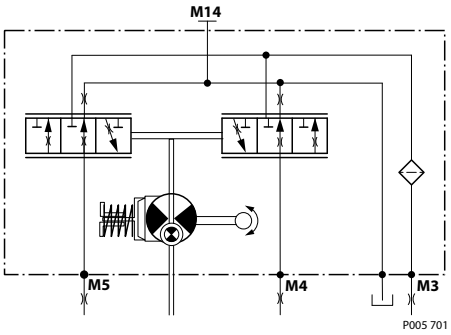
The drain port should be used when the control is mounted on the unit's bottom side to flush residual contamination out of the control.

Control options

MDC w/h drain port shown



MDC schematic diagram



Lever

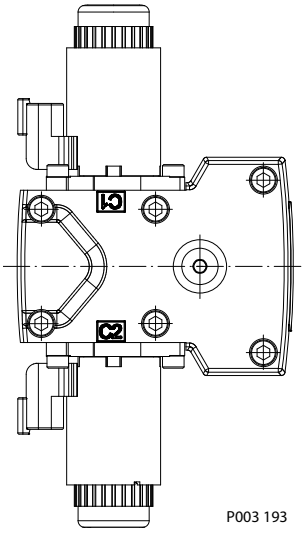
MDC-controls are available with an integrated leveler.

Control options

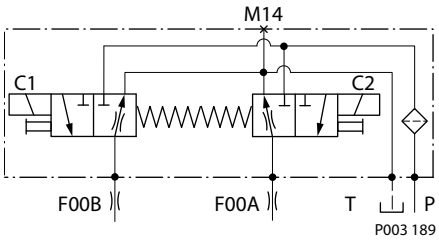
Forward-Neutral-Reverse electric control (FNR), options: A9 (12 V) and B1 (24 V)

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

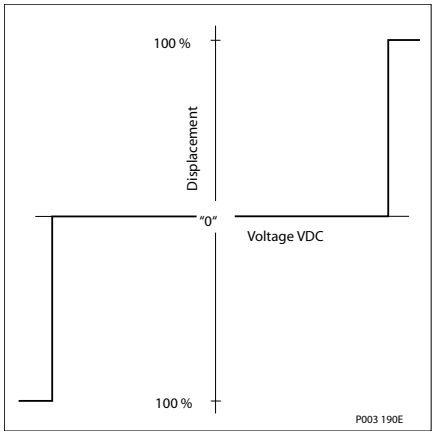
Forward-Neutral-Reverse electric control (FNR)



FNR hydraulic schematic



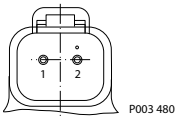
Pump displacement vs. electrical signal



Control current

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

Connector



Connector ordering data

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

Control options

Solenoid data

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

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

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

* For coil location see *Installation drawings* on page 48.

Control response

H1 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.

H1 pumps are limited in mechanical orificing combinations. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.

Typical response times shown below at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm^2/s [141 SUS] and 50 °C [122 °F]
Charge pressure	20 bar [290 psi]
Speed	1800 min^{-1} (rpm)

Response time, FNR 069/078

Stroking direction	0.8 mm [0.03 in] Orifice	1.3 mm [0.05 in] Orifice	No orifice
Neutral to full flow	2.2 s	1.0 s	1.1 s
Full flow to neutral	2.0 s	0.9 s	0.8 s

Control options

Non Feedback Proportional Electric Control (NFPE), options: A8 (12 V) / B8 (24 V)

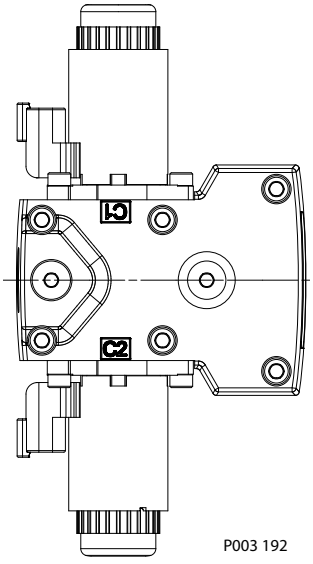
The **N**on **F**eedback **P**roportional **E**lectric (NFPE) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder.

The NFPE control has no mechanical feedback mechanism. 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.

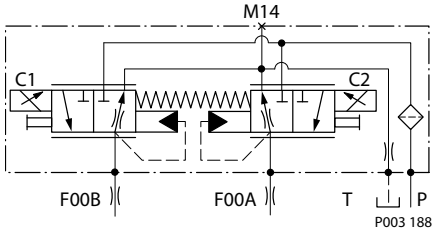
A typical response characteristic is shown in *the accompanying graph*. Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

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

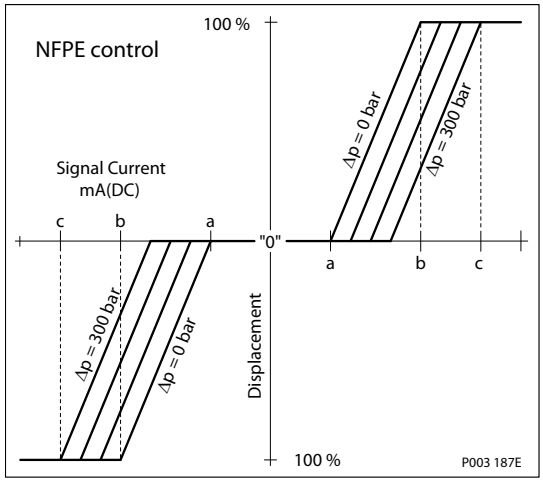
NFPE Control



NFPE schematic



Pump displacement vs. input signal



Control signal requirements, NFPE 069/078

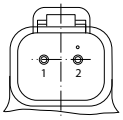
Control minimum current to stroke pump

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

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

Control options

Connector



Connector ordering data

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

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	**Range**	70-200 Hz	
	Frequency (preferred)*	100 Hz	
IP Rating	**IEC 60 529**	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

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

* For coil location see *Installation drawings* on page 48.

Control response

H1 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.

H1 pumps are limited in mechanical orificing combinations. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.

Control options

Typical response times shown below 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	20 bar [290 psi]
Speed	1800 min^{-1} (rpm)

Response time, NFPE 069/078

Stroking direction	0.8 mm [0.03 in] Orifice	1.3 mm [0.05 in] Orifice	No orifice
Neutral to full flow	3.1 s	1.4 s	0.8 s
Full flow to neutral	2.0 s	0.9 s	0.4 s

Control options

Automotive Control (AC)

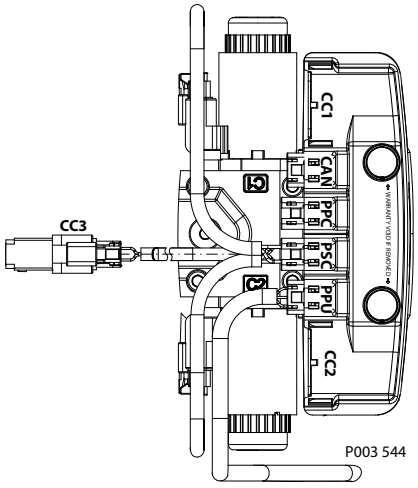
The H1 **A**utomotive **C**ontrol (AC) is an electric NFPE Control with an integrated microcontroller, installed on the pump.

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

The H1 Automotive Control is divided into 2 systems:

- AC-1
- AC-2

AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control and Flow Limiter.



Mode types

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

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

Basic functions

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

Control options

Performance functions

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

Protection and safety functions

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

Engine control and protection

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

Installation features

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

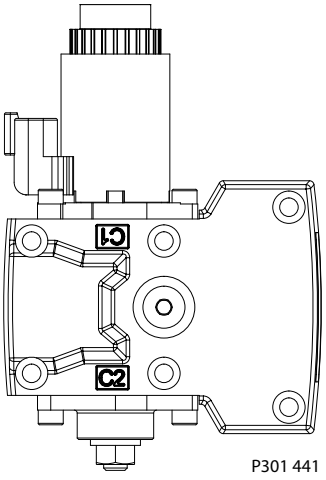
Refer to the *Technical Information, H1 Automotive Control* **L1223856** for more details.

Control options

Fan Drive Control (FDC), options: F1 (12V) / F2 (24V)

The **F**an **D**rive **C**ontrol (FDC) is a non-feedback control in which an electrical input signal activates the proportional solenoid that ports charge pressure to either side of the pump servo cylinder. The single proportional solenoid is used to control pump displacement in the forward or reverse direction. The control spool is spring biased to produce maximum forward pump displacement in the absence of an electrical input signal. Based on the spring bias spool default forward flow for a CW rotation pump is out of Port B while default forward flow for a CCW rotation pump is out of Port A.

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characterisistic also provides a power limiting function by reducing the pump swashplate angle as sytem pressure increases. The pump should be configured with 0.8 mm control orifices to provide slowest response and maximize system stability. Additionally pressure limiter (PL) valves are used to limit maximum fan trim speed in both (forward and reverse) directions.



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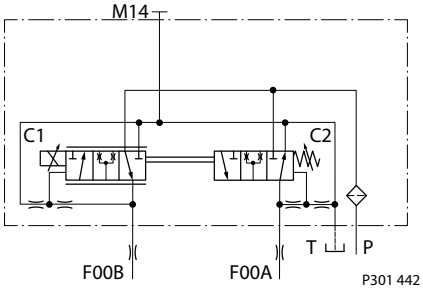
Schematic diagram



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H1 pumps with FDC will be delivered from factory with nominal PL setting of 150 bar [2175 psi]. The PL must be re-adjusted to ensure that the fan reaches the desired fan speed to satisfy the cooling needs of the system. HPRV-setting must be always at least 30 bar [435 psi] higher than PL-setting.

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

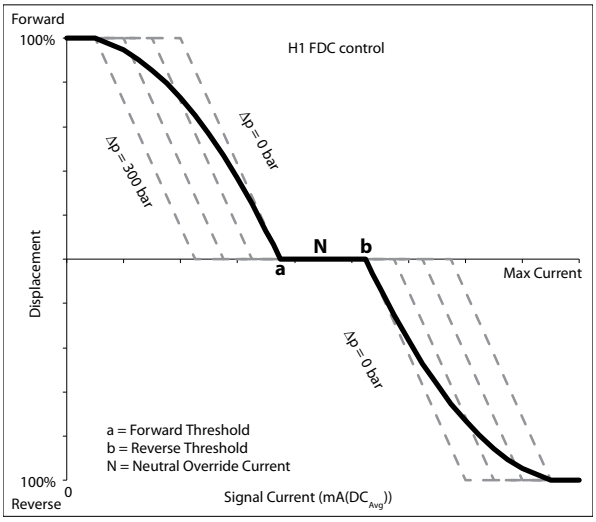
Refer to *Hydraulic Fan Drive Design Guidelines,* **520L0926** for detailed information necessary to properly size and configure a hydraulic fan drive system.

Warning

The FDC is for Fan Drive systems only! Use in other systems could result in unintended movement of the machine or it's elements. Loss of the input signal to this control will cause the pump to produce maximum flow.

Control options

Pump displacement vs. control current



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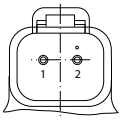
Control signal requirements

Control current

Voltage	a*	N	b*	Pin Config
12 V	780 mA	1100 mA	1300 mA	any order
24 V	400 mA	550 mA	680 mA	

* Factory test current, for fan movement expect higher or lower value.

Connector



P003 480

Connector ordering data

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

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

Control options

Solenoid data (continued)

Description		12 V	24 V
PWM	**Range**	70-200 Hz	
	Frequency (preferred)*	100 Hz	
IP Rating	**IEC 60 529**	IP 67	
	DIN 40 050, part 9	IP 69K with mating connector	

* PWM signal required for optimum control performance.

Pump output flow direction vs. control signal

Shaft rotation		CW			CCW		
Control Logic	**12 V**	0-780 mA	1100 mA	1300-1800 mA	0-780 mA	1100 mA	1300-1800 mA
	24 V	0-400 mA	550 mA	680-920 mA	0-400 mA	550 mA	680-920 mA
Port A		in	no flow	out	out	no flow	in
Port B		out	no flow	in	in	no flow	out
Servo port pressurized		M5	n/a	M4	M5	n/a	M4

Warning

Loss of input signal to this control will cause the pump to produce maximum flow.

Control response

H1 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.

H1 pumps are limited in mechanical orificing combinations. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.

Typical response times shown below at the following conditions:

Δp	250 bar [3626 psi]
Viscosity and temperature	30 mm^2/s [141 SUS] and 50 °C [122 °F]
Charge pressure	20 bar [290 psi]
Speed	1800 min^{-1} (rpm)

Response time, FDC 069/078

Stroking direction	0.8 mm [0.03 in] Orifice
Full flow to neutral	2.9 s
Full forward flow to full reverse flow	4.3 s

Control options

Manual Over Ride (MOR)

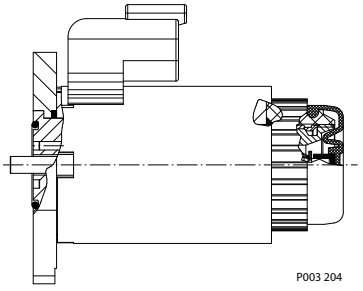
All controls are available with a Manual Over Ride (MOR) either standard or as an option for temporary actuation of the control to aid in diagnostics. Forward-Neutral-Reverse (FNR) and Non Feedback Proportional Electric (NFPE) controls are always supplied with MOR functionality.

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

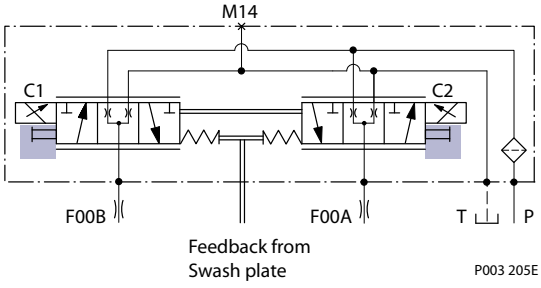
Warning

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

Manual Over Ride (MOR)



MOR-schematic diagram (EDC shown)



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

Swash Angle Sensor

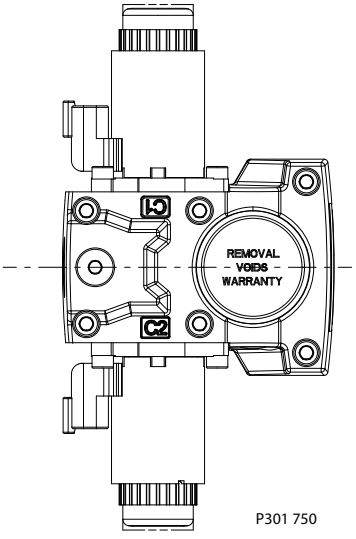
The angle sensor detects the swash plate angle position and direction of rotation from the zero position. This gives feedback to the ECU to precisely control the position of swash plate.

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.

The swashplate angel sensor is available for all NFPE- controls and ACII controls.



Control options

Swash Angle Sensor parameters

Swash Angle Sensor parameters

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	-18°	0°	18°
Correlation between signals 1 and 2[2)]	475 mV	500 mV	525 mV

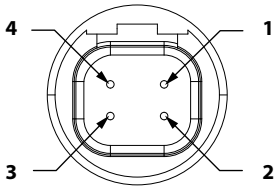
[1)] Up to duration of 2.5 seconds at 25°C

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

Accuracy for working range at 50°C calibration:

- ±0.65° for Signal 1 – primary (nominal)
- ±0.85° for Signal 2 – secondary (redundant)

Swash Angle Sensor connector



Angle sensor connector	
Pin	Assignment
1	Ground (GND)
2	Output Signal 2(SIG2) – Secondary (redundant) Signal
3	Output Signal 1(SIG1) – Primary (nominal) Signal
4	Supply (V+)

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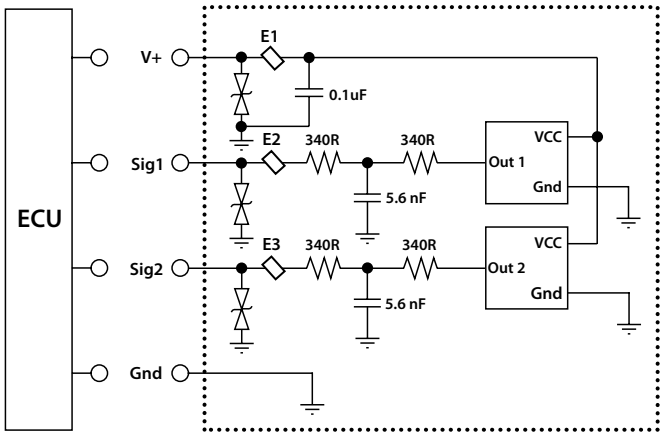
Swash Angle Sensor connector order numbers

Description	Quantity	Ordering number
Mating connector Deutsch® DT 06-4S	1	11105824
Wedge lock Deutsch® W4S	1	11084558
Socket contact (16-18 AWG) Deutsch® 0462-201-16141	2	K02325

Control options

Interface with ECU

Interface with ECU schematic



Minimum recommended load resistance is 100 kΩ.

Fault codes and diagnostics

During short circuit between signal output and supply (V+), the output reaches greater than 94% of full scale. During short circuit between signal output and ground, the output reaches lesser than 6% of full scale.

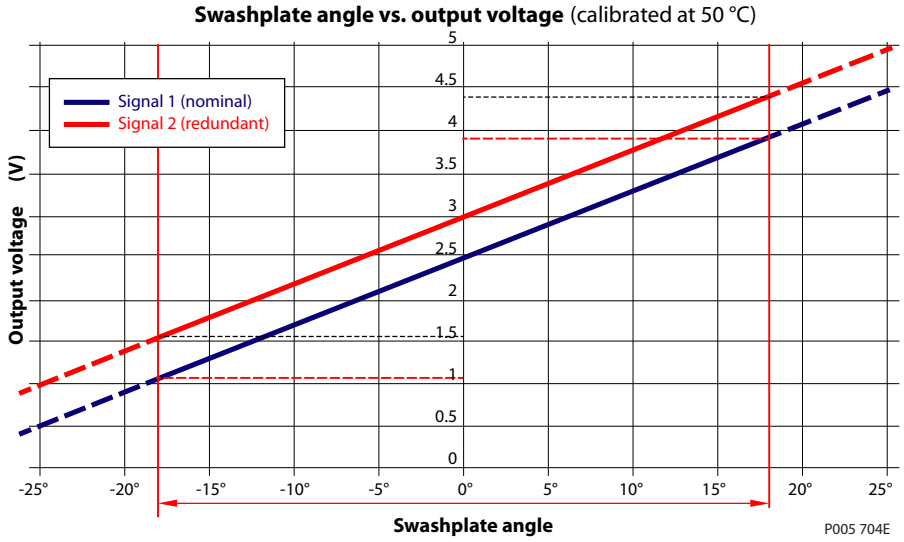
The sensor withstands up to duration of 2.5 seconds (at 25°C) in worst case with each output having 7.5 mA and the input supply current above 25 mA. The sensor accuracy and reliability is reduced by each occurrence of such event. In case, the level of over shoot current is higher than 30 mA, then the sensor sustains permanent damage. At over voltage 28 V, output is clamped low, sensor would not comply the specifications.

Environmental conditions

Parameter	Min	Max
Operating temperature range ±0.65% accuracy	+20 °C	+95°C
Operating temperature range ±1.5% accuracy	-40°C	+120°C
Storage temperature range	-40°C	+125°C
Operating angle nominal	-18°C	+18°C
IP Rating (IEC 60 529) + DIN 40 050, part 9	IP 65 / IP 69k with mating connector	

Control options

Swashplate angle vs output voltage



The displacement can be calculated by:

$$V = \frac{\tan \alpha \cdot V}{\tan 18°} \quad [cc]$$

The corresponding flow is:

$$Q = \frac{V \cdot n \cdot \eta_{vol}}{1000} \quad [l/min]$$

The volumetric losses are depending on:

- Pump size (max displacement)
- Actual displacement
- Speed (rpm)
- Delta pressure
- Viscosity / temperature

Control-Cut-Off valve (CCO valve)

The H1 pump offers an optional control cut off valve integrated into the control. This valve will block charge pressure to the control, allowing the servo springs to de-stroke 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.

Control options

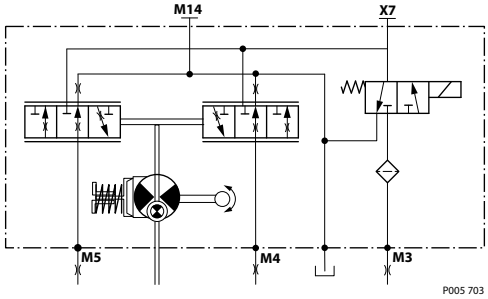
All MDC controls are available with a CCO valve.

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

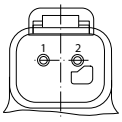
The CCO-valve is available with 12 V or 24 V solenoid.

The location of the brake port see chapter outline drawings.

CCO-schematic (MDC shown)



CCO connector



Description	Quantity	Ordering number
Mating connector	1	Deutsch® DT06-2SC
Wedge lock	1	Deutsch® W2SC
Socket contact (16 and 18 AWG)	2	Deutsch® 0462-201-16141

CCO solenoid data

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

Brake gauge port with MDC

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

Control options

Displacement limiter

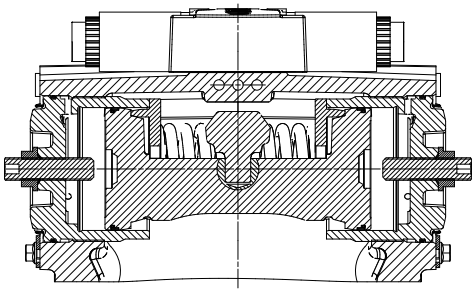
H1 pumps are designed with optional mechanical displacement (stroke) limiters factory set to max. displacement.

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 down to 50 % displacement.

Adjustments under operating conditions may cause leakage. The adjustment screw can be completely removed from the threaded bore if backed out to far.

Adjustment procedures can be found in the H1 pumps Service Manuals.

Displacement limiter



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Displacement change (approximately) H1P 069/078

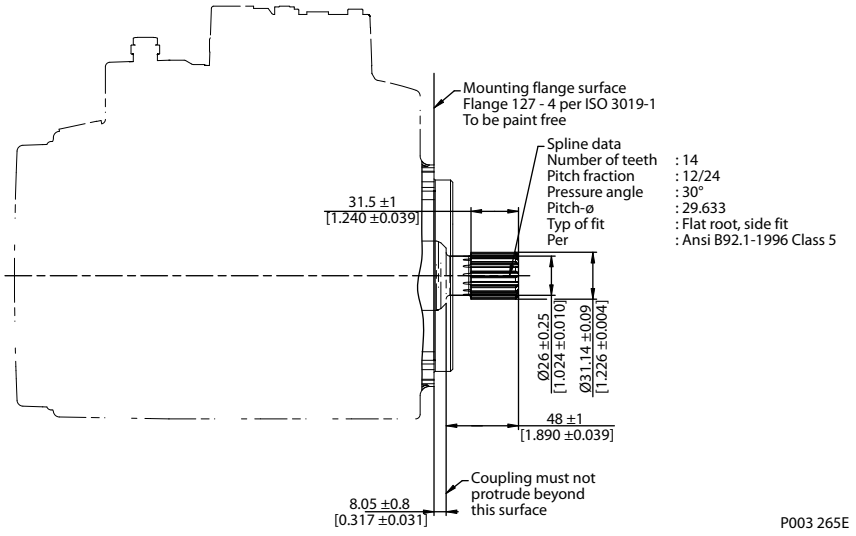
Parameter	Size 069/078
1 Turn of displacement limiter screw	7.4 cm^3 [0.45 in^3]
Internal wrench size	4 mm
External wrench size	13 mm
Torque for external hex seal lock nut	24 N•m [212 lbf•in]

For more information refer to *H1 pumps Service Manual* **520L0848**, section *Displacement Limiter Adjustment*.

Dimensions

H1P input shaft - Option G1 (SAE C, 14 teeth)

Option G1, ISO 3019-1, outer dia 32 mm-4 (SAE C, 14 teeth)



Specifications

Option		G1
Spline		14 teeth, 12/24 pitch
Min. active spline length[1)]		31.45 mm [1.238 in]
Torque rating[2)]	**Rated**	534 N•m [4720 lbf•in]
	Maximum	816 N•m [7220 lbf•in]

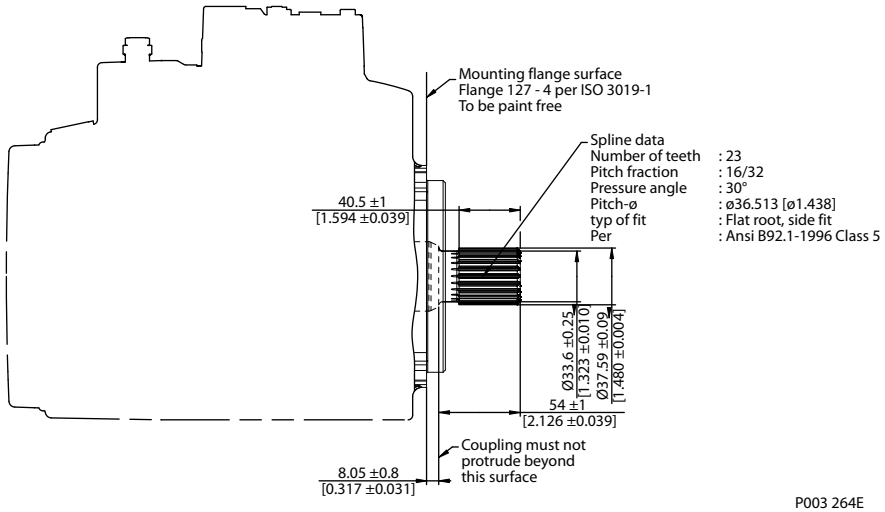
[1)] Minimum active spline length for the specified torque ratings.

[2)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

H1P input shaft - Option G9 (SAE C-C, 23 teeth)

Option G9, ISO 3019-1, outer dia 38 mm-4 (SAE C-C, 23 teeth)



Specifications

Option		G9
Spline		23 teeth, 16/32 pitch
Min. active spline length[1)]		40.33 mm [1.588 in]
Torque rating[2)]	Rated	999 N•m [8840 lbf•in]
	Maximum	1818 N•m [16 090 lbf•in]

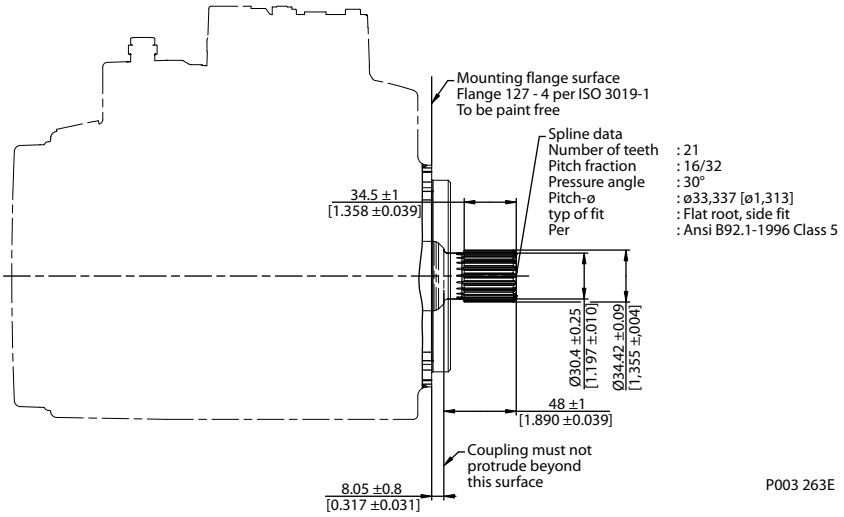
[1)] Minimum active spline length for the specified torque ratings.

[2)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

H1P input shaft - Option F1 (SAE C, 21 teeth)

Option F1, ISO 3019-1, outer dia 35 mm-4 (SAE C, 21 teeth)



Specifications

Option		F1
Spline		21 teeth, 16/32 pitch
Min. active spline length[1)]		34.5 mm [1.358 in]
Torque rating[2)]	Rated	760 N•m [6730 lbf•in]
	Maximum	1137 N•m [10 060 lbf•in]

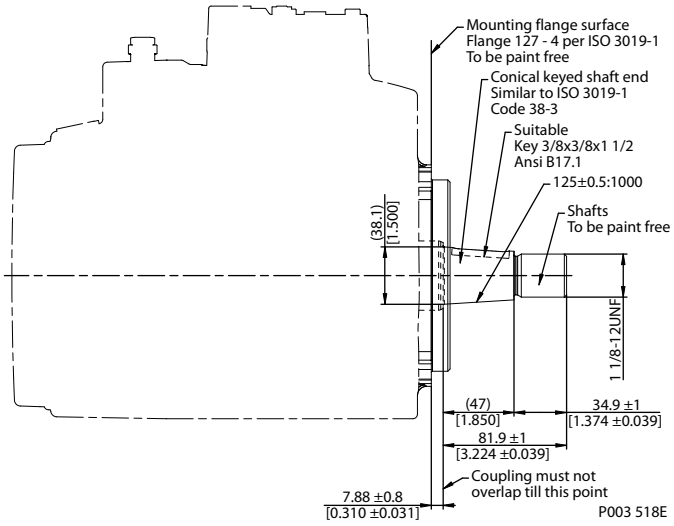
[1)] Minimum active spline length for the specified torque ratings.

[2)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

Dimensions

H1P input shaft, option F4, Code 38-3

Option F4, ISO 3019-1, Code 38-3, Diameter 38.1 taper 1:8, without key and no through-hole in the end of the shaft



Specifications

Option		F4
Tapered shaft[1)]		38.1 taper without key
Torque rating[2)]	Rated[3)]	1116 N•m [9880 lbf•in]
	Maximum	1488 N•m [13 170 lbf•in]

[1)] Mating part must maintain a minimum gap width of 1.0 mm with the shaft shoulder after installation of the part. Transmittable torque will be reduced if the minimum gap requirement is not met.

[2)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

[3)] Rated torque includes just the capability of the press-fit in accordance with an assumed fastener grade 5.

Tapered shaft customer acknowledgement

The Danfoss H1 tapered shaft has been designed using the industry standard ISO 3019-1, minus the through-hole in the end of the shaft. Danfoss recommends a self-locking nut instead of a castle nut and pin. The nut and mating square-cut key are customer supplied.

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

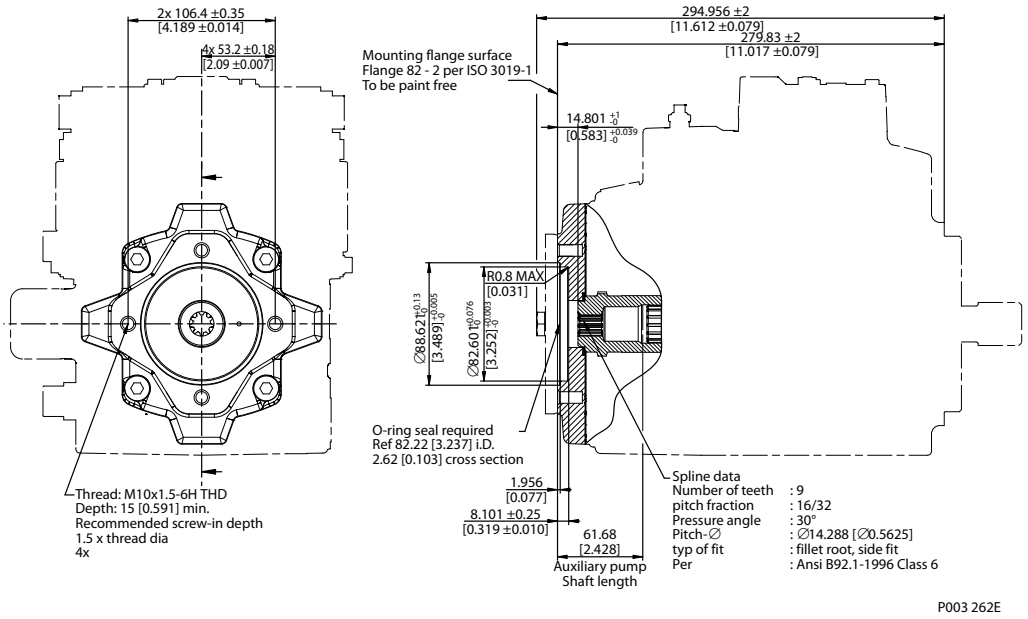
Caution

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

Dimensions

H1P Auxiliary mounting, option H2 (SAE A, 9 teeth)

Option H2, ISO 3019-1, flange 82-2 (SAE A, 9 teeth)



Specifications

Option	H2
Spline	9 teeth, 16/32 pitch
Maximum torque[1)]	162 N•m [1430 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

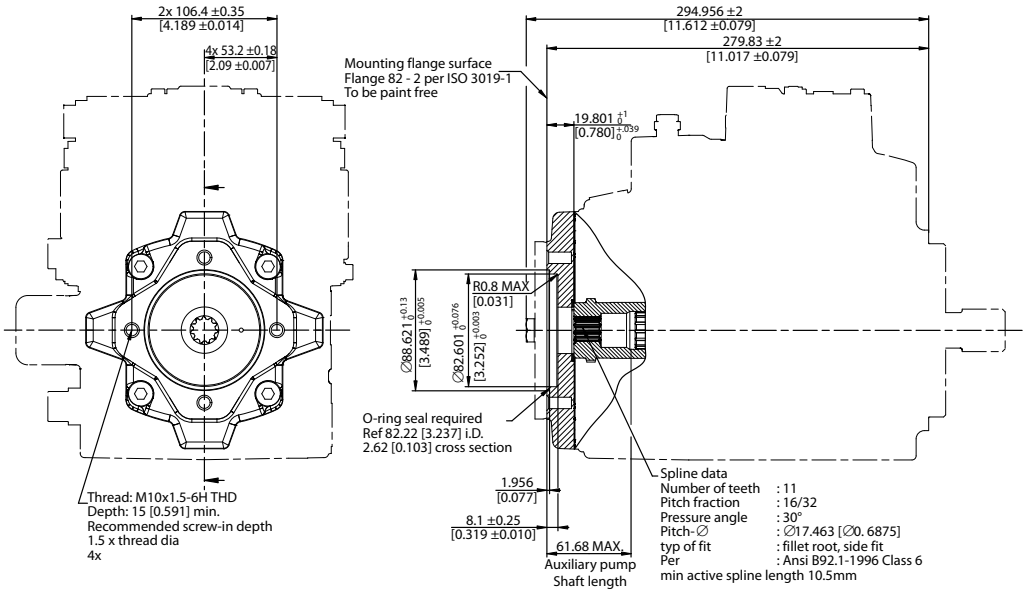
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

H1P Auxiliary mounting, option H1 (SAE A, 11 teeth)

Option H1, ISO 3019-1, flange 82-2 (SAE A, 11 teeth)



Specifications

Option	H1
Spline	11 teeth, 16/32 pitch
Maximum torque[1)]	296 N•m [2620 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

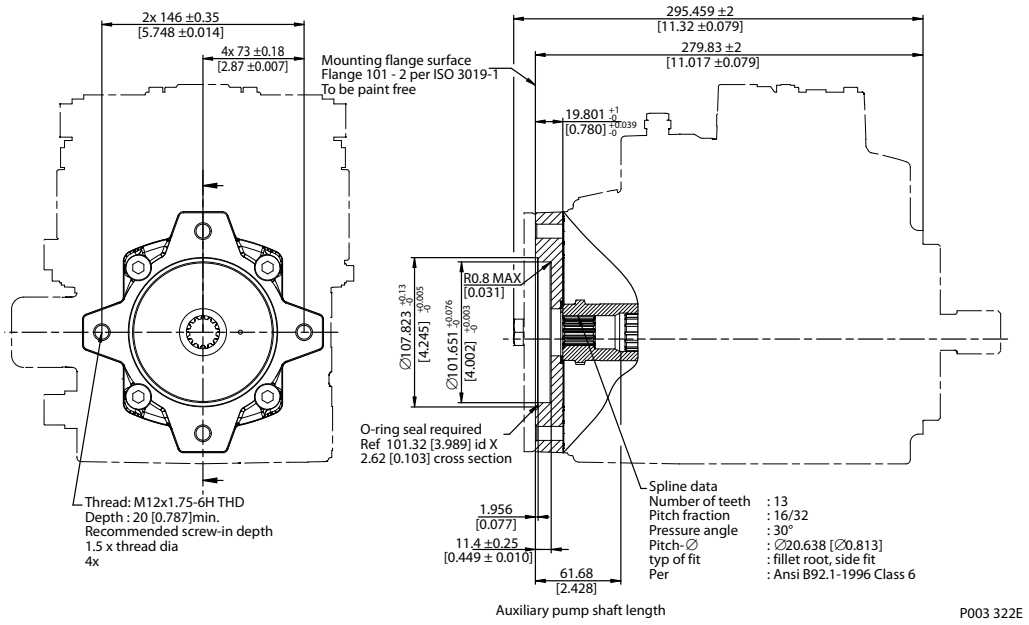
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

H1P Auxiliary mounting, option H3 (SAE B, 13 teeth)

Option H3, ISO 3019-1, flange 101-2 (SAE B, 13 teeth)



Specifications

Option	H3
Spline	13 teeth, 16/32 pitch
Maximum torque[1)]	395 N•m [3500 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

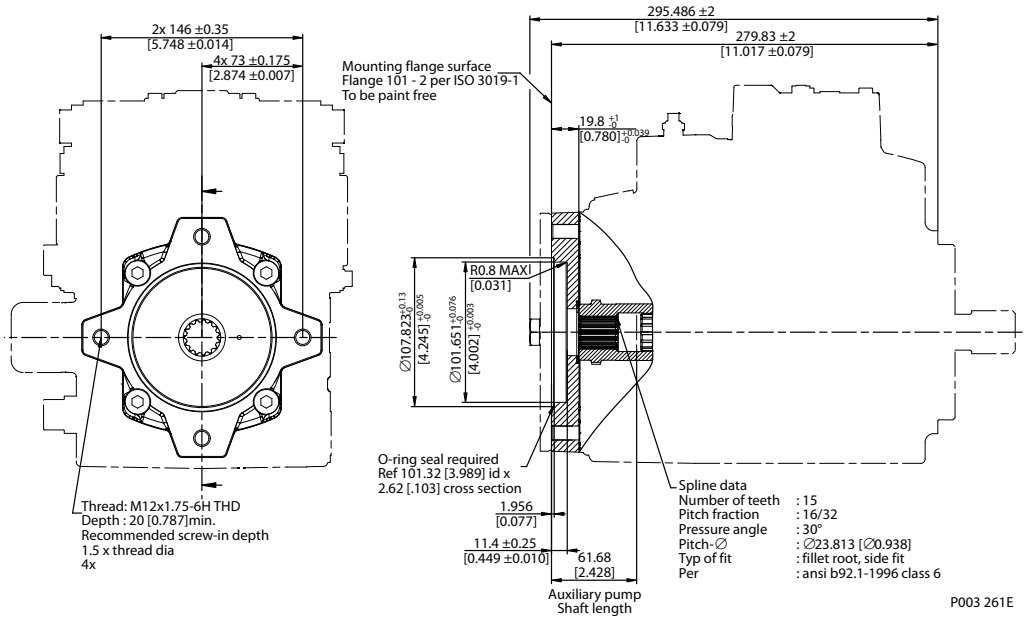
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

H1P Auxiliary mounting, option H5 (SAE B-B, 15 teeth)

Option H5, ISO 3019-1, flange 101-2 (SAE B-B, 15 teeth)



Specifications

Option	H5
Spline	15 teeth, 16/32 pitch
Maximum torque[1)]	693 N•m [6130 lbf•in]

[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

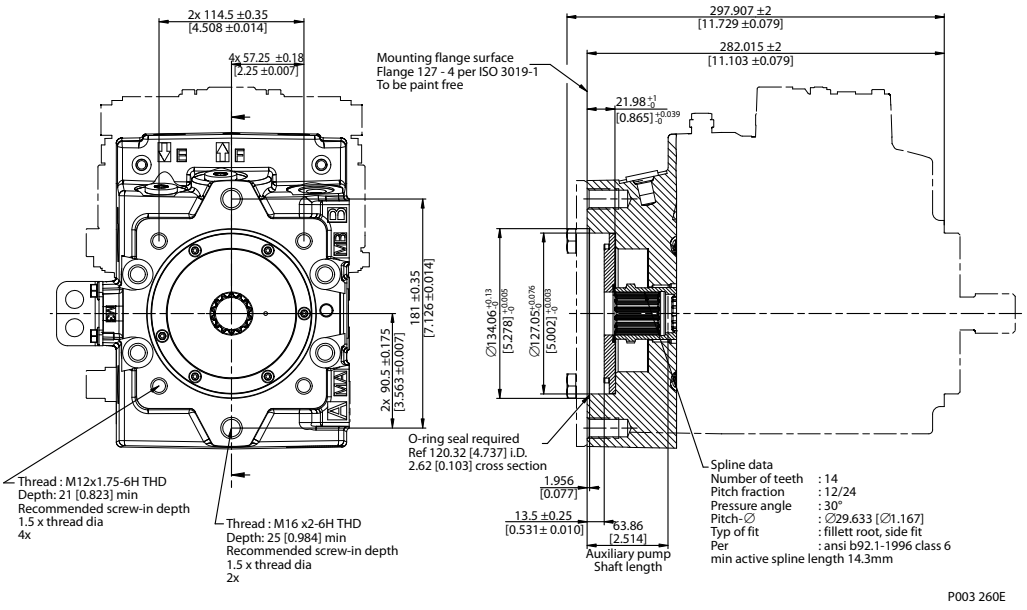
Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

H1P Auxiliary mounting, option H6 (SAE C, 14 teeth)

Option H6, ISO 3019-1, flange 127-4 (SAE C, 14 teeth)



Specifications

Option	H6
Spline	14 teeth, 12/24 pitch
Maximum torque[1)]	816 N•m [7220 lbf•in]

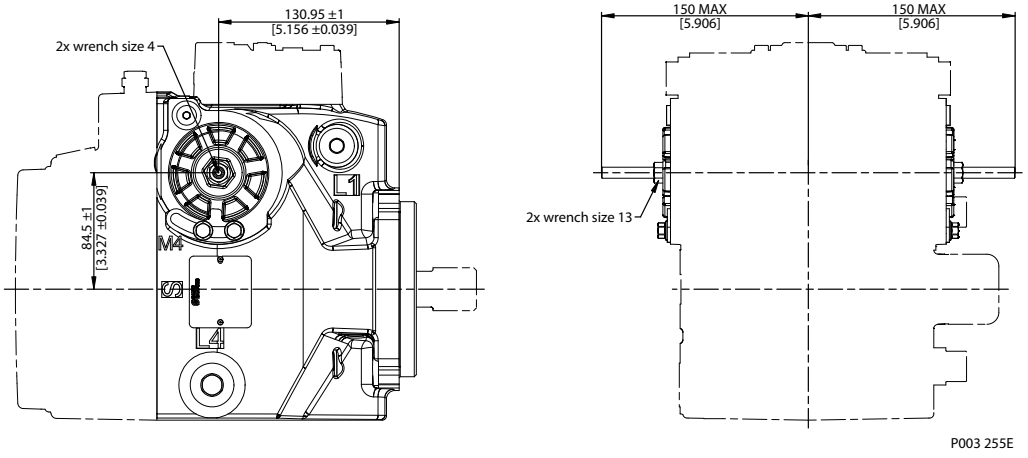
[1)] For definitions of maximum and rated torque values, refer to *Basic Information* **11062168**, section Shaft Torque Ratings and Spline Lubrication.

Caution

Standard pad cover is installed only to retain coupling during shipping. Do not operate pump without an auxiliary pump or running cover installed.

Dimensions

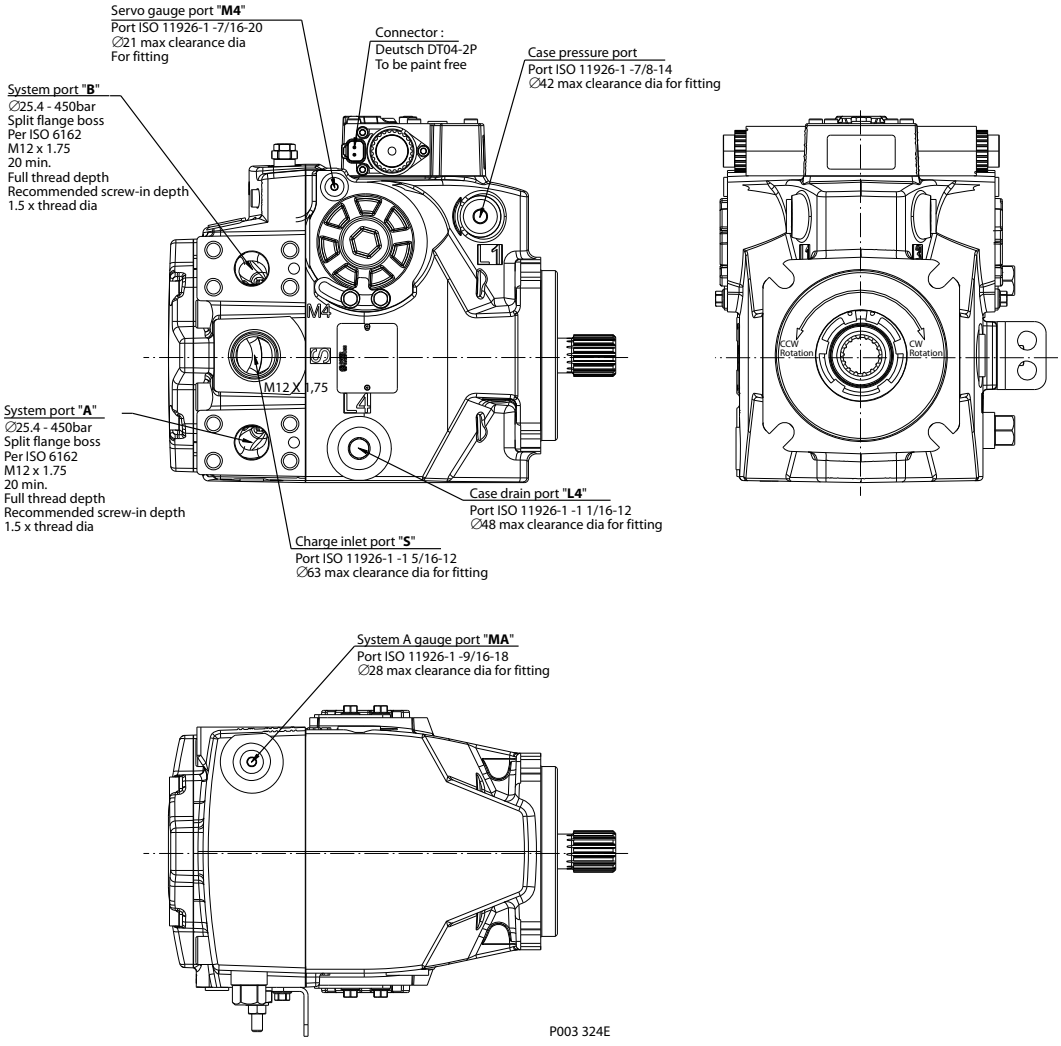
H1P 069/078 displacement limiter, option B



Please contact Danfoss for specific installation drawings.

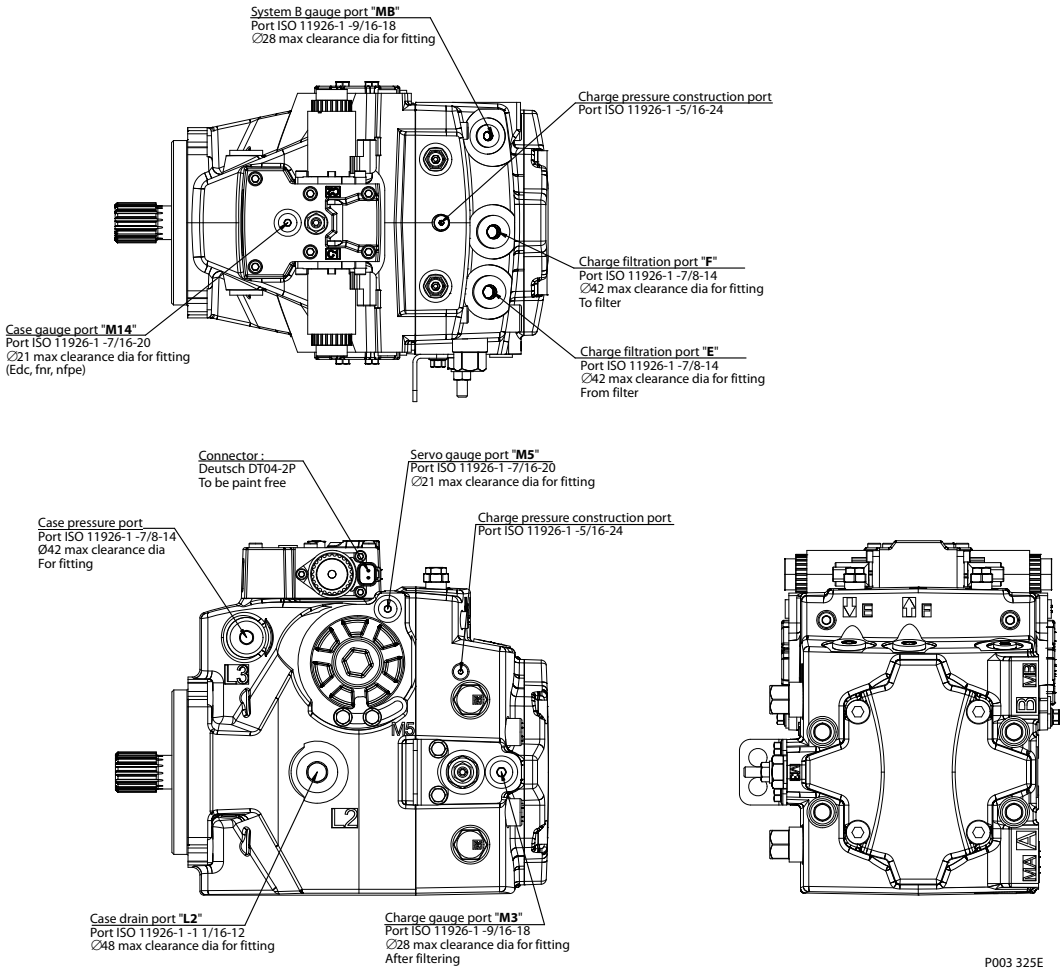
Installation drawings

Ports description H1P 069/078



Please contact Danfoss for specific installation drawings.

Installation drawings

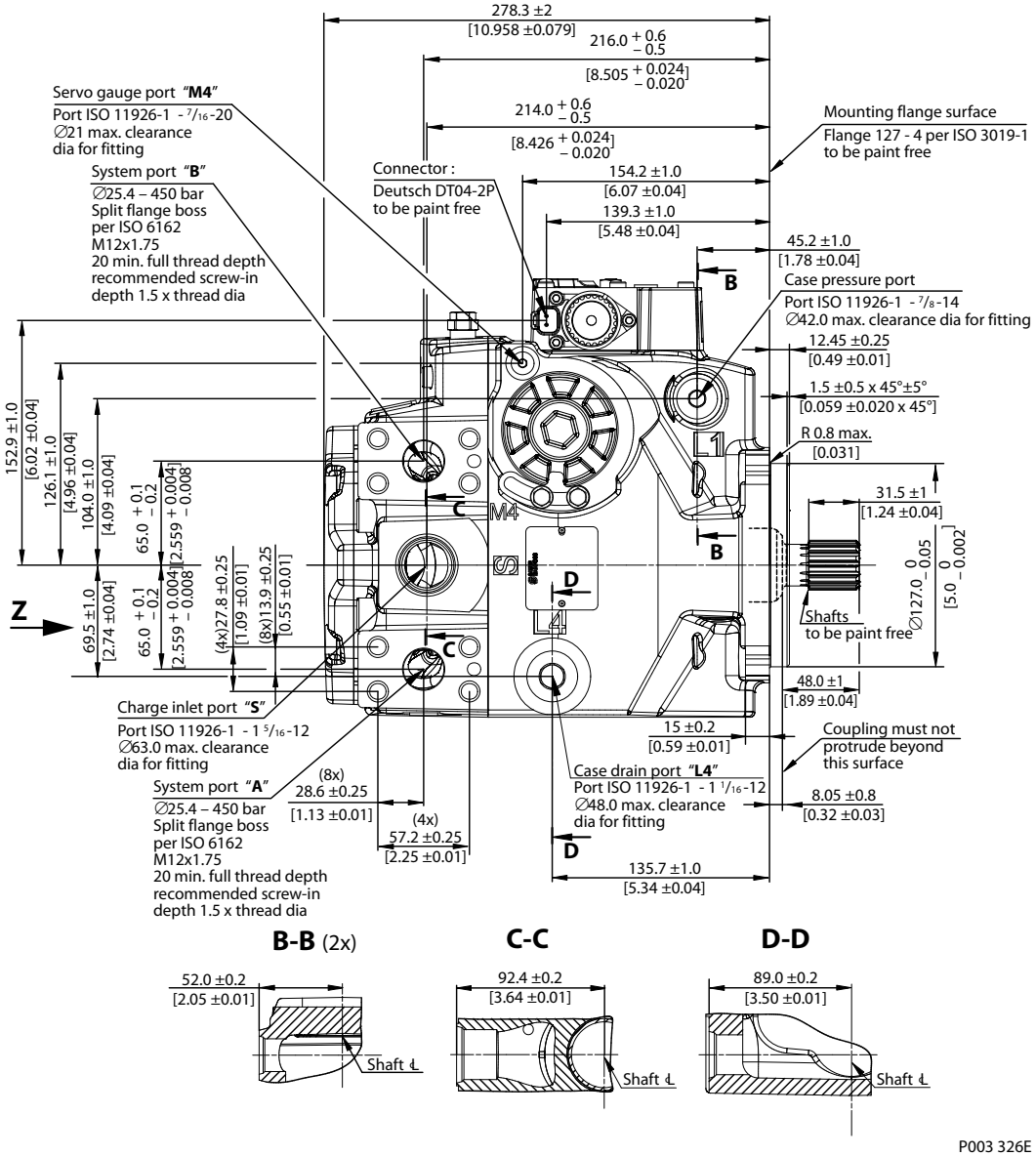


Ports description

Port	Description	Size
A, B	System ports **A** and **B**	Ø 25.4 mm
E	Charge filtration port, from filter	$^{7}/_{8}$ – 14
F	Charge filtration port, to filter	$^{7}/_{8}$ – 14
L2, L4	Case drain ports	1 $^{1}/_{16}$ –12
MA, MB	System **A** and **B** gauge ports	$^{9}/_{16}$ – 18
M3	Charge gauge port, after filtering	$^{9}/_{16}$ – 18
M4, M5	Servo gauge ports	$^{7}/_{16}$ – 20
M14	Case gauge port	$^{7}/_{16}$ – 20
S	Charge inlet port	1 $^{5}/_{16}$ –12

Installation drawings

Dimensions H1P 069/078



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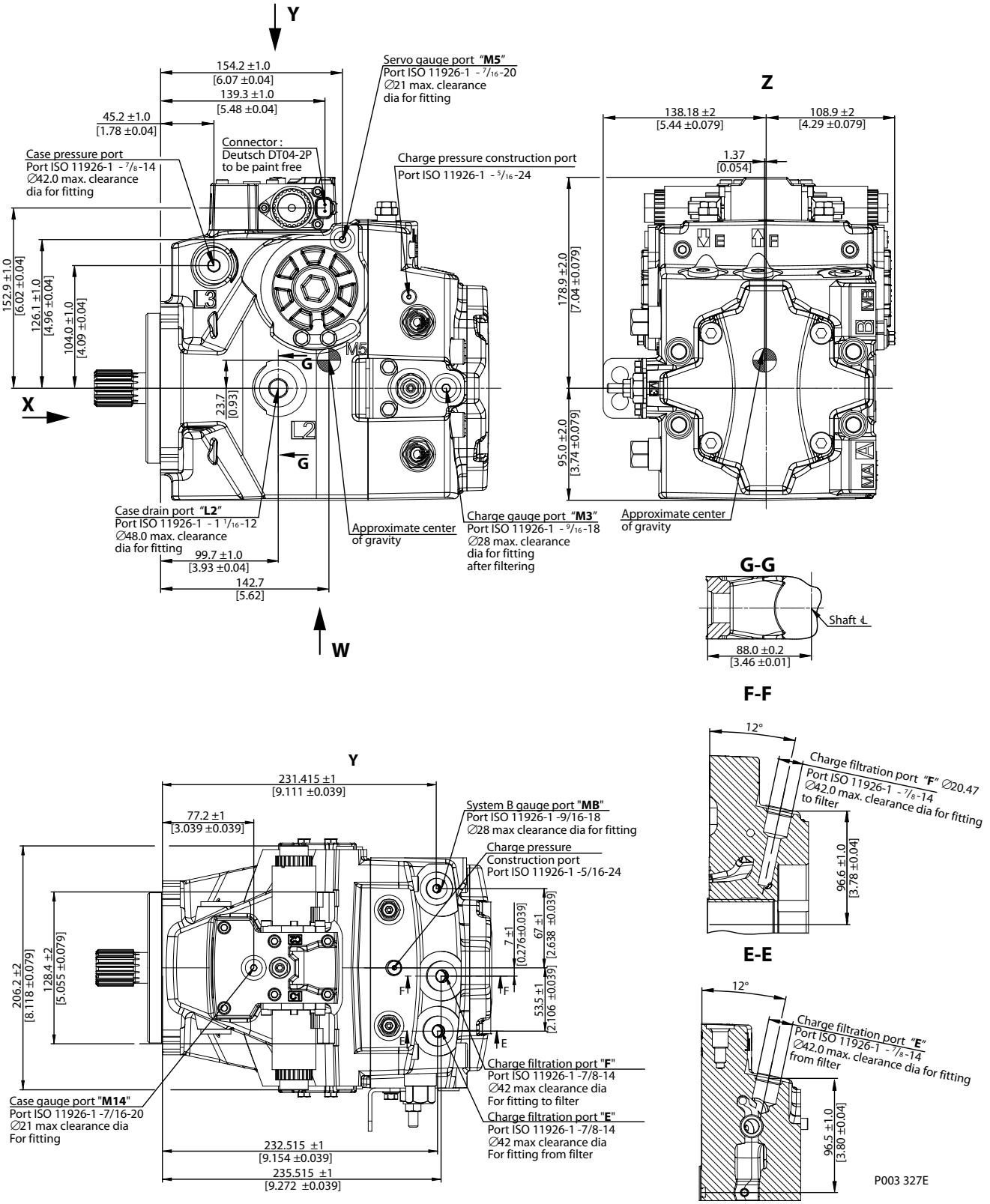
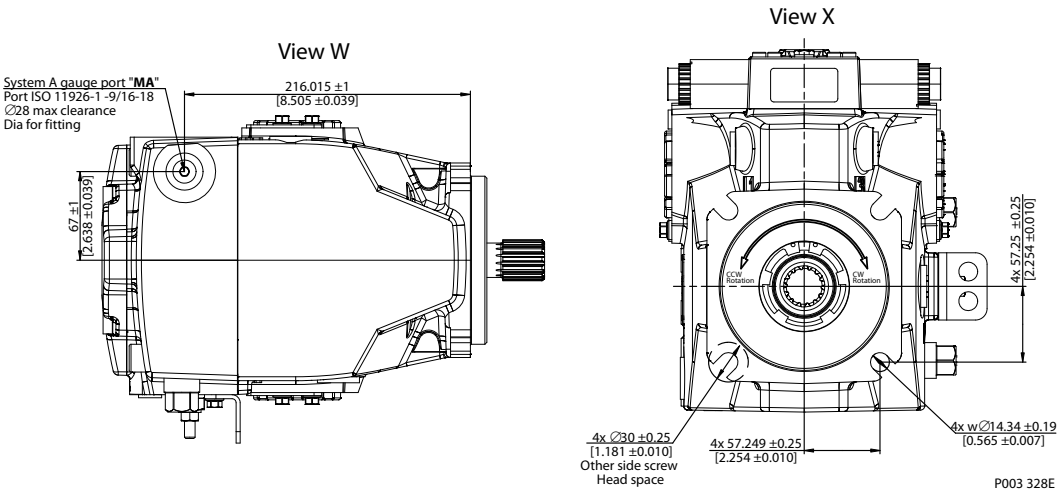
Please contact Danfoss for specific installation drawings.

Installation drawings



Please contact Danfoss for specific installation drawings.

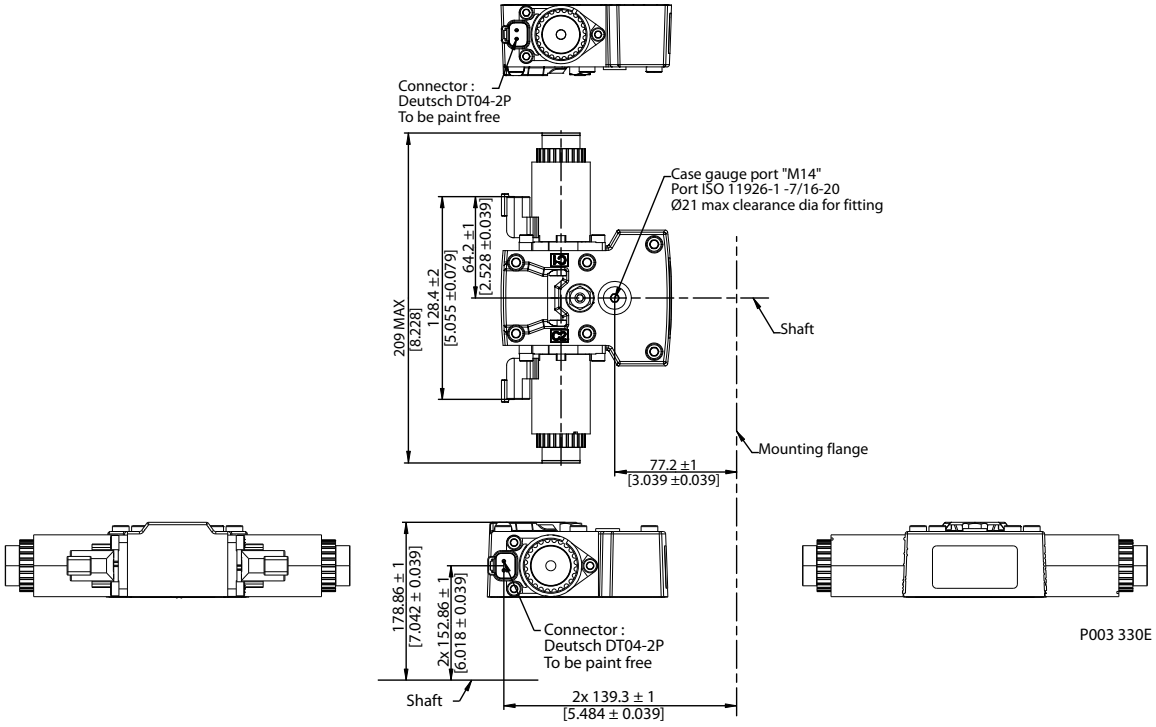
Installation drawings



Please contact Danfoss for specific installation drawings.

Controls

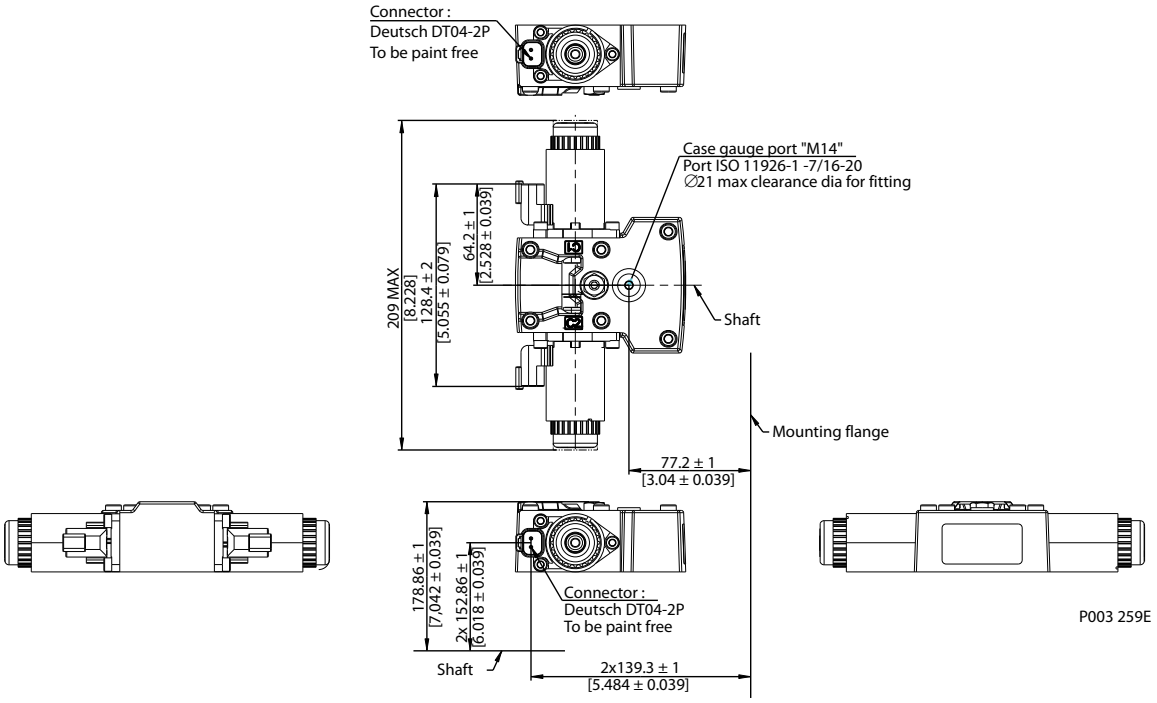
Electric Displacement Control (EDC), option A2 (12 V)/A3 (24 V)



Please contact Danfoss for specific installation drawings.

Controls

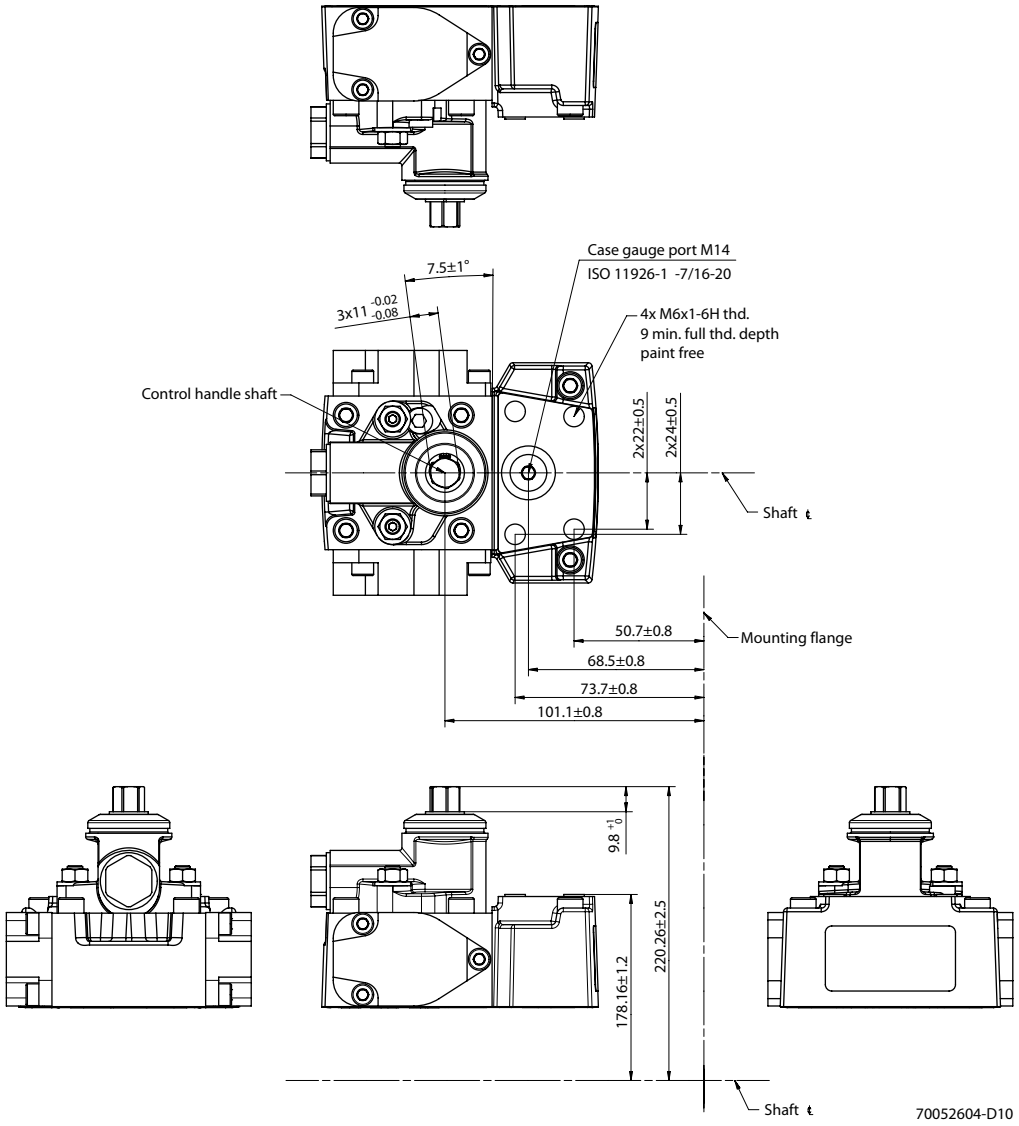
Electric Displacement Control (EDC), with MOR, option A4 (12 V)/A5 (24 V)



Please contact Danfoss for specific installation drawings.

Controls

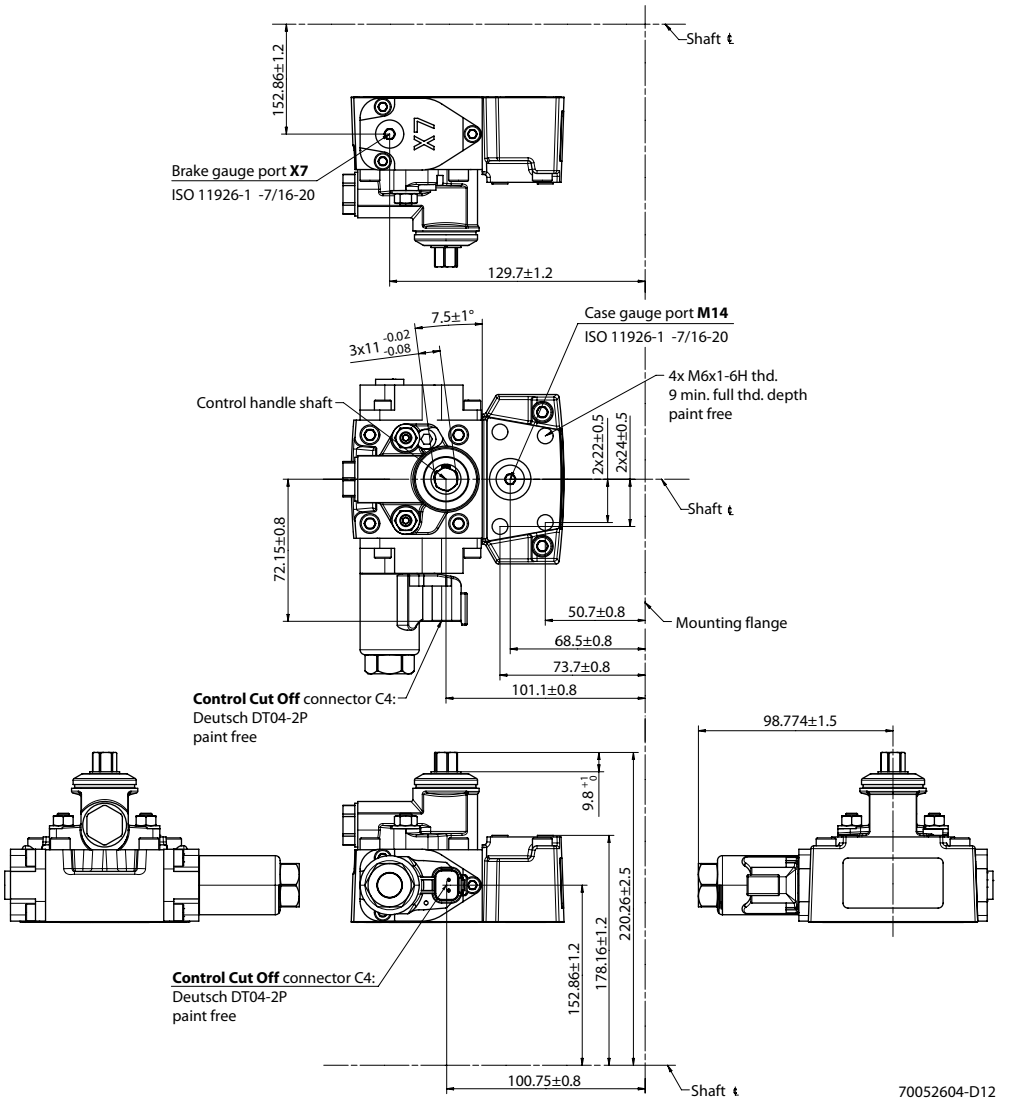
H1P 069/078 Manual Displacement Control (MDC), option M1



Please contact Danfoss for specific installation drawings.

Controls

H1P 069/078 Manual Displacement Control (MDC) with CCO, option M3, M4



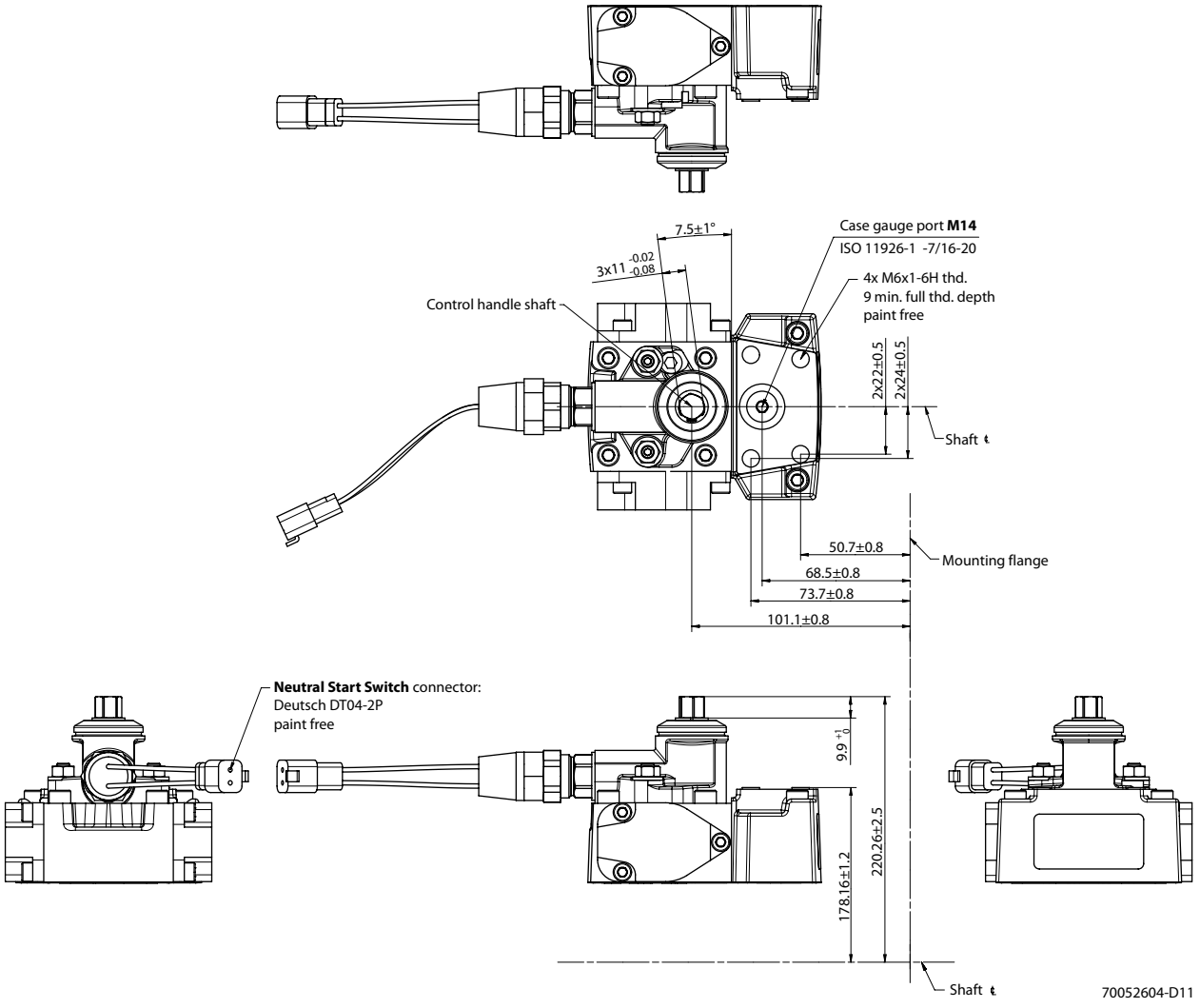
Control Cut Off connector C4:

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

Please contact Danfoss for specific installation drawings.

Controls

H1P 069/078 Manual Displacement Control (MDC) with NSS, option M2



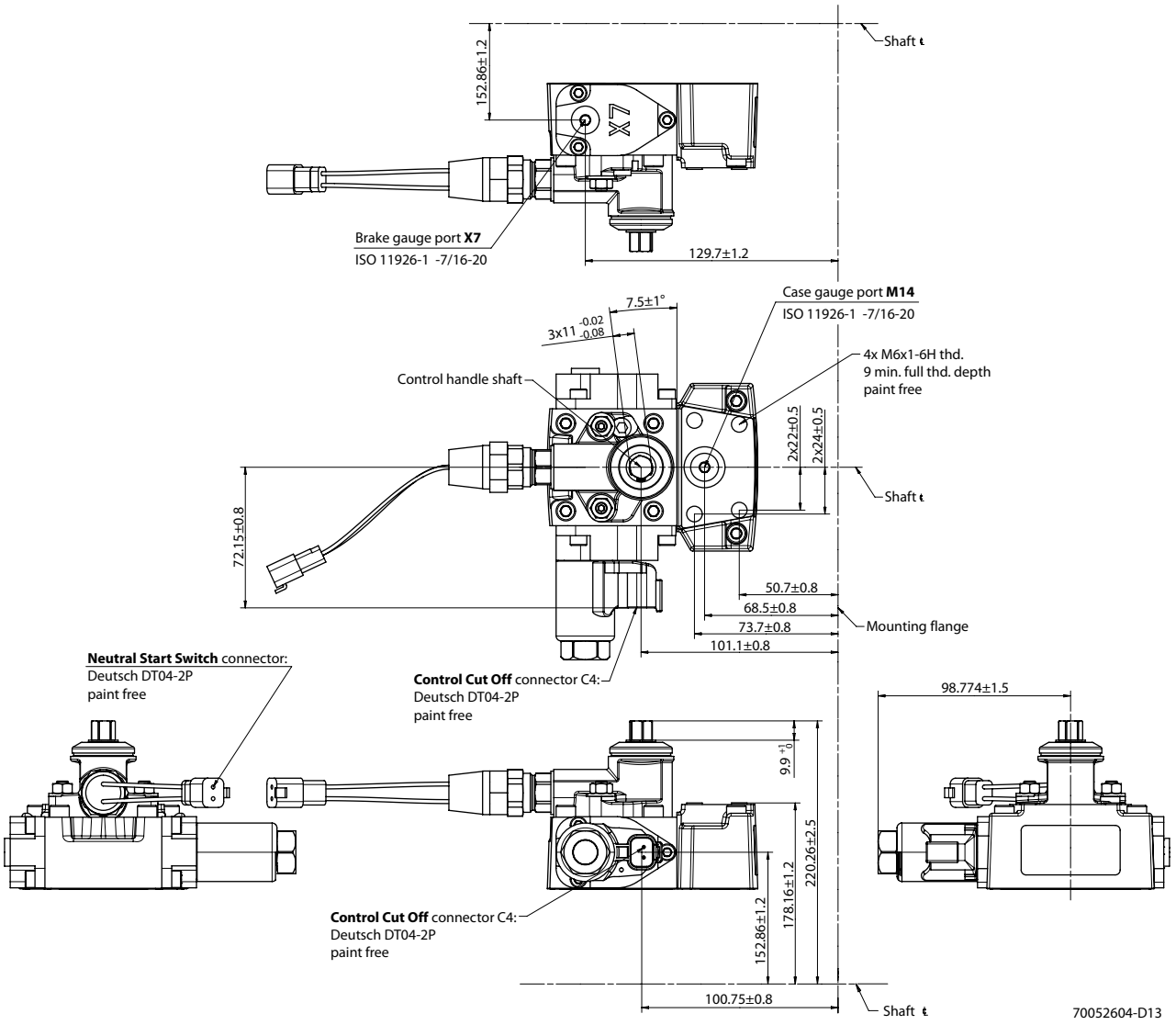
Neutral Start Switch connector:

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

Please contact Danfoss for specific installation drawings.

Controls

H1P 069/078 Manual Displacement Control (MDC) with NSS and CCO, option M5, M6



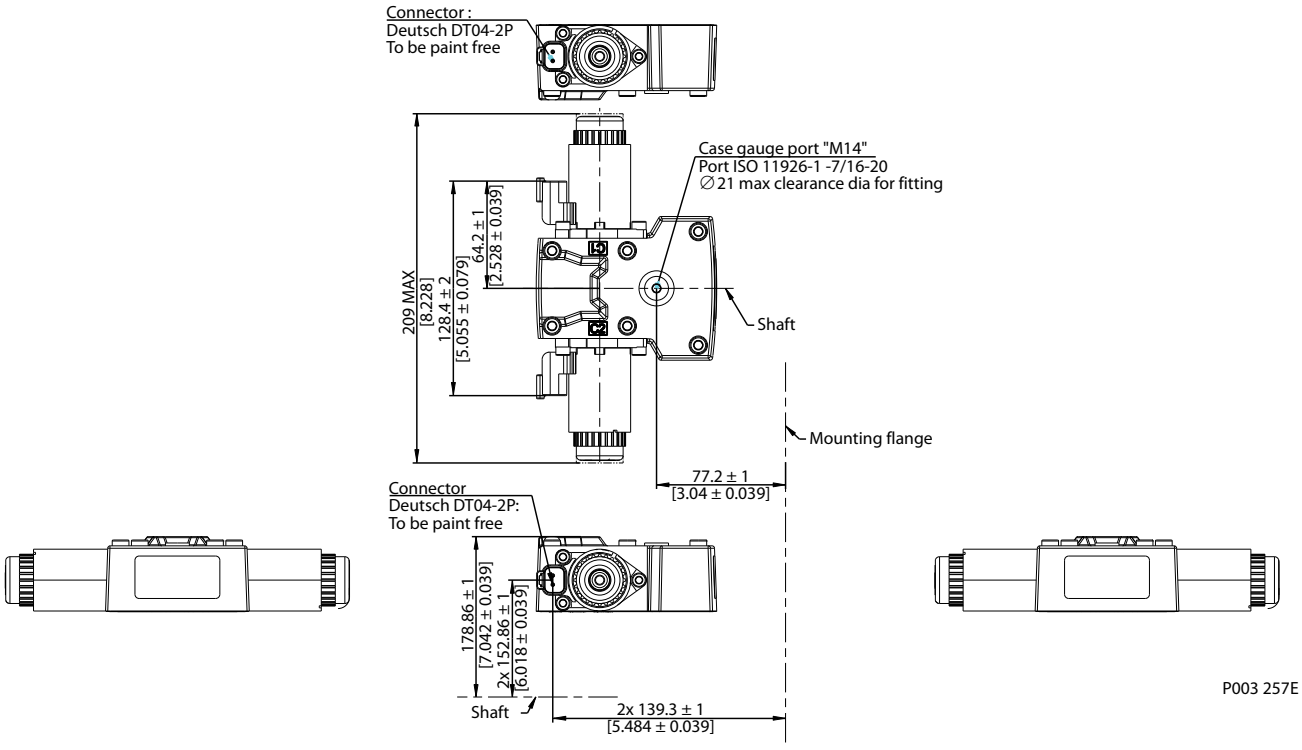
Neutral Start Switch connector / Control Cut Off connector C4:

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

Please contact Danfoss for specific installation drawings.

Controls

Forward-Neutral-Reverse (FNR) with manual override, option A9 (12 V)/B1 (24 V)



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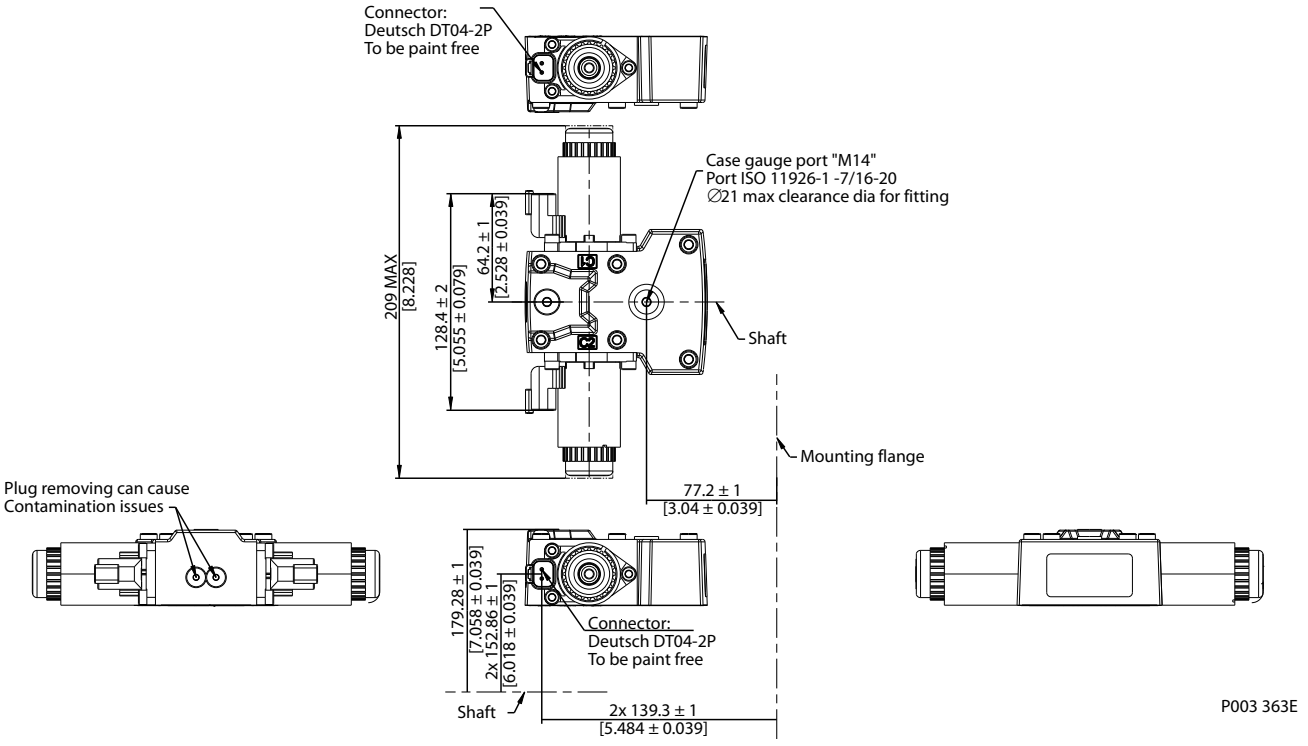
Controls

Non Feedback Proportional Electric control (NFPE), with MOR, option A8 (12 V)/B8 (24 V)



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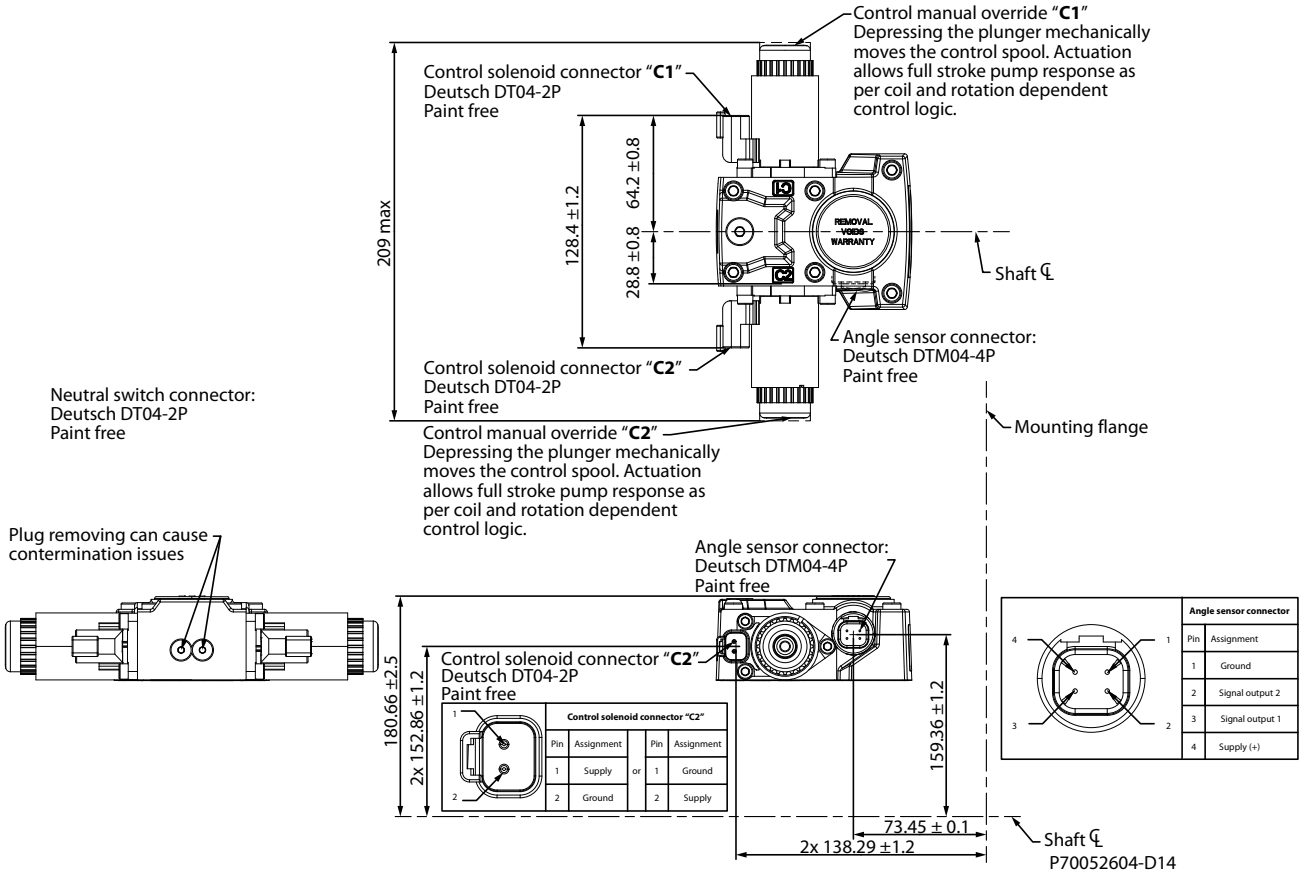
Controls

Non Feedback Proportional Electric control (NFPE) with Angle Sensor

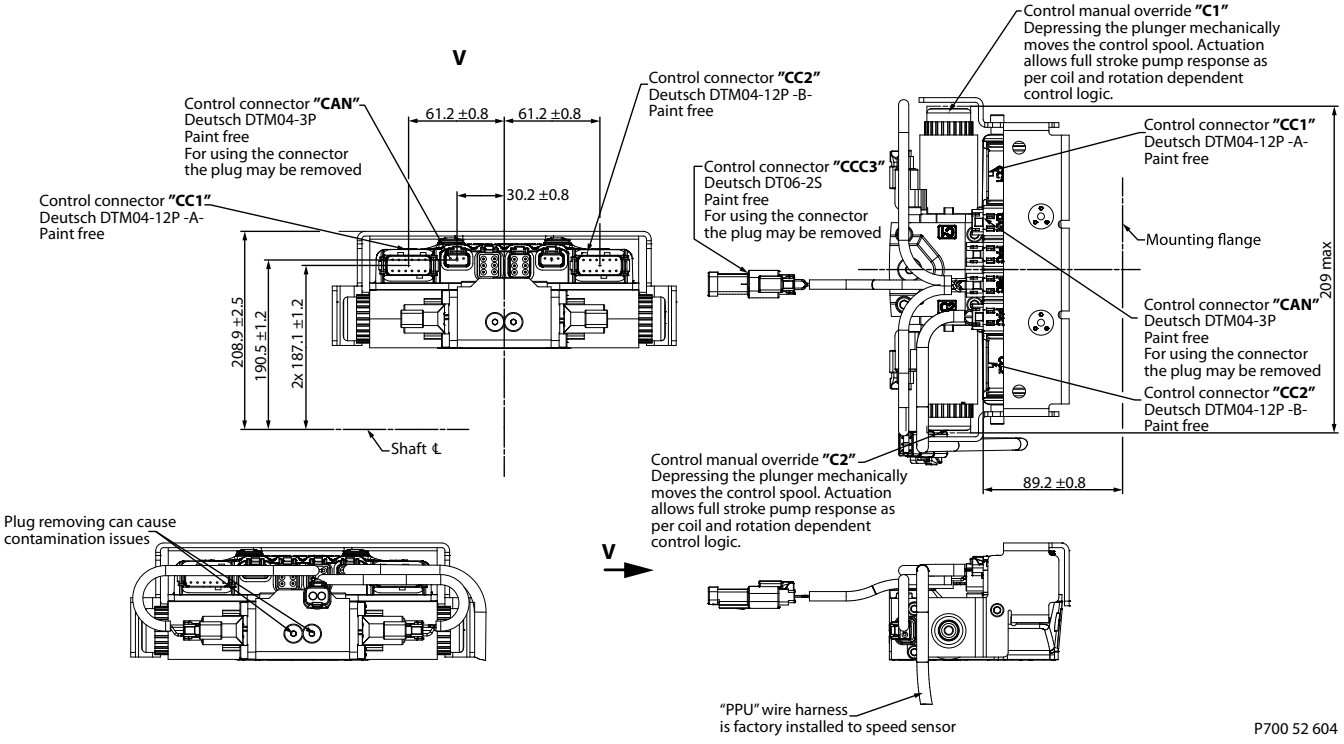


Please contact Danfoss for specific installation drawings.

Controls

Automotive controls with MOR (AC I: option A7, C2 and AC II: option B7, C3)

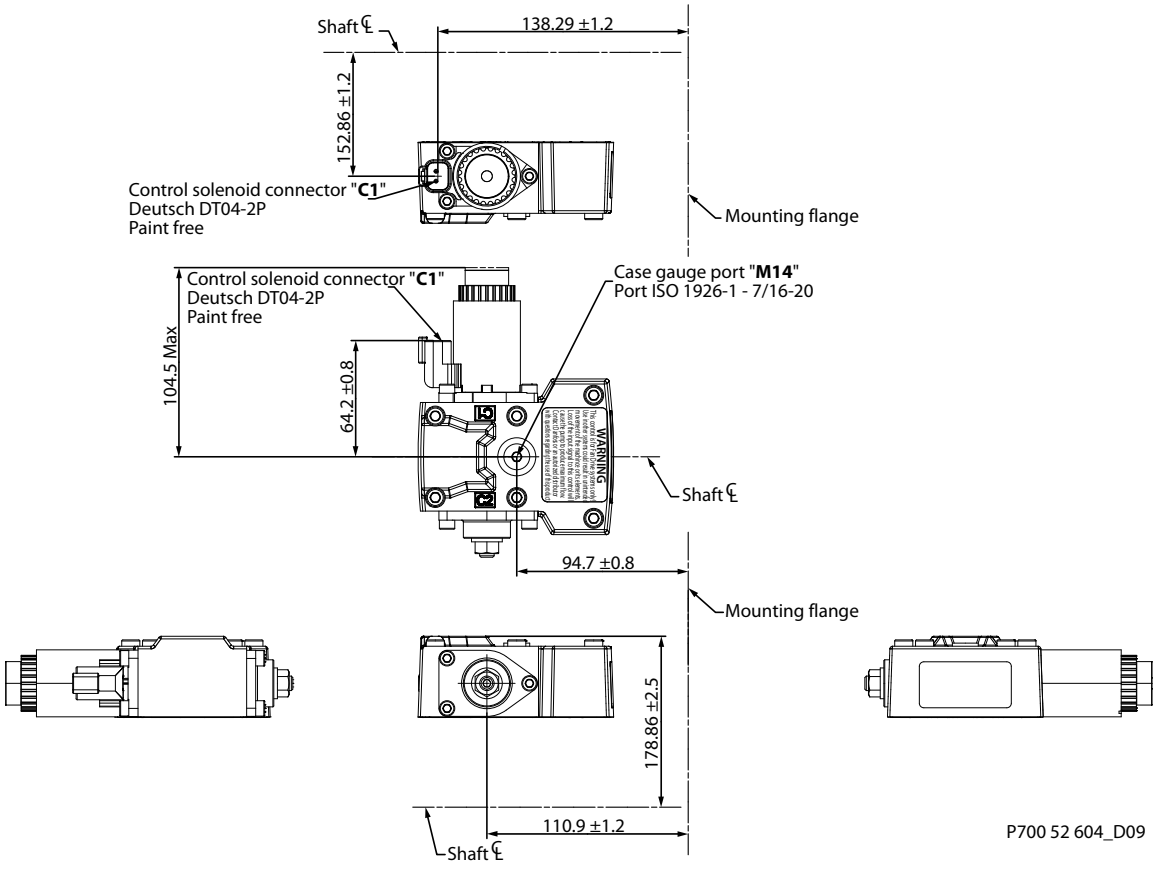
Automotive control with MOR: AC I – option A7 (12 V) and C2 (24 V)
Automotive control with MOR: AC II – option B7 (12V) and C3 (24V)



Please contact Danfoss for specific installation drawings.

Controls

Fan Drive Control (FDC), option F1 (12 V)/F2 (24 V)



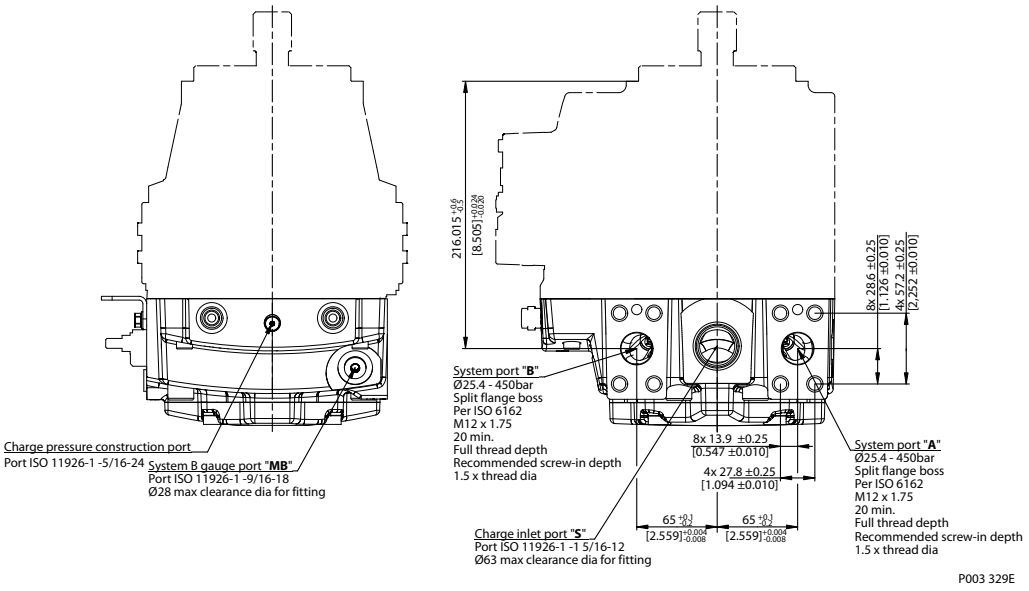
Control solenoid connector C1 and C2:

Pin	Assignment	Alternative	Pin	Assignment
1	Supply	OR	1	Ground
2	Ground		2	Supply

Please contact Danfoss for specific installation drawings.

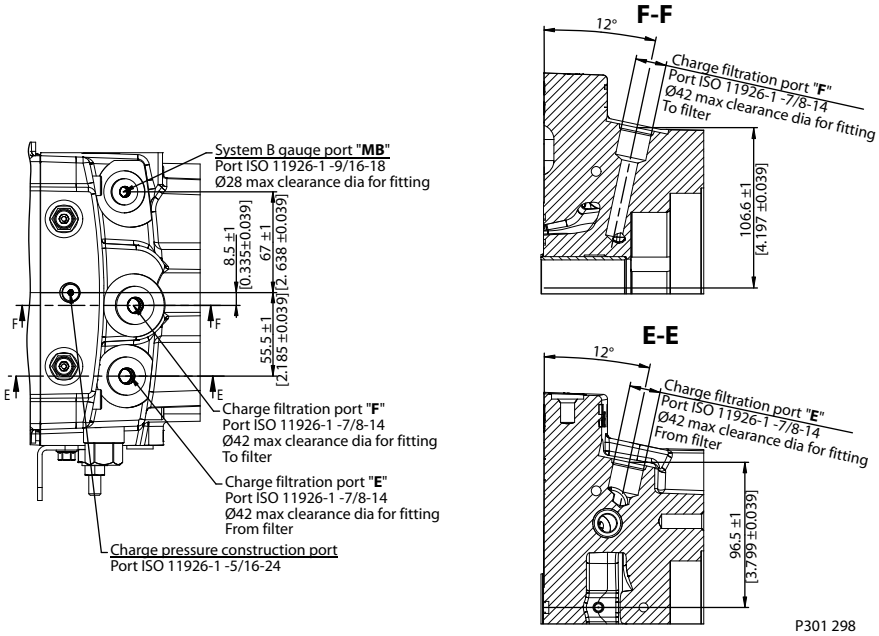
Filtration

H1P 069/078, suction filtration, option L



Please contact Danfoss for specific installation drawings.

Remote full charge pressure filtration, option P for end cap option F5 (SAE-C PTO)

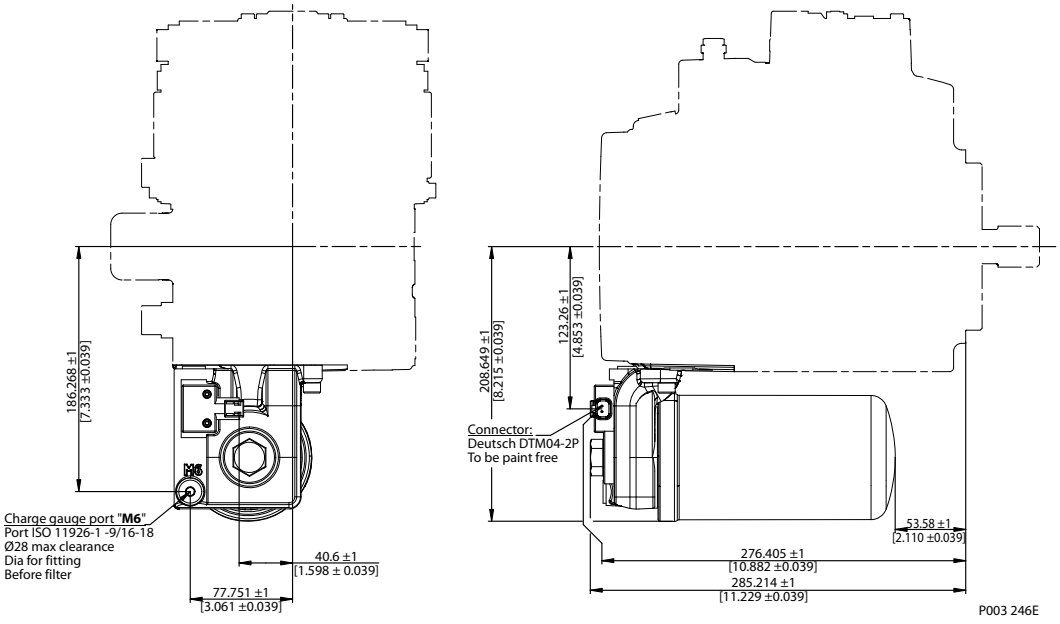


Please contact Danfoss for specific installation drawings.

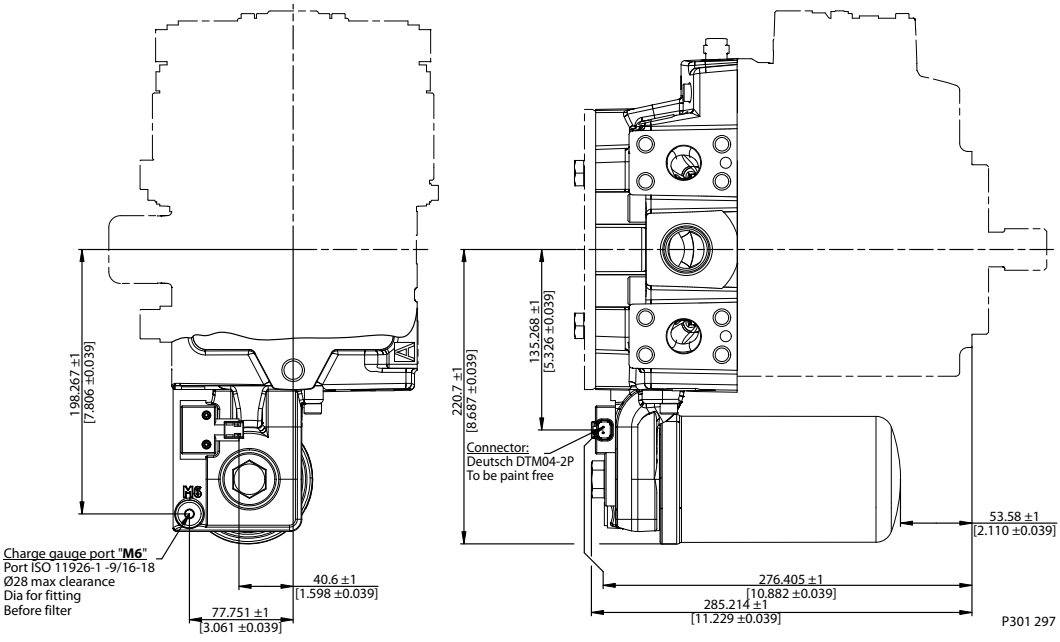
Filtration

Integral full flow charge pressure filtration with filter bypass sensor, option M

Integral full flow charge pressure filtration with filter bypass sensor, option M



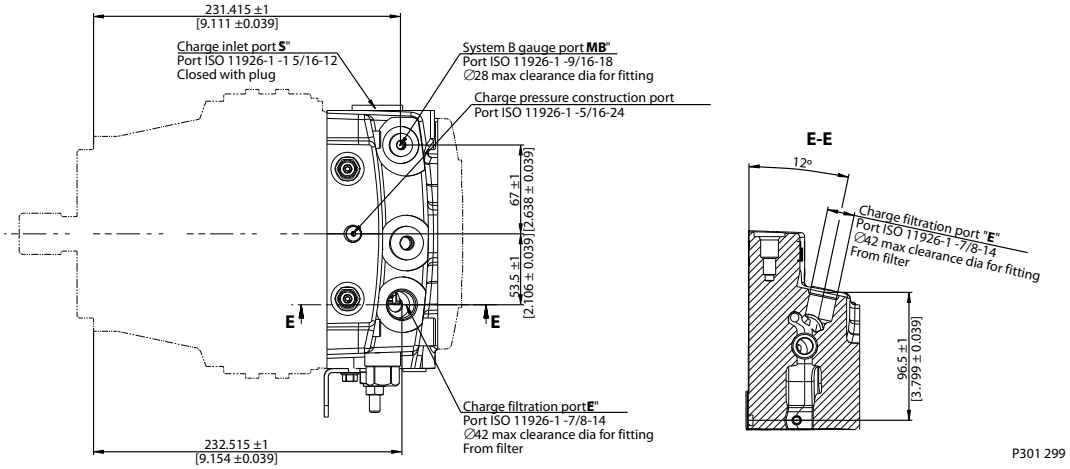
Integral full flow charge pressure filtration with filter bypass sensor, option M, for end cap option F4 (SAE-C PTO)



Please contact Danfoss for specific installation drawings.

Filtration

External full flow charge pressure filtration, option S for end cap options D8 or F5



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