

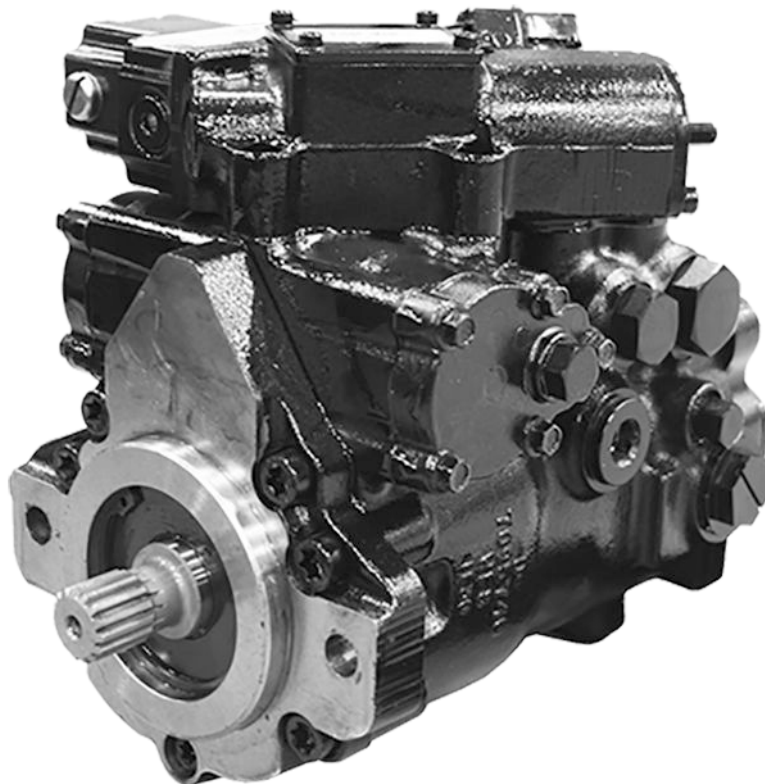
ENGINEERING
TOMORROW



Technical Information

Axial Piston Pumps

Series 40 M46



Revision history

Table of revisions

Date	Changed	Rev
March 2017	Minor updates - FNR Control options	0209
October 2016	Minor updates	0208
May 2015	more corrections to tandem pumps model code	BG
March 2015	correction to tandem pumps model code	BF
January 2015	minor edits	BE
January 2015	added port callouts - HC EDC drawings	BD
November 2014	corrections to shaft options	BC
July 2014	Edits to HC EDC Schematic	BB
April 2014	Danfoss layout	BA

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Specifications

Design Specifications

Product line	Series 40 Pumps
Pump type	In-line, axial piston, variable, positive displacement pumps
Direction rotation	Clockwise (CW) or counterclockwise (CCW) available
Installation position	Discretionary, the housing must be filled with hydraulic fluid
Filtration configuration	Suction or charge pressure filtration
Other system requirements	Independent braking system, suitable reservoir and heat exchanger

Technical Specifications

Model		Unit	M46 Single Pump	M46 Tandem Pump
Displacement		cm ³ /rev [in ³ /rev]	45.9 [2.80]	45.9 x 2 [2.80 x 2]
Shaft Speed	Minimum	min-1 (rpm)		
	Rated	min-1 (rpm)	4000	
	Maximum	min-1 (rpm)	4100	
System Pressure	Maximum working*	bar [psi]	345 [5000]	
	Maximum		385 [5585]	
	Minimum low loop		10 [145]	
Weight (MDC without aux pad)		kg [lb]	33 [73]	59 [131]
Mass moment of inertia of the rotating components		kg · m ² [slug · ft ²]	0.0050 [0.0037]	0.0100 [0.0073]
Charge Pressure	Minimum	bar [psi]	6 [87]	
	Maximum		31 [450]	
Control Pressure	Minimum @ corner power	bar [psi]	21.5 [312]	
Case Pressure	Continuous	bar [psi]	1.7 [25]	
	Maximum (cold start)		5.2 [75]	
Inlet Pressure	Rated	bar absolute [inches of Mercury vacuum]	0.8 [6]	
	Minimum		6 [9.2 Maximum]	

* Operation above maximum working pressure is permissible with Danfoss application approval.

Operating Parameters

Fluid Viscosity	Minimum	mm ² /s (cSt) [SUS]	7 [49]
	Continuous		12-16 [70-278]
	Maximum (cold start)		1600 [7500]
	Intermittent ¹		6 [46]

Specifications

Fluid Temperature	Minimum (intermittent cold start)	degrees C [degrees F]	- 40° C [- 40° F]
	Continuous		82.2° C [180° F]
	Maximum Intermittent ¹		104.4° C [220° F]

(1) Intermittent equals a short period of time at less than one minute per incident and not exceeding two percent of duty cycle based on load life.

Options

		Single	Tandem
Mounting Flange	SAE - B	X	X
Input Shaft	Ø 25.4 mm [1.000 in] straight keyed	X	X
	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501)	X	X
	13-tooth, 16/32 pitch (ANSI B92.1 1970 - Class 5)	X	-
	15-tooth, 16/32 pitch (ANSI B92.1 1970 - Class 5)	X	X
	19-tooth, 16/32 pitch (ANSI B92.1 1970 - Class 5)	-	X
Auxillary Mounting Flange	9-tooth internal spline, 16/32 pitch (SAE A)	X	X
	11-tooth internal spline, 16/32 pitch (SAE A)	X	X
	13-tooth internal spline, 16/32 pitch (SAE B)	X	X
	15 - tooth internal spline, 16/32 pitch (SAE BB)	-	X
Main Port Configuration	1-5/16 - 12 SAE A straight thread O-ring Ports (SAE J514)	X	X

Fluid specifications

Ratings and data are based on operation with premium petroleum-based hydraulic fluids reftaining oxidation, rust, and foam inhibitors.

Parameter	Unit	Minimum	reftinuous	Maximum
Viscosity	mm /sec (cSt) [SUS]	7 [47]	12-60 [70-278]	1600 [7500]
Temperature	°C [°F]	-40 [-40]	82 [180]	104 [220]
Cleanliness		ISO 4406 Class 18/13 or better		
Filtration efficiency	suction filtration	$\beta_{35-44}=75$ ($\beta_{10}\geq 1.5$)		
	charge filtration	$\beta_{15-20}=75$ ($\beta_{10}\geq 10$)		

General Information

M46 Pumps

M46 pumps are designed for medium power applications with maximum loads of 345 bar [5000 psi]. These pumps can be combined with other products in a system to transfer and control hydraulic power.

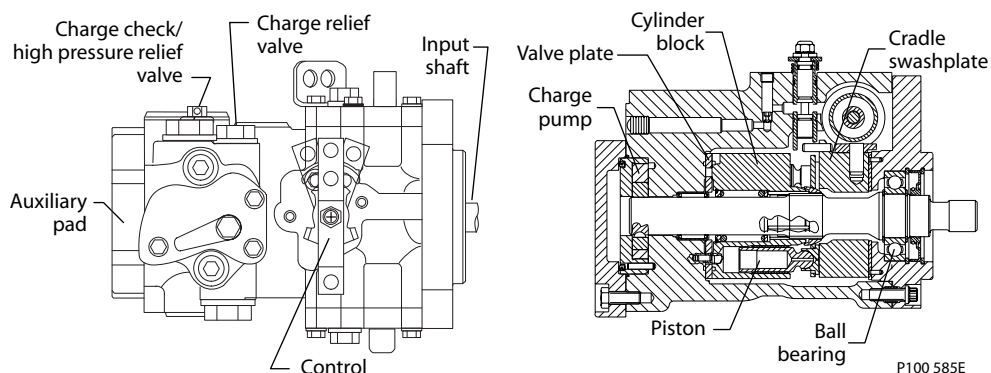
M46 pumps provide an infinitely variable speed range between zero and maximum in both forward and reverse modes of operation.

M46 pumps are compact, high power density units. All models use the parallel axial piston / slipper concept in conjunction with a tiltable swashplate to vary the pump's displacement. Reversing the angle of the swashplate reverses the flow of fluid from the pump, reversing the direction of rotation of the motor output.

M46 pumps may include an integral charge pump to provide system replenishing and cooling fluid flow, as well as servo control fluid flow. M46 pumps feature a range of auxiliary mounting pads to accept auxiliary hydraulic pumps for use in complementary hydraulic systems.

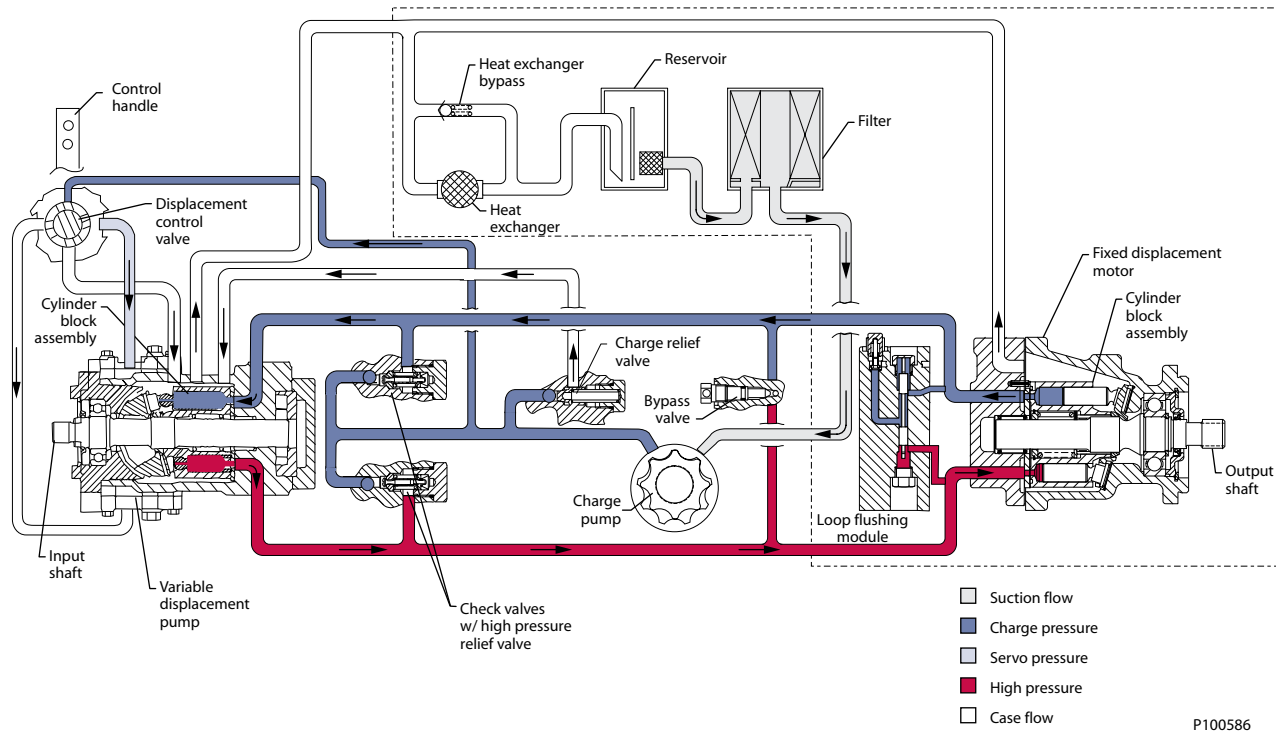
M46 pumps offer proportional controls with either manual, hydraulic, or electronic actuation. An electric three-position control is also available.

M46 Variable Pumps

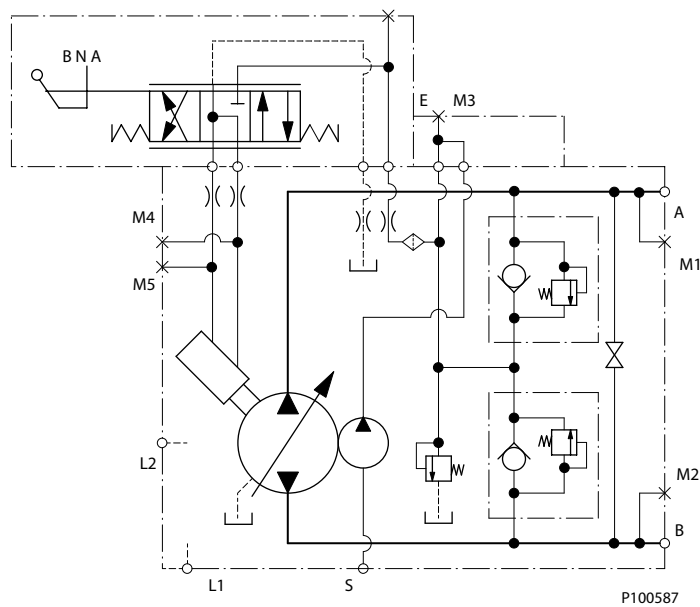


General Information

System Circuit Diagram



Schematic Diagram



Features and Options

Features

- Efficient Axial Piston Design
- Compact, Lightweight Pumps
- Worldwide Support
- Low Noise
- Single and Tandem Integrated Tandem Configurations
- Manual, Hydraulic or Electric Control

Options

High Pressure Relief Valve (HPRV) - A high pressure relief valve limits the system pressure to protect the system from over-pressure.

Charge Relief Valve - The charge pressure relief valve regulates charge pressure.

Displacement Limiters - Optional displacement limiters allow maximum displacement adjustment to allow for fine tuning of the propel system.

Auxiliary Mounting Pads - Several auxiliary mounting pad options allow for adding a second pump.

Control Options - Control options include manual displacement control (MDC), hydraulic displacement control (HDC), electric displacement control (EDC), and threeposition electric displacement control (FNR).

Input Shafts - Straight keyed, tapered keyed, and several splined shaft options are available.

Operating Parameters

Fluids

Ratings and performance data are based on operating with premium hydraulic fluids containing oxidation, rust, and foam inhibitors. These include premium turbine oils, API CD engine oils per SAE J183, M2C33F or G automatic transmission fluids (ATF), Dexron II (ATF) meeting Allison C-3 or Caterpillar T0-2 requirements, and certain specialty agricultural tractor fluids. For more information on hydraulic fluid selection, see Danfoss publications: *Hydraulic Fluids and Lubricants, Technical Information, 520L0463* and, *Experience with Biodegradable Hydraulic Fluids, Technical Information, 520L465*.

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.

Maximum temperature is based on material properties. Measure maximum temperature at the hottest point in the system. This is usually the case drain. The maximum viscosity should be encountered only at cold start, and is merely a reflection of a viscosity condition supporting an engine start, at idle. Normal vehicle operation and performance should not occur until the fluid viscosity improves with increased temperature. For more information on viscosity, see Danfoss publication, *Hydraulic Fluids and Lubricants, Technical Information 520L0463*.

Temperature

Maintain fluid temperature within the limits shown in the table. Minimum temperature relates to the physical properties of the component materials. Cold oil will not affect the durability of the pump components. However, it may affect the ability of the pump to transmit power.

Maximum temperature is based on material properties. Measure maximum temperature at the hottest point in the system. This is usually the case drain.

Ensure fluid temperature and viscosity limits are concurrently satisfied.

Charge Pressure

An internal charge relief valve regulates charge pressure. Charge pressure supplies the control with pressure to operate the swashplate and to maintain a minimum pressure in the low side of the transmission loop.

The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating at 1800 min⁻¹ [rpm], and with a fluid viscosity of 32 mm²/s [150 SUS]. Pumps configured with no charge pump (external charge supply) are set with a charge flow of 19 l/min [5 US gal/min] (single pumps), 38 l/min [10 US gal/min] (tandem pumps), and a fluid viscosity of 32 mm²/s [150 SUS].

The charge pressure setting is referenced to case pressure. Charge pressure is the differential pressure above case pressure.

Minimum charge pressure is the lowest pressure allowed in order to maintain a safe working condition in the low side of the loop. Minimum **control** pressure requirements are a function of speed, pressure, and swashplate angle, and may be higher than the minimum charge pressure shown in the *Specifications* section.

Maximum charge pressure is the highest charge pressure allowed by the charge relief adjustment, and which provides normal component life. Elevated charge pressure can be used as a secondary means to reduce the swashplate response time.

Control Pressure

Control pressure is the pressure in the servo system needed to position and hold the pump on stroke. Servo pressure depends on system pressure and speed.

Operating Parameters

At **minimum** control pressure, the pump will run at reduced stroke depending on speed and pressure.

Minimum control pressure at corner power holds the pump on full stroke at maximum speed and maximum pressure.

Maximum control pressure is the highest pressure typically given by the charge pressure setting.

Case Pressure

Under normal operating conditions, do not exceed rated case pressure. During cold start, keep case pressure below maximum intermittent case pressure.

CAUTION

Operating outside of charge and case pressure limits will damage the pump. To minimize this risk, use full size inlet and case drain plumbing, and limit line lengths.

System Pressure

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

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

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

Maximum pressure is the highest allowable application pressure under any circumstance. Application pressures above maximum working pressure will only be considered with duty cycle analysis and factory approval.

Minimum low loop pressure must be maintained under all operating conditions to avoid cavitation.

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

Speed Ratings

Minimum speed is the lowest input speed recommended during engine idle condition. Operating below minimum speed limits the 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.

For more information consult Pressure and Speed Limits BLN-9884, when determining speed limits for a particular application.

Operating Parameters

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.

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.

Inlet Pressure

Achieving acceptable pump life and performance requires proper charge pump inlet design. A **continuous inlet pressure** of not less than 0.8 bar absolute (not more than 6.3 inches Hg vacuum) is recommended. Normal pressure less than the **minimum inlet pressure** of 0.7 bar absolute (greater than 9.2 inches Hg vacuum) indicates inadequate inlet design or a restricted filter. Pressures less than 0.7 bar absolute (greater than 9.2 inches Hg vacuum) during cold start are likely, but should improve quickly as the fluid warms.

System Design Parameters

Sizing Equations

Use these equations to help choose the right pump size and displacement for your application.

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

Variables

SI units [US units]

V_g = Displacement per revolution cm^3/rev [in^3/rev]

p_o = Outlet pressure bar [psi]

p_i = Inlet pressure bar [psi]

$\Delta p = p_o - p_i$ (system pressure) bar [psi]

n = Speed min^{-1} (rpm)

η_v = Volumetric efficiency

η_m = Mechanical efficiency

η_t = Overall efficiency ($\eta_v \cdot \eta_m$)

Filtration

Ensure fluid entering pump is free of contaminants to prevent damage (including premature wear) to the system. M46 pumps require system filtration capable of maintaining fluid cleanliness at ISO 4406-1999 class 22/18/13 or better.

Consider these factors when selecting a system filter:

- Cleanliness specifications
- Contaminant ingress rates
- Flow capacity
- Desired maintenance interval

Locate filter either on the inlet (suction filtration) or discharge (charge pressure filtration) side of the charge pump.

Filter efficiency can be measured with a Beta ratio¹ (βX). 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. Systems with multiple cylinders that are feed from a single reservoir require a more efficient filter. This also applies to systems with gears or clutches using a common reservoir.

For high volume systems, use 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.

Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. Please see *Design Guidelines for Hydraulic Fluid Cleanliness Technical Information 520L0467* for more information.

System Design Parameters

Cleanliness level and β_x -ratio			
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.

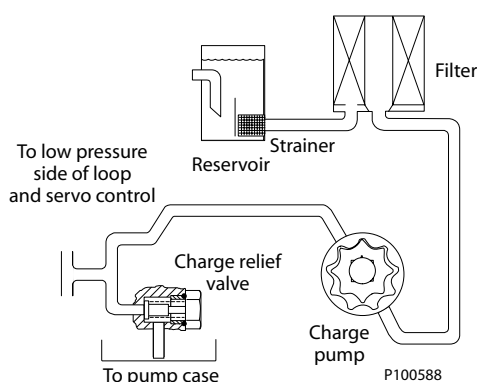
Suction Filtration

The filter is located between the reservoir and the charge pump inlet, as shown in the accompanying illustration.

! CAUTION

Operating outside of charge and case pressure limits will damage the pump. To minimize this risk, use full size inlet and case drain plumbing, and limit line lengths.

Suction filtration



Charge Pressure Filtration

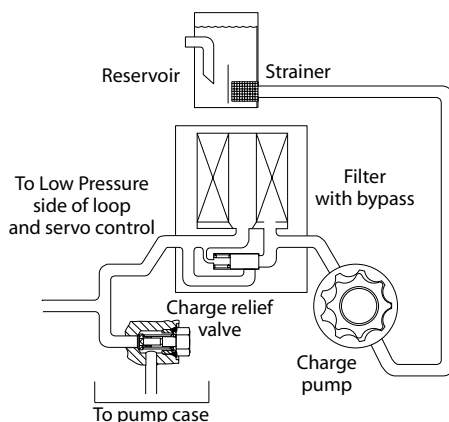
The filter is mounted remotely after the charge pump outlet, as shown in the accompanying illustration.

For charge pressure filtration, use a filter that is rated to at least 34.5 bar [500 psi] pressure. Use a 100 - 125 μm screen in the reservoir or charge inlet line.

A bypass valve is necessary to prevent filter damage and to avoid contaminants from being forced through the filter by high pressure. In the event of high pressure drop associated with a blocked filter or cold start-up conditions, fluid will bypass the filter. Avoid working with an open bypass for an extended period. We recommend a visual or electrical bypass indicator. Proper filter maintenance is mandatory.

System Design Parameters

Charge filtration



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Redundant Braking System Requirement

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.

Loop Flushing

Closed circuit systems may require loop flushing to meet temperature and cleanliness requirements. A loop flushing valve removes hot fluid from the low pressure side of the system loop for additional cooling and filtering. Ensure the charge pump provides adequate flow for loop flushing and the loop flushing valve does not cause charge pressure to drop below recommended limits.

Reservoir

The reservoir provides clean fluid, dissipates heat, and removes entrained air from the hydraulic fluid. It allows for fluid volume changes associated with fluid expansion and cylinder differential volumes. Minimum reservoir capacity depends on the volume needed to perform these functions. Typically, a capacity of one half the charge pump flow (per minute) is satisfactory for a closed reservoir. Open circuit systems sharing a common reservoir require greater fluid capacity.

Locate the reservoir outlet (suction line) near the bottom, allowing clearance for settling foreign particles. Use a 100 - 125 μm screen covering the outlet port.

Place the reservoir inlet (return lines) below the lowest expected fluid level, as far away from the outlet as possible.

Use a baffle (or baffles) between the reservoir inlet and outlet ports to promote de-aeration and reduce fluid surging.

Case Drain Usage for Tandem Pumps

The tandem housings are connected through the center section via a drilled hole. The charge relief valve discharges oil into the front housing. In order to provide positive flow through both housings, use a case

System Design Parameters

drain in the rear housing. The front housing case drain ports should only be used if the pump is used as a common drain manifold for the vehicle where external drain flow is brought into the rear housing and discharged out the front.

Allowable case pressure limits must be satisfied.

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.

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 L20 bearing life (80% survival) will exceed the hydraulic load-life of the unit.

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

M46 pumps are designed with bearings that can accept some external radial and thrust loads. 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. A high capacity (cylindrical roller) input shaft bearing is available for applications with high external shaft loads. Contact your Danfoss representative.

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

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

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

Contact your Danfoss representative for an evaluation of unit bearing life if continuously applied external radial loads are 25% or more of the maximum allowable, or if thrust loads are known to exist.

Shaft loading parameters

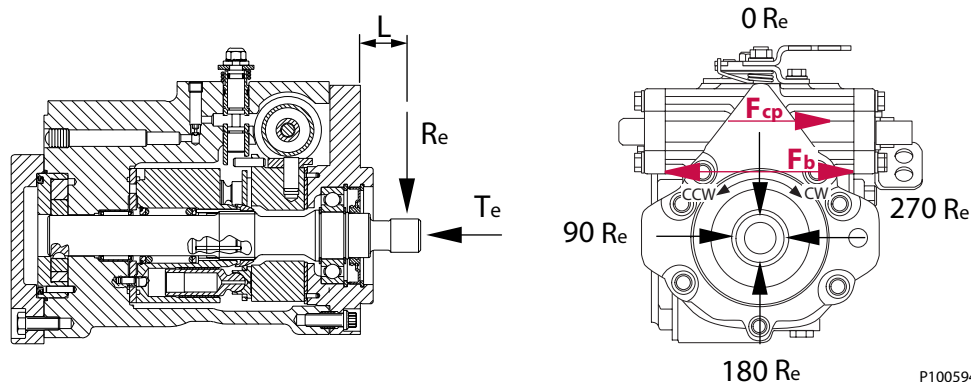
R_e	Maximum external radial load
M_e	M_e Maximum external moment
L	Distance from mounting flange to point of load
F_b	Force of cylinder block
T_e	Thrust external load
F_{cp}	Force of charge pump

System Design Parameters

Maximum external shaft moments

Standard Bearing	
Me/N•m [in•lbf]	186 [1650]

External radial shaft load



P100594

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.

M46 pumps will meet most application hydraulic unit life expectancies if applied within the parameters specified in this manual and chosen considering the guidelines within Danfoss publication *Selection of Driveline Components* **BLN-9885**. For more detailed information on hydraulic unit life, see Danfoss publication *Pressure and Speed Limits* **BLN-9884**.

Mounting Flange Loads

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

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

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

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

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

System Design Parameters

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

Estimated maximum and continuous acceleration factors for some typical Series 40 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.

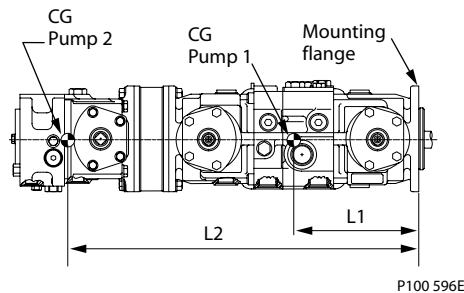
Overhung loading parameters

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

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]	
M46 PV	517	[4600]	832	[7400]
M46 PT	517	[4600]	754	[6700]

Shaft loading parameters



The illustration shows a tandem plus a single pump.

G-factors 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
* 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 spline lubrication

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

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

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

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

Shaft torque for tapered shafts

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

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

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

Model Code - Single Pumps

Single Pumps

Product	Frame	Type	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	Z
M P V	046	C																

C Swashplate

Description	Code	Remarks
Standard	B	

D - Seal Group

Description	Code	Remarks
Seal group for MDC	A	Must select an MDC control
Seal group for EDC/HDC/FNR	B	Must select an EDC/HDC/FNR control

E - Input Shaft/Auxiliary Spline

Description	Code	Remarks
13T 16/32 Spline / None	A	Requires S: None aux.. pad
13T 16/32 Spline / 9T 16/32 SplineR	B	Requires S: SAE-A aux.. pad
13T 16/32 Spline / 11T 16/32 Spline	L	Requires S: SAE-A aux.. pad
13T 16/32 Spline / 13T 16/32 Spline	D	Requires S: SAE-B aux.. pad
15T 16/32 Spline / None	G	Requires S: None aux.. pad
15T 16/32 Spline / 9T 16/32 Spline	H	Requires S: SAE-A aux.. pad
15T 16/32 Spline / 11T 16/32 Spline	J	Requires S: SAE-A aux.. pad
15T 16/32 Spline / 13T 16/32 Spline	K	Requires S: SAE-B aux.. pad
Tapered, 1 inch dia., 1.5 in/foot, square key/9T 16/32 Spline	P	Requires S: SAE-A aux.. pad. Includes key and nut
Tapered, 1 inch dia., 1.5 in/foot, square key/ 13T 16/32 Spline	S	Requires S: SAE-B aux.. pad. Includes key. Nut is customer supplied
Straight key, 1 inch diameter / None	V	Requires S: None aux.. pad. Includes key.
Straight key, 1 inch diameter / 9T 16/32 Spline	W	Requires S: SAE-A aux.. pad, includes key.

F - Rotation and valve plate

Description	Code	Remarks
CW, Quiet (Standard)	S	CP15; 3 deg. index. Requires charge pressure > 19.5 bar.
CCW, Quiet (Standard)	T	CP15; 3 deg. index. Requires charge pressure > 19.5 bar.

G - Charge pump

Description	Code	Remarks
None	A	Charge relief set at 19 l/min, external supply
13.9 cc [0.85 in./cu]	B	Charge relief set at 1800 rpm

Model Code - Single Pumps

H - Charge pressure

Description	Code	Remarks
19.5 bar	B	
21.5 bar	J	
25.0 bar	S	EDC/HDC controls calibrated at 20.7 bar charge

J - Filtration

Description	Code	Remarks
Suction, with charge pump	AA	Requires G: with charge pump
Remote pressure, with charge pump	BA	Requires G: with charge pump
Remote (external) pressure , without charge pump	BC	Requires G: no charge pump
Suction, with charge pump (HC EDC housing)	HA	requires G: with charge pump, N: with HC EDC
Remote pressure with charge pump(HC EDC housing)	HB	requires G: with charge pump, N: with HC EDC
Remote (external) pressure, without charge pump (HC EDC housing)	HC	requires G: no charge pump, N: with HC EDC

K - Displacement limiters

Description	Code	Remarks
Full displacement, 46 cc/rev [2.8 cu. in./rev]	A	
46 cc/rev [2.8 cu. in./rev] with adj. limiter, side #2 only, centered side #2	V	

L - Bypass valve

Description	Code
Bypass valve	A

M - System pressure protection, A and B ports

		Port protection	
Plug type	Letter	Port A	Port B
Standard	B	Relief/Check	Relief/Check

Second and Third Letter	
M	140 bar
B	175 bar
C	100 bar
D	210 bar
E	230 bar
F	250 bar
G	280 bar
H	300 bar
R	325 bar
J	345 bar

Contact your Danfoss representative for configurations or pressures not shown.

Model Code - Single Pumps

N - Control type

Description	Code	Remarks
MDC handle with (2) 10 mm diameter holes, standard spring	AB	Recommend AW with metered spool
MDC with (3) 10 mm diameter holes, standard spring	AC	Recommend AK with metered spool
MDC with (3) 10 mm diameter holes, U shaped, standard spring, metered spool	AK	
MDC handle with (2) 10 mm diameter holes, standard spring, metered spool	AW	
MDC heavy duty handle with (4) 10 mm diameter holes, heavy spring, metered spool	GB	P; handle position to be B
HDC 1.3-11.7 bar	BA	19-170 psi
HDC 3.0-13.8 bar	BB	44-200 psi
HDC 4.8-15.2 bar	BC	70-220 psi
EDC dual coil, oil filled, Packard connector, 4-pin, 23-132 mA	CE	
EDC dual coil, oil filled, MS connector, 4-pin, 23-132 mA	CG	
EDC dual coil, oil filled, Deutsch connector, 4-pin, 23-132 mA	CN	
FNR 12 volt, DIN 43650 connector	DA	
FNR 24 volt, DIN 43650 connector	DB	
EDC, high current, 12 volt, Deutsch connector, 2-pin	HA	
EDC, high current, 24 volt, Deutsch connector, 2-pin	HB	

P - Handle position

Description	Code	Remarks
Not applicable (EDC, HDC, FNR)	A	
Both, up and down	B	N: MDC to include heavy duty 4-hole handle. Handle is symmetric over spool
Down (MDC)	D	2, or 3 hole handles only. Handle oriented away from suction port.
Up (MDC)	U	2, or 3 hole handles only. Handle oriented towards from suction port.

R - Control orifice (contact factory for orifice options not shown)

MDC							
		Supply				Drain	(Supply and drain orifice chosen independently)
F	-	None		F	-	None	
A	-	0.031 inch		A	-	0.031 inch	
B	-	0.036 inch		B	-	0.036 inch	
C	-	0.041 inch		D	-	0.041 inch	
D	-	0.046 inch					

EDC/HDC/FNR - Servo A and B							
		Servo A&B					
GG	-	0.055 inch					
HH		0.037 inch					
JJ		None					

Model Code - Single Pumps

HC EDC - Servo A and B							
		Servo A&B					
HA	-	0.046 inch					
HB		0.055 inch					
HC		0.037 inch					
HD		0.024 inch					
HE		None					

S - Auxiliary mounting flange

Description	Code	Remarks
SAE A, side #2 lift bracket location	A	E: Shaft to include 9T or 11T aux.. spline
SAE B, side #2 lift bracket location	B	E: Shaft to include 13T aux.. spline
None, side #2 lift bracket location	C	E: Shaft to include no aux.. pad

T - Special hardware

Description	Code	Remarks
Black paint, Danfoss tag, Layout A	NNN	
High capacity shaft bearing, black paint, Danfoss tag, Layout A	NNR	

Z - Special features, Non hardware

Description	Code	Remarks
None	***	

Model Code - Tandem Pumps

Tandem Pumps

Product	Frame	Type	E	F	G	H	J
M P T	046	C					

Front Section	C	D	K	L	M	N	P	R			
Rear Section	Q	D	U	X	V	Y	Z	W	S	T	Z

E - Input Shaft

Description	Code	Remarks
15T 16/32 Spline	A	Requires S: None aux.. pad
19T 16/32 Spline	B	Requires S: SAE-B aux.. pad
Tapered, 1 inch dia., 1.5 in/foot, square key without thru hole	H	Includes key and nut.
Straight key, 1 inch diameter	D	Includes key.

F - Rotation and valve plate

Description	Code	Remarks
CW, without charge pump. Quiet (Standard)	S	CP15; 3 deg. index. Requires charge pressure > 19.5 bar.
CCW, without charge pump. Quiet (Standard)	T	CP15; 3 deg. index. Requires charge pressure > 19.5 bar.
CW, with 22.9 cc charge pump. Quiet (Standard)	V	CP15; 3 deg. index. Requires charge pressure > 19.5 bar.
CCW, with 22.9 cc charge pump. Quiet (Standard)	Z	CP15; 3 deg. index. Requires charge pressure > 19.5 bar.

G - Charge pump

Description	Code	Remarks
None	A	Charge relief set at 38 l/min, external supply
22.9 cc [1.4 in./cu]	C	Charge relief set at 1800 rpm. Filtration and rotation must include charge pump

H - Charge pressure

Description	Code	Remarks
19.5 bar	B	
21.5 bar	J	
25.0 bar	S	EDC/HDC controls calibrated at 20.7 bar charge

J - Filtration

Description	Code	Remarks
Suction, with charge pump	AA	Requires a charge pump
Remote pressure, with charge pump	BA	Requires a charge pump
Remote (external) pressure, without charge pump	BC	Requires no charge pump

Model Code - Tandem Pumps

C - Swashplate group, front pump/Q - Swashplate group, rear pump

Description	Code	Remarks
Balanced	B	

D - Seal Group

Description	Code	Remarks
Seal group for MDC - Front pump	A	Must select an MDC control
Seal group for EDC/HDC/FNR - Front pump	B	Must select an EDC/HDC/FNR control
Seal group for MDC - Rear pump	C	Must select an MDC control
Seal group for EDC/HDC/FNR - Rear pump	D	Must select an EDC/HDC/FNR control

K - Displacement limiters, front pump, U- Displacement limiters, rear pump

Description	Code	Remarks
Full displacement, 46 cc/rev [2.8 cu. in./rev]	A	
46 cc/rev [2.8 cu. in./rev] with adj. limiter, side #2 only, centered side #2	V	

L/X - Bypass valve

Description	Code
Bypass valve	A

M - System pressure protection, A and B ports V - System pressure protection, rear pump, A and B ports

		Port protection	
Plug type	First Letter	Port A	Port B
Standard	B	Relief/Check	Relief/Check

Second and Third Letter	
M	140 bar
B	175 bar
C	100 bar
D	210 bar
E	230 bar
F	250 bar
G	280 bar
H	300 bar
R	325 bar
J	345 bar

Contact your Danfoss representative for configurations or pressures not shown.

N - Control type, front pump/Y - Control type, rear pump

Description	Code	Remarks
MDC handle with (2) 10 mm diameter holes, standard spring	AB	Recommend AW with metered spool
MDC with (3) 10 mm diameter holes, standard spring	AC	Recommend AK with metered spool
MDC with (3) 10 mm diameter holes, U shaped, standard spring, metered spool	AK	

Model Code - Tandem Pumps

N - Control type, front pump / Y - Control type, rear pump (continued)

Description	Code	Remarks
MDC handle with (2) 10 mm diameter holes, standard spring, metered spool	AW	
MDC heavy duty handle with (4) 10 mm diameter holes, heavy spring, metered spool	GB	P; handle position to be B
HDC 1.3-11.7 bar	BA	19-170 psi
HDC 3.0-13.8 bar	BB	44-200 psi
HDC 4.8-15.2 bar	BC	70-220 psi
EDC dual coil, oil filled, Packard connector, 4-pin, 23-132 mA	CE	
EDC dual coil, oil filled, MS connector, 4-pin, 23-132 mA	CG	
EDC dual coil, oil filled, Deutsch connector, 4-pin, 23-132 mA	CN	
FNR 12 volt, DIN 43650 connector	DA	
FNR 24 volt, DIN 43650 connector	DB	

P/Z - Handle position

Description	Code	Remarks
Not applicable (EDC, HDC, FNR)	A	EDC, HDC, FNR only
Both, up and down	B	N: MDC to include heavy duty 4-hole handle. Handle is symmetric over spool
Down (MDC)	D	2, or 3 hole handles only. Handle oriented away from suction port.
Up (MDC)	U	2, or 3 hole handles only. Handle oriented towards from suction port.

R - Control orifice, front pump, W - Control orifice, rear pump

MDC							
		Supply				Drain	(Supply and drain orifice chosen independently)
F	-	None		F	-	None	
A	-	0.031 inch		A	-	0.031 inch	
B	-	0.036 inch		B	-	0.036 inch	
C	-	0.041 inch		D	-	0.041 inch	
D	-	0.046 inch					

EDC/HDC/FNR - Servo A and B							
		Servo A&B					
GG	-	0.055 inch					
HH		0.037 inch					
JJ		None					

S - Auxiliary mounting flange and coupling

Description	Code	Remarks
None	C	
SAE A, 9 tooth 16/32 spline	A	

Model Code - Tandem Pumps

S - Auxiliary mounting flange and coupling (continued)

Description	Code	Remarks
SAE A, 11 tooth 16/32 spline	D	
SAE B, 11 tooth 16/32 spline	B	

T - Special hardware

Description	Code	Remarks
Black paint, Danfoss tag, Layout A	NNN	
High capacity shaft bearing, black paint, Danfoss tag, Layout A	NNR	

Z - Special features, Non hardware

Description	Code	Remarks
None	***	

Options

Shaft options

Recommended mating splines for Series 40 splined output shafts should be in accordance with ANSI B 92.1 Class 5. Danfoss external splines are modified Class 5 Fillet Root Side Fit. The external splined Major Diameter and Circular Tooth Thickness dimensions are reduced in order to assure a clearance fit with the mating spline. Other shaft options may exist. Contact your Danfoss representative for availability.

Single pumps

Code	Description	Maximum torque rating Nm [lbf in]	Drawing
V, W	Ø 25.4 mm [1.000 in] Straight keyed - Shipped with key	362 [3200]	P104415
P, S	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501) - No thru hole - Shipped with key only	497 [4400]	P104417

Options

Code	Description	Maximum torque rating Nm [lbf in]	Rated torque Nm [lbf in]	Drawing
A, B, L, D	13-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	226 [2000]	124 [1100]	
G, H, J, K	15-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	362 [3200]	153 [1350]	

Shaft options	Length	Shaft diameter	Full spline	Major diameter	Pitch diameter	No. teeth
	S	T	U	V	W	Y
A, B, D, L	32.9 [1.297]	20.3 [0.80]	16.26 [0.64]	21.72 [0.8550]	20.64 [0.8125]	13
G, H, J, K	37.7 [1.485]	22.3 [0.88]	23.4 [0.92]	24.89 [0.9800]	23.81 [0.9375]	15

Other shaft options may exist. Contact your Danfoss representative for availability and for specific installation drawings.

Options

Tandem pumps

Code	Description	Maximum torque rating Nm [lbf in]	Drawing
D	Ø 25.4 mm [1.000 in] Straight keyed - Shipped with key	362 [3200]	P104412
H	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501) - No thru hole - Shipped with key only	497 [4400]	P104414

Code	Description	Maximum torque rating Nm [lbf in]	Rated torque Nm [lbf in]	Drawing
A	15-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	362 [3200]	153 [1350]	P104416
B	19-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	734 [6500]	305 [2700]	

Options

Shaft options	Length	Shaft diameter	Full spline	Major diameter	Pitch diameter	No. teeth
	S	T	U	V	W	Y
A	37.7 [1.485]	22.3 [0.88]	23.4 [0.92]	24.89 [0.9800]	20.638 [0.9375]	15
B	37.7 [1.497]	28.7 [1.13]	24.1 [0.95]	31.24 [1.230]	30.163 [1.1875]	19

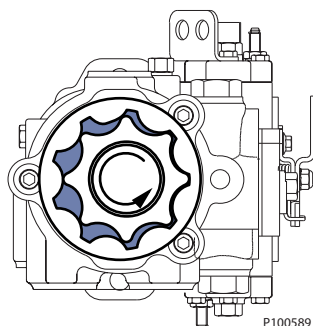
Other shaft options may exist. Contact your Danfoss representative for availability and for specific installation drawings.

Charge Pump

Charge flow is required on all M46 units to make up for internal leakage, maintain positive pressure in the main circuit, provide flow for cooling, replace any leakage losses from external valving or auxiliary systems, and to provide flow and pressure for the control system.

Maintain minimum charge pressure under all conditions of operation to prevent damage to the transmission.

Charge pump



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, control response characteristics, auxiliary flow requirements, hydraulic motor type, etc. Charge pump displacement should be equal to or greater than 10% of the total displacement of all units in the system.

The total charge flow requirement is the sum of the charge flow requirements of each of the components in the system. Use the information provided on the following pages to make a charge pump selection for a given application.

System features and conditions that may invalidate the 10% of displacement rule include (but are not limited to):

- Operation at low input speeds (below 1500 RPM)
- Shock loading
- Excessively long system lines
- Auxiliary flow requirements
- Use of low speed high torque motors

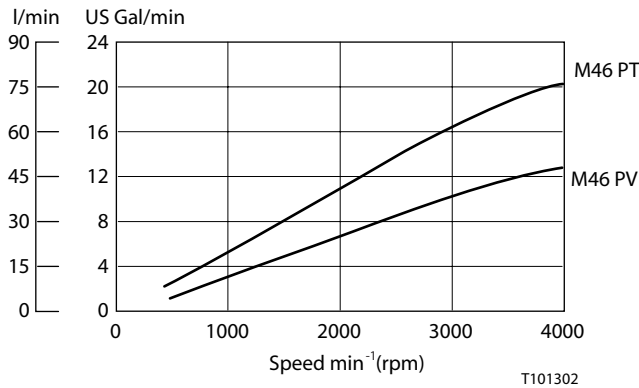
If a charge pump of sufficient displacement to meet the 10% of displacement rule is not available or if any of the above conditions exist which could invalidate the 10% rule, contact your Danfoss representative. A charge pump sizing worksheet is available in *Selection of Driveline Components* **BLN-9885**.

When an integral charge pump is not used, an external charge supply is required to ensure adequate charge pressure and cooling.

Options

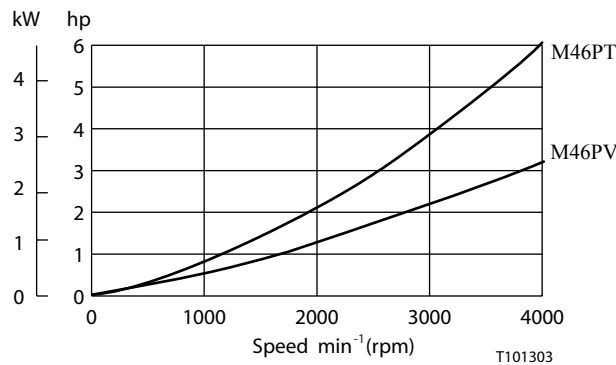
Charge Pump Output Flow

Flow at 19.5 bar charge relief setting, 70°C [160°F] inlet



Charge Pump Power Requirements

Power at 19.5 bar charge relief setting, 70°C [160°F] inlet



Higher charge pressure will influence charge flow and power.

Charge Relief Valve

An integral charge pressure relief valve provides a relief outlet for charge flow. This valve, in effect, sets charge pressure. Flow through the valve is ported to case.

The M46 PV/PT uses a cone-style poppet valve which dumps hydraulic fluid to the front pump.

The nominal charge relief setting is referenced to case pressure. It is factory set at 1800 min-1 (rpm) with the pump in neutral position. A proper charge relief setting takes into account input speeds and control requirements.

The charge pressure setting for pumps without an internal charge pump is set with an externally supplied charge flow of 19 l/min [5 US gal/min] on pumps and 38 l/min [10 US gal/min] on tandem pumps. These units must have adequate charge flow supplied to the charge inlet in order to maintain charge pressure at all times.

Incorrect charge pressure settings may result in the inability to build required system pressure and/or inadequate loop flushing flows. Ensure correct charge pressure under all conditions.

Options

The charge relief valve is factory set. If necessary, it can be field adjusted with shims.

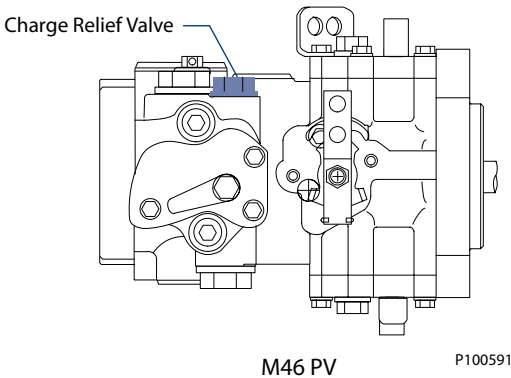
Charge Relief Valve Specs

M46		
Type	Cone poppet valve	
Available Setting	19.5-26.2 bar [285-380 psi]	
Adjustment	Via shims inside of valve cartridge*	
Rise Rate	Adjustment	2.3 bar [33 psi]/mm
	Performance	1.8 bar [26 psi]/10 lpm (Approx.)

*Shimming offers adjustment over a limited range. A spring change may be required to reach a higher setting.

Contact your Danfoss representative for further information regarding charge pressure relief valve options.

Charge relief valve location



High Pressure Relief Valve (HPRV) and Charge Check

All M46 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 loop, into the charge gallery, and into the low pressure loop via the charge check.

High pressure relief valves are a differential pressure valve referencing high system to charge (low system). The numeric model code represents the differential pressure setting, in bar. The model code allows for different pressure settings to be specified at each system port.

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.

CAUTION

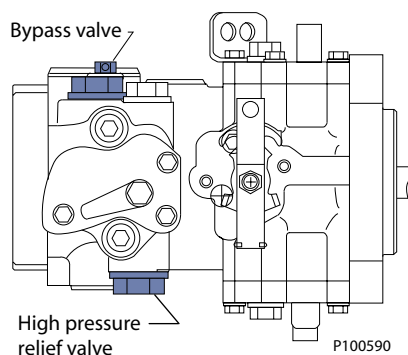
High pressure relief valves are intended for transient overpressure protection and are not intended for continuous pressure control. Flow over relief valves for extended periods of time may result in severe heat build up. High flows over relief valves may result in pressure levels exceeding the nominal valve setting and potential damage to system components.

Options

Check/high pressure relief valve specs

Type	Cartridge-style poppet valve
Setting	140-345 bar (2030-5000 psi)
Option	Check only - no relief valve

High pressure relief valve locations



Bypass Function

All M46 pumps are equipped with a loop bypass valve that connects the A and B sides of the working loop. The bypass function allows a machine to be moved without rotating the pump shaft or prime mover. To open the bypass valve turn it counterclockwise 2 full turns. Do not open past 2 full turns. Use a 5/8 inch hex wrench to open the valve. To return to normal operation, close the valve and torque to 20 Nm [15 ft•lbs]. Do not over torque the valve.

CAUTION

Do not move the machine faster than 20% of maximum speed or for more than 3 minutes. Towing faster or longer than described may result in damage to the drive motor(s). To return to normal operation, carefully close and torque the bypass valve.

Displacement Limiters

M46 single or tandem units are designed with optional non-adjustable mechanical displacement (stroke) limiters located in the servo piston. You can limit maximum displacement of the pump to a certain percent of its maximum displacement. These displacement limiters are fixed physical stops inside the pump, are not externally adjustable, and limit the pump symmetrically across both sides. Contact your Danfoss representative for a list of available settings.

It is also possible to configure an M46 pump with an externally adjustable displacement limiter screw on side #2 only. The screw is located on the side of the servo piston opposite the neutral adjustment screw.

Warning

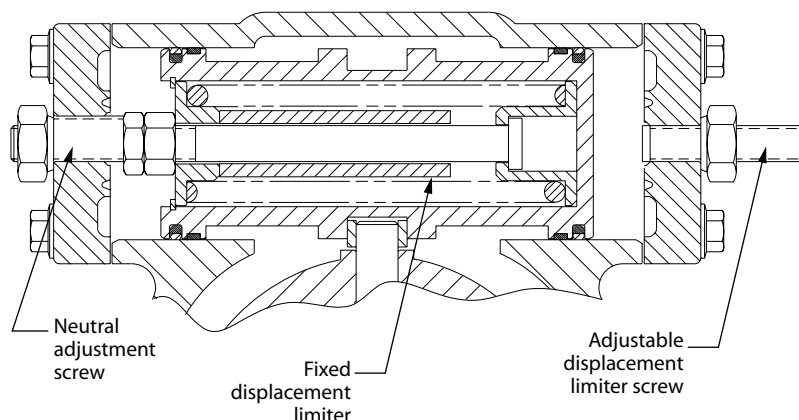
Unintended vehicle or machine movement hazard

Take care in adjusting displacement limiters to avoid an undesirable condition of output flow or speed. Re-torque the sealing lock nut after every adjustment to prevent an unexpected change in output conditions and to prevent external leakage during pump operation.

One full revolution of the adjustment screw produces a change in displacement of approximately 4.4 cm³/rev [0.27 in³/rev]. Full unit displacement is attained with the adjustment screw at its maximum extension from servo cover. All pumps are shipped with the limiter set for maximum pump displacement.

Options

M46 Displacement limiter (side #2)



P100 592E

Auxiliary Mounting Pads and Auxiliary Pumps

Auxiliary mounting pads are available on all pumps. A sealed shipping cover is included as standard equipment on all mounting pads.

An O-ring seals the auxiliary pump mounting flange to the pad. The drive spline is lubricated (flooded) with oil from the main pump case.

Spline specifications and torque ratings are shown in the accompanying table.

- All auxiliary mounting pads meet SAE J744 specifications
- Do not exceed the maximum pump input shaft rating shown in the Shaft availability and torque ratings table in the Shaft Options section
- Applications subject to severe vibratory or high G loading require an additional structural support. This is necessary to prevent leaks and possible mounting flange damage. Refer to Mounting flange loads in the System Design Parameters section, for additional information

Auxiliary mounting pad specs

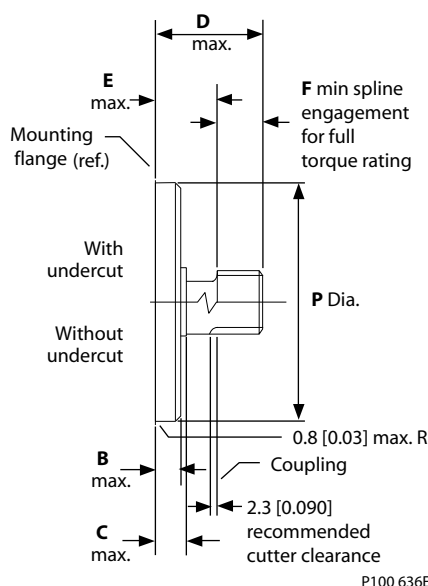
Internal spline size	Pad size	Maximum Torque Rating	
		Nm	[in lbf]
9T 16/32P	SAE A	107	[950]
11T 16/32P	SAE A	147	[1300]
13T 16/32P	SAE B	248	[2200]

The drawing and table below show the dimensions of the auxiliary pump mounting flanges and shafts. Auxiliary pump mounting flanges and shafts with the dimensions noted are compatible with the auxiliary mounting pads on the Series 40 pumps.

Auxiliary pump mating dimensions mm [in.]

Pad size	P	B	C	D	E	F
SAE A	82.55 [3.250]	6.35 [0.250]	12.70 [0.500]	58.2 [2.29]	15.0 [0.59]	13.5 [0.53]
SAE B	101.60 [4.000]	9.65 [0.380]	15.2 [0.60]	53.1 [2.09]	17.5 [0.69]	14.2 [0.56]

Options



Manual Displacement Control (MDC) - Options AB, AC, AK, AW, and GB

The Manual Displacement Control (MDC) converts a mechanical input signal to a hydraulic signal with a spring centered 4-way servo valve, and ports hydraulic pressure to either side of a double acting servo piston. The MDC provides output flow to the servo piston in proportion to the angular position of the control handle. The servo piston tilts the cradle swashplate, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

Due to normal operating force changes, the swashplate tends to drift from the position preset by the machine operator. Drift, sensed by the feedback linkage system connecting the swashplate to the control valve, activates the valve and supplies pressure to the servo piston, maintaining the swashplate in its preset position.

A metered control porting spool is available that provides improved controllability. The metered spool has machined notches that feather the porting of oil into and out-of the double acting servo piston when very small changes in control input are commanded. Nevertheless, the metered spool remains a high response control when normal input changes open the porting to a full open position, porting maximum flow to the servo cylinder. In neutral, these notches allow a small amount of pressure into both ends of the servo, elevating the neutral servo pressure slightly above case. This servo piston preloading improves the swashplate control coming out of neutral.

For a list of available control options, refer to the Model Code section.

Features:

- The MDC is a high gain control: with only a small movement of the control handle (input signal) the control valve moves to a full open position porting maximum flow to the servo cylinder. This is a high response control system with low input forces.
- Mechanical feedback senses swashplate reactions to load.
- Precision parts provide repeatable, accurate displacement settings with a given input signal.
- The servo piston is coupled to a spring centering mechanism.

Benefits:

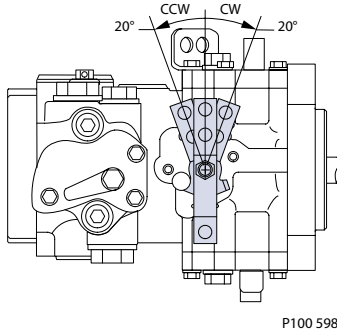
Options

- Simple-low cost design.
- Pump output is maintained regardless of load.
- Pump will return to neutral after prime mover shuts down.
- Pump returns to neutral if external control linkage becomes disconnected from the control handle or if there is a loss of charge pressure.

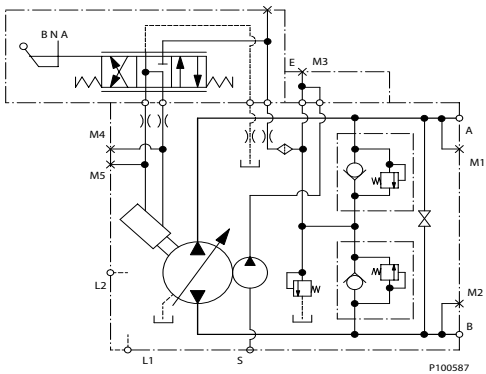
Control Handles and Springs

The standard MDC encompasses a three hole control handle with a standard return spring. This control is available with metered (standard) or non-metered porting spool. Optional two hole or four hole (heavy duty) control handles are available. The two hole handle is available with metered or non-metered spool and only available with a standard return spring. The four hole heavy duty handle is only available with metered spool and heavy return spring.

Three hole handle shown (in up position)



MDC Hydraulic schematic



Pump flow direction with MDC control

		Pump flow direction with MDC control			
		CW		CCW	
Single or Front Tandem	Handle Rotation	CW	CCW	CW	CCW
	Port A Flow	Out	In	In	Out
	Port B Flow	In	Out	Out	In
Rear Tandem	Handle Rotation	CW	CCW	CW	CCW
	Port C Flow	In	Out	Out	In
	Port D Flow	Out	In	In	Out
High Servo Gauge Port		M4	M5	M4	M5
Refer to pump installation drawing for port locations.					

All M46 pumps have a 40 mesh [0.4 mm (0.015 inch)] servicable screen located in the control supply port.

Response Time

The time required for the pump output flow to change from neutral to full flow (acceleration) or full flow to neutral (deceleration) is a function of the size of the supply orifice in the control inlet passage and the size of the drain orifice in the control sleeve.

A range of orifice sizes is available to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. The table at right shows some sample response times under certain conditions. (These figures assume 1775 min⁻¹ (rpm), 140 bar [2000 psi] system pressure, and 20 bar [290 psi] charge pressure.) Vehicle testing is required to determine the proper orifice sizes for the desired response.

Options

MDC Response time

Orifice diameter* mm [in]		Average response time [seconds]	
Supply	Drain	Acceleration	Deceleration
0.9 [0.036]	0.8 [0.031]	2.5	1.9
0.9 [0.036]	1.2 [0.046]	2.0	1.4
1.4 [0.054]	1.2 [0.046]	1.2	0.9
None	None	0.5	0.4

*Contact Danfoss for special orifice combinations.

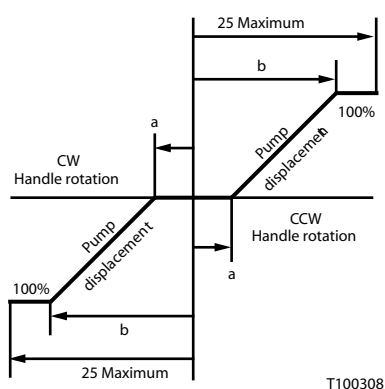
External control handle torque requirements

	Standard spring	Heavy duty spring
Rotation of handle to reach full displacement	20 degrees	20 degrees
Maximum handle rotation	25 degrees	25 degrees
Neutral deadband	± 1.5 degrees	± 0.8 degrees
Torque needed to begin handle rotation (1 degree)	1.2 Nm [11 in·lbf]	2.5 Nm [22 in·lbf]
Torque required to reach full stroke (20 degrees)	1.7 N·m [15 in·lbf]	3.4 N·m [30 in·lbf]
Maximum allowable handle torque	17 N·m [150 in·lbf]	17 N·m [150 in·lbf]

Handle direction

The MDC handle can be configured in either the up or down or both (symmetric) positions. The up position is shown on the previous page. The down position is oriented 180° of the up position.

Pump displacement vs control lever rotation



MDC signal required for swashplate position

	Swashplate position (refer to above chart)	
Handle configuration	Swashplate movement begins (point A) degrees	Full displacement reached (point B) degrees
Metered	0.8°	20°
Non-metered	1.5°	20°

Hydraulic Displacement - Options BA, BB and BC

The Hydraulic Displacement Control (HDC) is a two stage design which uses a hydraulic input signal to operate a spring centered 4-way servo valve, which ports hydraulic pressure to either side of a double

Options

acting servo piston. The servo piston tilts the cradle swashplate, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The HDC provides output flow in proportion to a hydraulic command signal. This allows for remote control of the machine with a hydraulic pressure source rather than with mechanical linkage. With no command signal, the control returns to neutral position. The HDC is only available with a non-metered spool.

For a list of available control options, refer to the Model Code section.

Features:

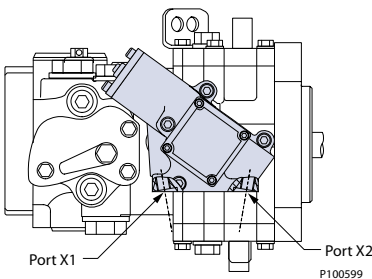
- The hydraulic displacement control is a high gain control: with only a small change in the input signal pressure level, the servo valve moves to a full open position, porting maximum flow to the servo cylinder.
- Internal mechanical stops on the servo valve allow rapid changes in input signal pressure without damaging the control mechanism.
- Precision parts provide repeatable, accurate displacement settings with a given input signal.
- Both ends of the double-acting servo piston are drained to case when input signal pressure is not present. The servo piston is coupled to a spring centering mechanism.

Benefits:

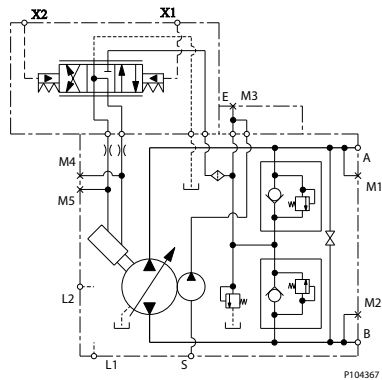
- Simple-low cost design.
- Pump will return to neutral after prime mover shuts down.
- Pump will return to neutral if external hydraulic input signal fails or if there is a loss of charge pressure.

All M46 pumps have a 40 mesh [0.4 mm (0.015 inch)] servicable screen located in the control supply port.

HDC on M46 PV



HDC Hydraulic schematic



Pump flow direction with HDC control

		Input Shaft Rotationump flow direction with MDC control			
		CW		CCW	
Single or Front Tandem	Higher pressure into control port:	X1	X2	X1	X2
	Port A Flow	Out	In	In	Out
	Port B Flow	In	Out	Out	In
Rear Tandem	Higher pressure into control port:	X1	X2	X1	X2
	Port C Flow	In	Out	Out	In
	Port D Flow	Out	In	In	Out
High Servo Gauge Port		M4	M5	M4	M5
Refer to pump installation drawing for port locations.					

Options

Response Time

The time required for the pump output flow to change from neutral to full flow (acceleration) or full flow to neutral (deceleration) is a function of the size of the supply orifice in the control inlet passage and the size of the drain orifice in the control sleeve.

A range of orifice sizes is available to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. The table at right shows some sample response times under certain conditions. (These figures assume 1775 min^{-1} (rpm), 140 bar [2000 psi] system pressure, and 20 bar [290 psi] charge pressure.) Vehicle testing is required to determine the proper orifice sizes for the desired response.

Control input signal requirements

The standard command signal range required to stroke the pump between neutral and full stroke is 1.3 to 11.7 bar [19 to 170 psi] differential. The maximum command pressure must not exceed 27.5 bar [400 psi].

HDC options

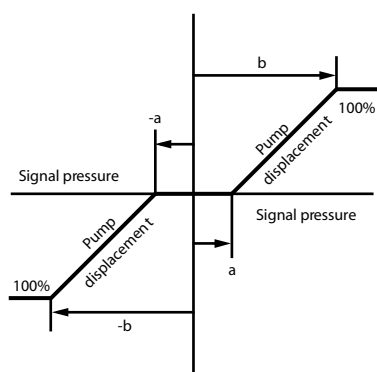
The HDC can be tailored to respond to a higher signal pressure. Optional heavy spring packs are available that operate in the 3 to 14 bar [44 to 200 psi] range and the 5 to 15 bar [70 to 220 psi] range.

HDC Response time

Orifice diameter* mm [in]		Average response time [seconds]	
		Acceleration	Deceleration
0.9 [0.037]	0.8 [0.031]	1.6	1.3
1.4 [0.055]	1.2 [0.046]	0.9	0.7
None	None	0.4	0.3

*Contact Danfoss for special orifice combinations.

Pump displacement vs control lever rotation



T101310-

HDC signal required for swashplate position

	Swashplate position (refer to above chart)			
	Swashplate movement begins (point A)		Full displacement reached (point B)	
Configuration	bar	[psid]	bar	[psid]
BA	1.3 ± 0.5	$[19 \pm 7]$	11.7 ± 1.1	$[170 \pm 16]$
BB	3.0 ± 0.7	$[44 \pm 10]$	13.8 ± 1.4	$[200 \pm 20]$
BC	4.8 ± 0.7	$[70 \pm 10]$	15.2 ± 1.4	$[220 \pm 20]$

Options

HDC Input specs

Maximum input pressure bar [psi]	27.5 [400]
----------------------------------	------------

Electrical Displacement Control- Options CE, CG, CM, and CN

The Electrical Displacement Control (EDC) is a three stage control similar to the HDC, but it uses an electrohydraulic Pressure Control Pilot (PCP) valve to control the pilot pressure. The PCP valve converts an electrical input signal to a hydraulic signal to operate a spring centered 4-way servo valve, which ports hydraulic pressure to either side of a double acting servo piston. The servo piston tilts the cradle swashplate, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The EDC provides output flow in proportion to a DC electrical command signal (current). This control is suited for applications where remote or automatic control of system function is required, or where closed loop feedback is needed. With no electrical command signal, the control returns to the neutral position. The EDC is only available with a nonmetered spool.

The M46 EDC is a current driven device designed for a DC signal. Use a PWM signal with a 100-200 Hz dither frequency for optimum control operation. Limit the amplitude of the PWM signal to 6 Vdc. For further assistance, contact your Danfoss representative.

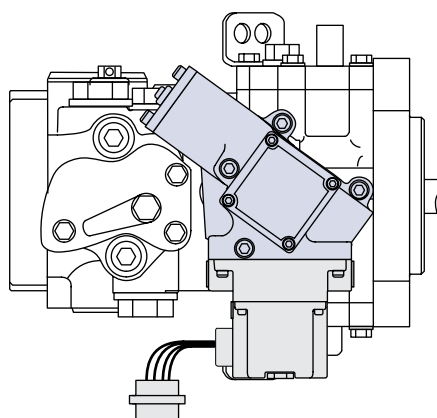
Features:

- The EDC is a high gain control: with only a small change in the input current, the servo valve moves to a full open position thus porting maximum flow to the servo cylinder.
- Oil filled PCP valve case lengthens control life by preventing moisture ingress and dampening component vibrations.
- Internal mechanical stops on the servo valve allow rapid changes in input signal voltages without damaging the control mechanism.
- Precision parts provide repeatable accurate displacement settings with a given input signal.
- Both ends of the double acting servo piston are drained to case when input signal current is not present. The servo piston is coupled to a spring centering mechanism.

Benefits:

- Simple, low-cost design.
- Pump will return to neutral after prime mover shuts down.
- Pump will return to neutral if external electrical input signal fails or if there is a loss of charge pressure.

EDC on M46 PV



P100600

Options

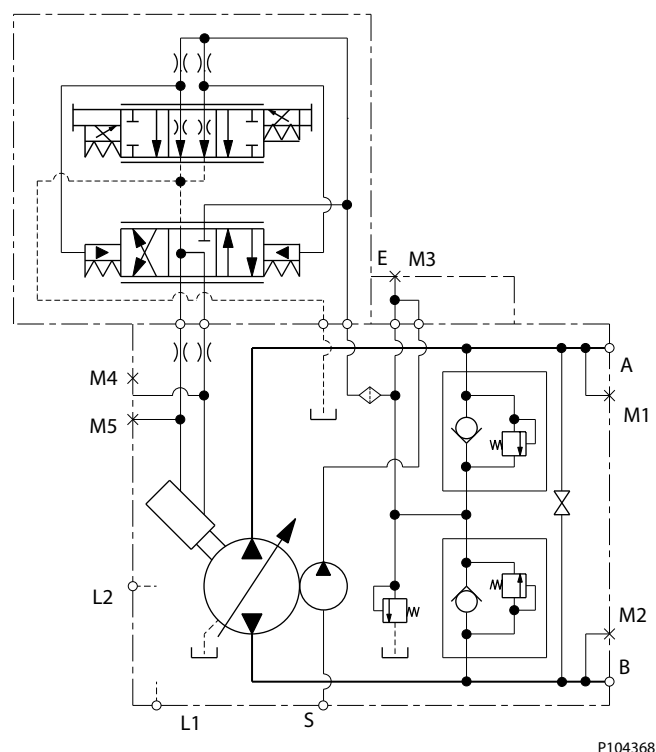
Pump flow direction with EDC control

	Positive signal to pin	Input Shaft Rotation			
		CW		CCW	
Single or Front Tandem	Single coil or Dual coil in parallel (A&C common, B&D common)	A or C	B or D	A or C	B or D
	Dual coil in series (B&C common)	A	D	A	D
	Port A Flow	Out	In	In	Out
	Port B Flow	In	Out	Out	In
Rear Tandem	Single coil or Dual coil in parallel (A&C common, B&D common)	A or C	B or D	A or C	B or D
	Dual coil in series (B&C common)	A	D	D	A
	Port C Flow	In	Out	Out	In
	Port D Flow	Out	In	In	Out
High Servo Gauge Port		M4	M5	M4	M5
Refer to pump installation drawing for port locations.					

All M46 pumps have a 40 mesh [0.4 mm (0.015 inch)] servicable screen located in the control supply port.

For a list of available control and connector options, refer to the Model Code section.

EDC Hydraulic Schematic



Response time

The time required for the pump output flow to change from neutral to full flow (acceleration) or full flow to neutral (deceleration) is a function of the size of the orifices in the servo and supply passages.

A range of orifice sizes is available to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. The table below shows some sample

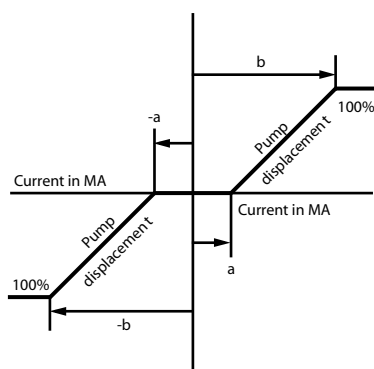
Options

response times under certain conditions. (These figures assume 1775 min⁻¹ (rpm), 140 bar [2000 psi] system pressure, and 20 bar [290 psi] charge pressure.) Test system response to determine the proper orifice selection for the desired response.

Control Input, Coils and Connectors

The standard EDC is a dual coil device with a silicone oil -filled case. It is available with a Packard Weather-Pak, Deutsch DT or MS connector. It is possible to design a system that uses only one coil or use both coils in series or in parallel. Using both coils allows for the use of two command stations with the resulting command being the algebraic sum of the two signals. The Deutsch DT connector has an IP67 rating. The MS connector is IP66 rated, and the Packard Weather-Pak connector is IP65 rated.

Pump displacement vs electrical control



T101312

EDC Input Options

Coil configuration	(Point a) mA	(Point b) mA	Pin Connections
Dual coil, using only one coil	23 ± 6	132 ± 18	A & B or C & D
Dual coil, coils in series	11.5 ± 3	65 ± 9	A & D (C & B common)
Dual coil, coils in parallel	23 ± 6	132 ± 18	AC & BD

* Dual coil EDCs are production tested using two coils in parallel.

Dual coil EDC input specs

	A-B coil	C-D coil
Coil resistance @24°C [75°F]	20 Ohms	16.5 Ohms
Coil resistance @104°C [220°F]	24.7 Ohms	19.7 Ohms

Contact factory for other control options, such as: Single coil or low current controls and for other connector options.

EDC Response time

Orifice diameter* mm [in]		Average response time [seconds]	
		Acceleration	Deceleration
0.9 [0.037]	0.8 [0.031]	1.6	1.3
1.4 [0.055]	1.2 [0.046]	0.9	0.7
None		0.4	0.3

*Contact Danfoss for special orifice combinations.

For further information refer to Danfoss publication *Electrical Displacement Control - MDT BLN-95-8988*.

Mount M46 pumps with an EDC control so the control is on the top or the side.

Options

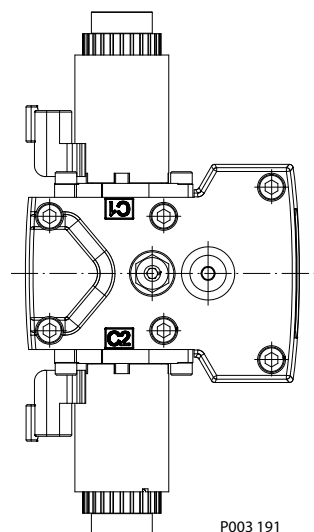
High Current Electric Displacement Control - Options HA (12Vdc) and HB (24Vdc)

High Current EDC principle

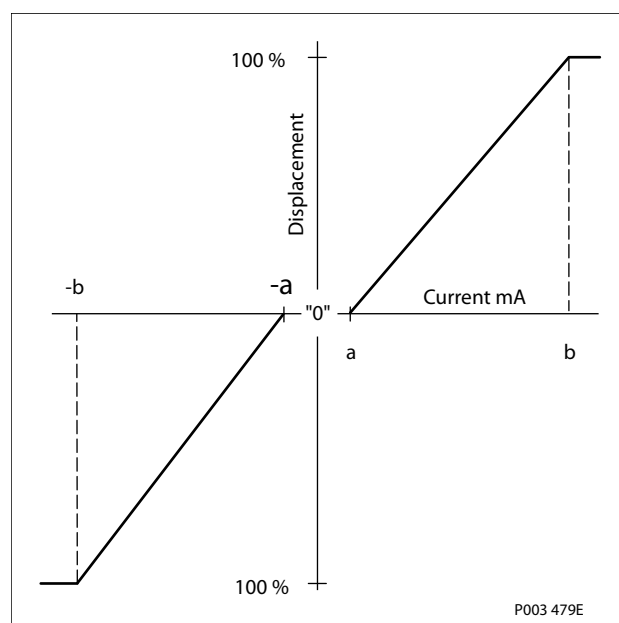
The High Current Electrical Displacement Control (HC EDC) consists of a pair of proportional solenoids on each side of a three-position, four-way porting spool. The proportional solenoid applies a force input to the spool, which ports hydraulic pressure to either side of a double acting servo piston. 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.

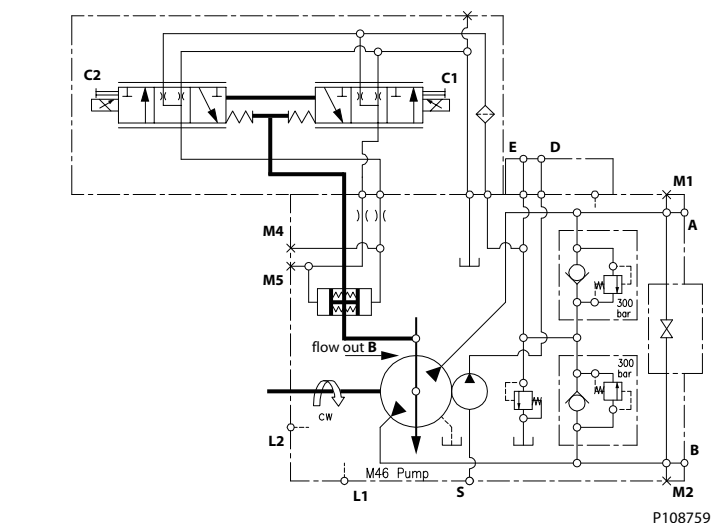


Pump displacement vs. control current



Options

Schematic diagram



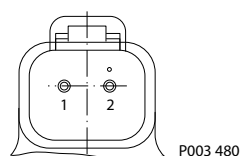
Control signal requirements

Control current

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

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

Connector



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

Voltage	12V	24V
Maximum current	1800 mA	920 mA
Coil resistance @ 20 °C [70 °F]	3.66 Ω	14.20 Ω
Coil resistance @ 80 °C [176 °F]	4.52 Ω	17.52 Ω
PWM Range	70-200 Hz	
PWM Frequency (preferred)**	100 Hz	

Options

Solenoid data (continued)

Voltage	12V	24V
Inductance	33 mH	140 mH
IP Rating (IEC 60 529) + DIN 40 050, part 9	IP 67	
IP Rating (IEC 60 529) + DIN 40 050, part 9 with mating connector	IP 69K	

* PWM signal required for optimum control performance.

Flow table

Shaft rotation	CW		CCW	
Coil energized*	C2	C1	C2	C1
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.

Response times

A range of servo orifice options are available to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). Software ramp or rate limiting should be used to control vehicle response in normal operation. 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. The table below shows some sample response times under certain conditions. These figures assume 1775 min⁻¹ (rpm), 140 bar [2000 psi] system pressure, and 20 bar [290 psi] charge pressure. Testing should be conducted to verify the proper software and orifice selection for the desired response.

Software is envisioned as the means to control the swashplate response in normal operating conditions. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.

Contact Danfoss technical representative for additional information regarding orifice options and response times.

Typical response times shown below at the following conditions:

Response times

HC EDC Response time

Orifice diameter* mm [in]	Average response time [seconds]	
	Acceleration	Deceleration
1.2 [0.046]	2.0	1.6
None	0.9	1.0

* Contact Danfoss for additional orifice combinations.

Manual OverRide (MOR)

All high current controls are standard with Manual Over Ride (MOR), used for temporary actuation of the control to aid in diagnostics.

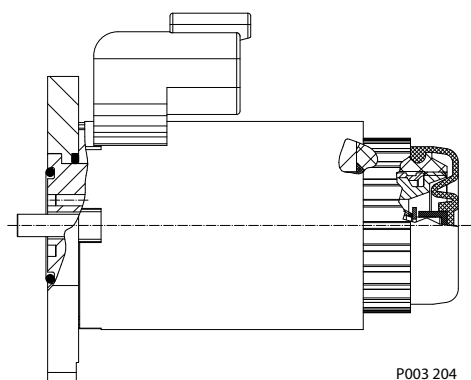
Options

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

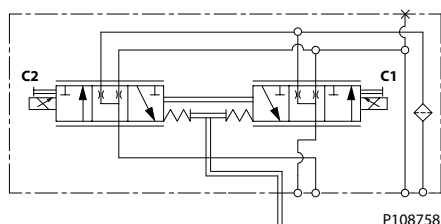
Warning

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

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



MOR Schematic diagram (EDC shown)



Three-position Electrical Control - Options DA and DB

The three-position Forward-Neutral-Reverse (FNR) is a two stage control that uses a solenoid operated 3-position, 4-way valve to move pump displacement from neutral to maximum displacement in either direction.

When a solenoid is energized, charge pressure is directed to one end of the pump servo control cylinder, which results in the pump going to maximum displacement. The direction of pump output flow is determined by which solenoid is energized. (See the accompanying table)

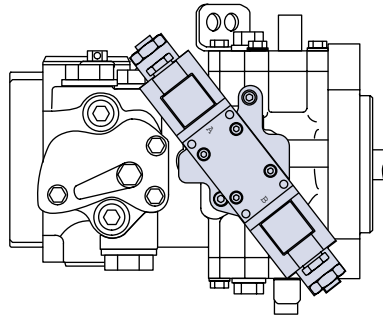
Features and benefits

- Electric control.
- If voltage is lost, the control returns pump to neutral.
- Simple, low-cost design.
- Ideal for non-propel applications that do not require proportional control.
- A manual override (MOR) option is available. It requires a 3 mm tool for engagement.

For a list of available control options, refer to the Model Code section.

Options

FNR Control on M46 PV



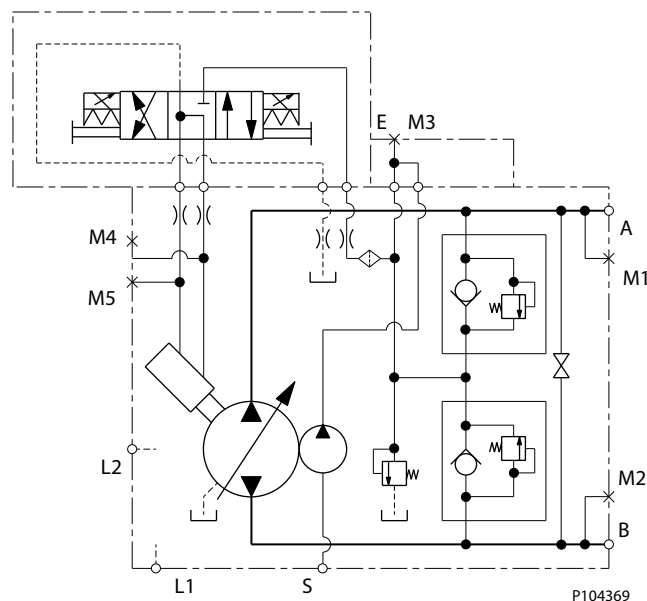
P100601

Pump flow direction with FNR control

		Input Shaft Rotation			
		CW		CCW	
Single or Front Tandem	Solenoid energized:	A	B	A	B
	Port A Flow	In	Out	Out	In
	Port B Flow	Out	In	In	Out
Rear Tandem	Solenoid energized:	A	B	A	B
	Port C Flow	Out	In	In	Out
	Port D Flow	In	Out	Out	In
High Servo Gauge Port		M5	M4	M5	M4
Refer to pump installation drawing for solenoid and port locations.					

All M46 pumps have a 40 mesh [0.4 mm (0.015 inch)] servicable screen located in the control supply port.

FNR Hydraulic schematic



Options

Response time

The time required for the pump output flow to change from neutral to full flow (acceleration) or full flow to neutral (deceleration) is a function of the size of the orifices in the servo, supply and drain passages.

A range of orifice sizes is available to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. The table below shows some sample response times under certain conditions. (These figures assume 1775 min⁻¹ (rpm), 140 bar [2000 psi] system pressure, and 20 bar [290 psi] charge pressure.) Test system response to determine the proper orifice selection for the desired response.

Control input signal requirements

The solenoids are available in versions for 12 or 24 Vdc. Maximum power consumption is 30 Watts. They are available with terminals for a DIN 43650 connector.

FNR Response time

Orifice diameter* mm [in]		Average response time [seconds]	
Acceleration	Deceleration		
0.9 [0.037]	0.8 [0.031]	1.6	1.3
1.4 [0.055]	1.2 [0.046]	0.9	0.7
None	None	0.4	0.3

*Contact Danfoss for special orifice combinations.

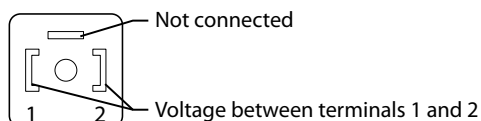
FNR input specifications

Vdc	12 or 24
Max power	30 W
Connectors	DIN 43650

FNR connector

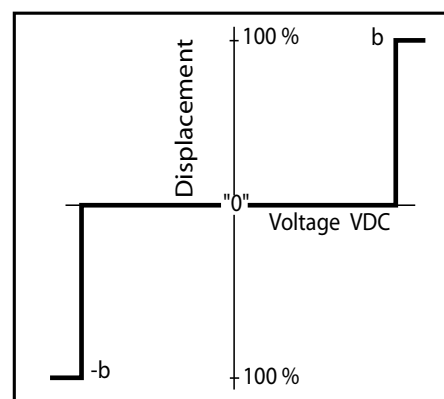
Solenoid plug face for DIN 43650 connector

DANFOSS
mating parts kit
Part No. K09129



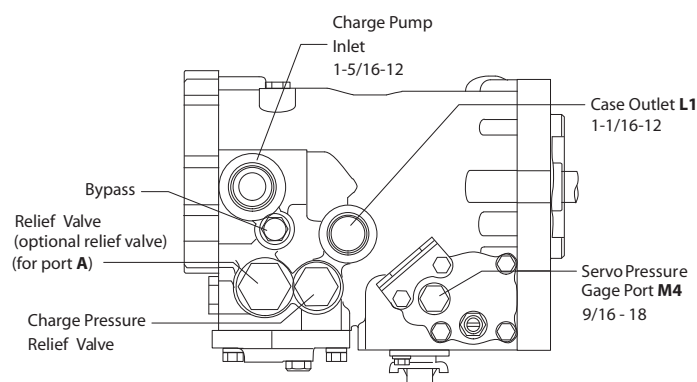
P109486

Pump displacement vs. electrical signal



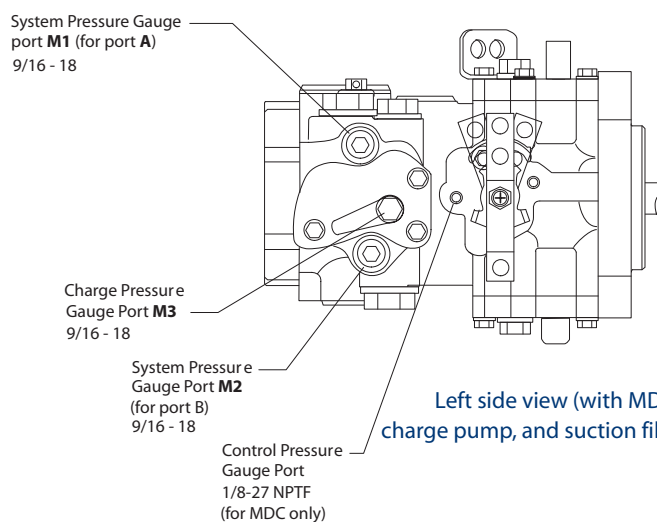
Port Locations

Single Pump



All ports are straight thread O-ring boss per ISO 11926-1 and SAE J1926/1

Top view (with MDC, charge pump, and suction filtration)



Left side view (with MDC, charge pump, and suction filtration)

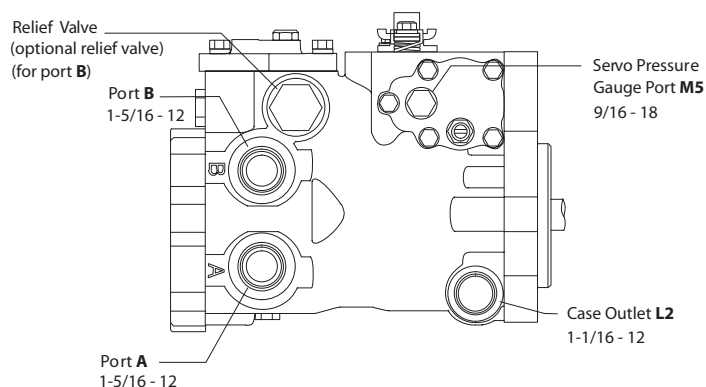
To remote filter D (pressure filter option) 7/8 - 14



From remote filter E (pressure filter option) or external charge supply E (no charge pump option) 7/8 - 14

LEFT SIDE VIEW

Remote filtration with or without charge pump

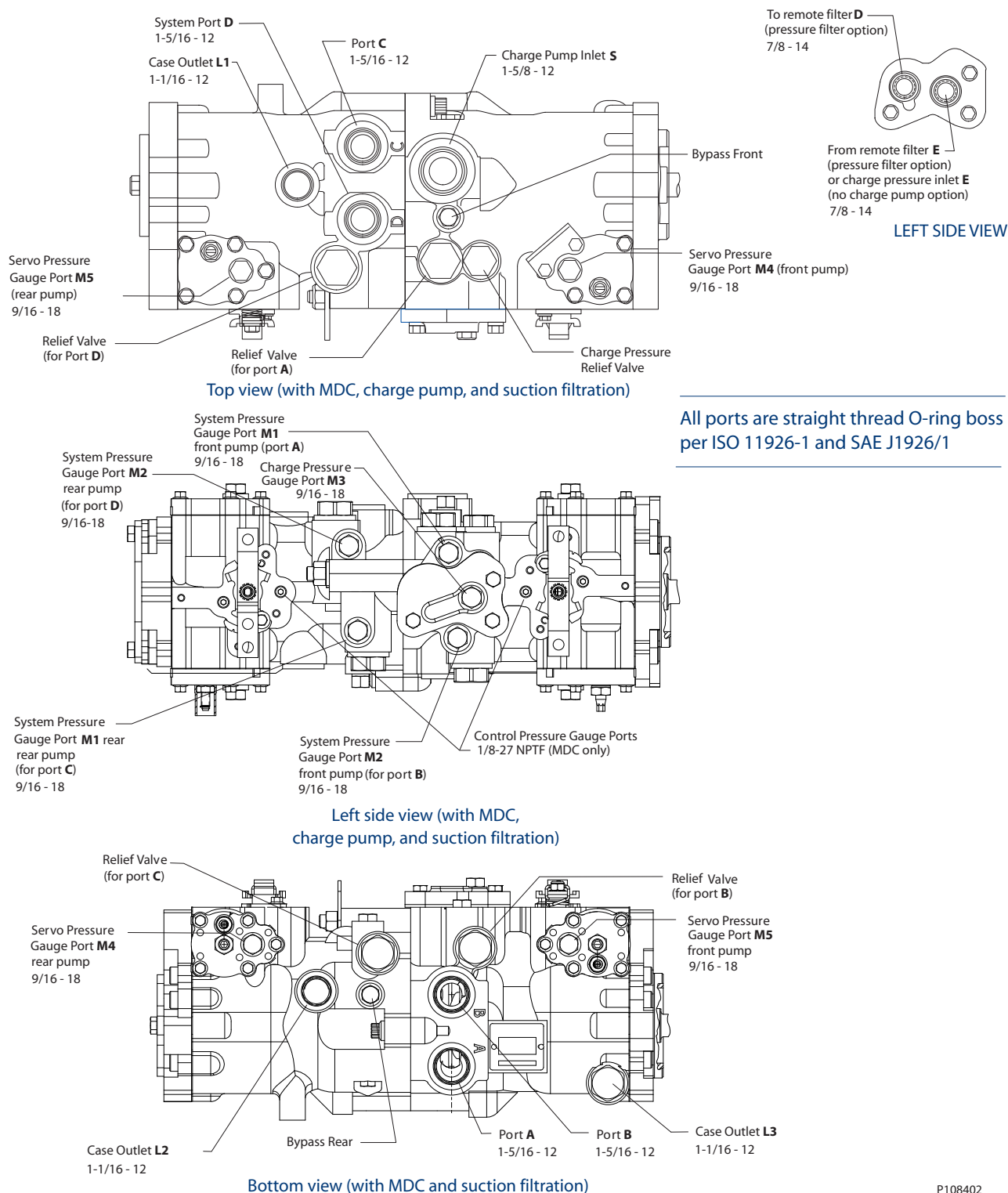


Bottom view (with MDC and suction filtration)

P108401

Port Locations

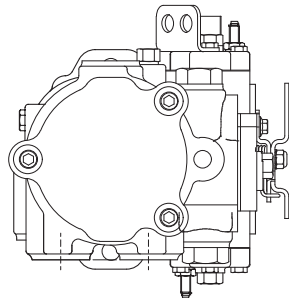
Tandem Pump



P108402

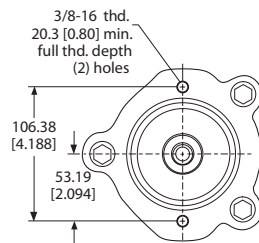
Installation Drawings - Single Pump Dimensions

Auxiliary Mounting Flanges

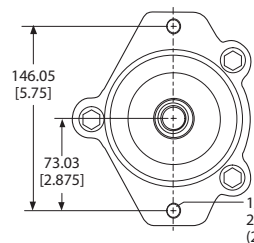
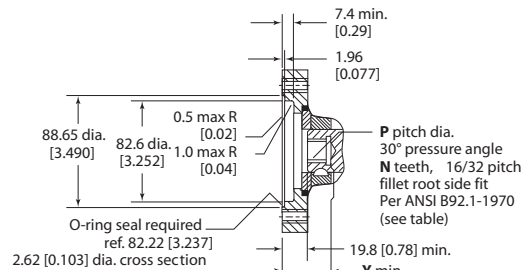


Rear view (no pads shown)

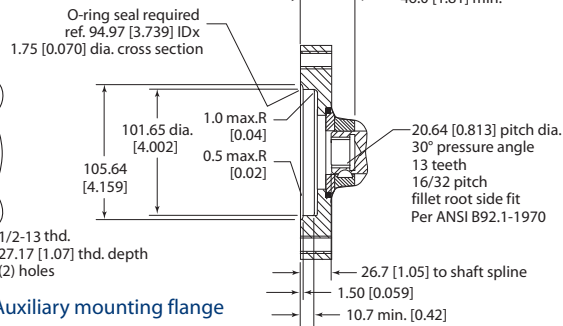
Contact Danfoss for individual dimension drawings



SAE A Auxiliary mounting flange
Options A and D



SAE B Auxiliary mounting flange
Option B



P100619

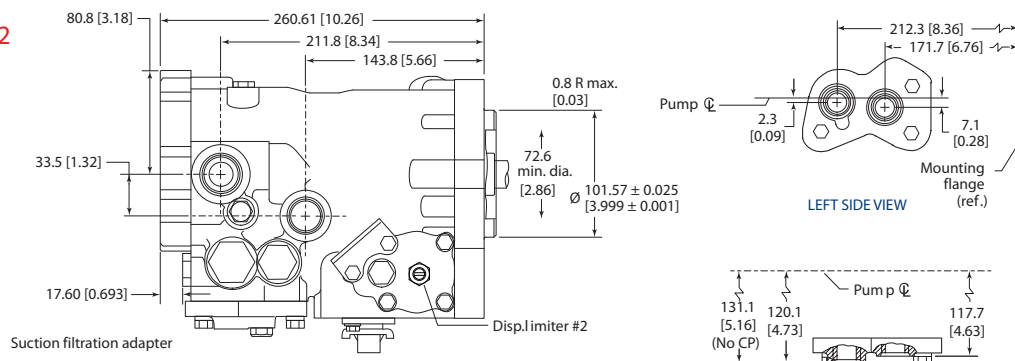
Auxiliary mounting flange and coupling options

Number of teeth N	Auxiliary mounting flange		Spline pitch dia. P	Minimum clearance Y
9	SAE A	Option A	14.29 [0.563]	36.6 [1.44]
11	SAE B	Option B	17.46 [0.688]	42.4 [1.67]

Installation Drawings - Single Pump Dimensions

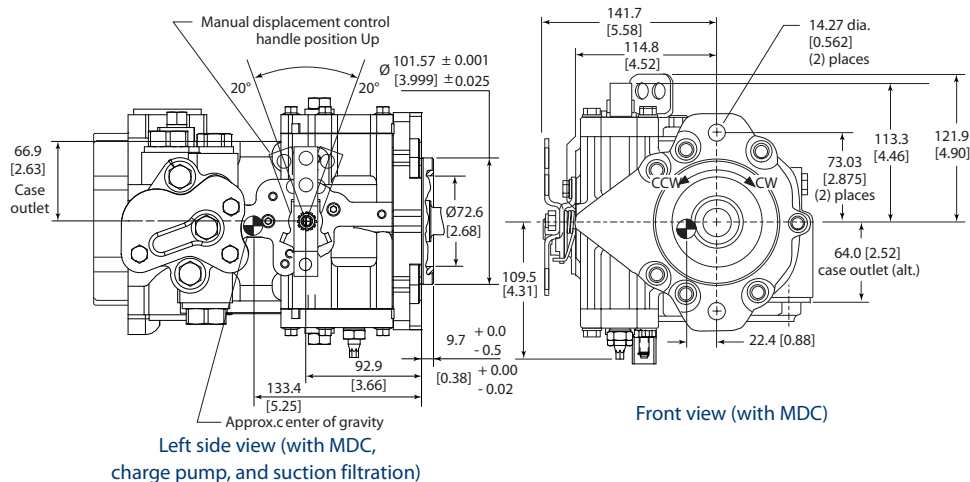
Pump, filtration/charge pump options, MDC, displacement limiter

Side #2



Top view (with MDC, charge pump, and suction filtration)

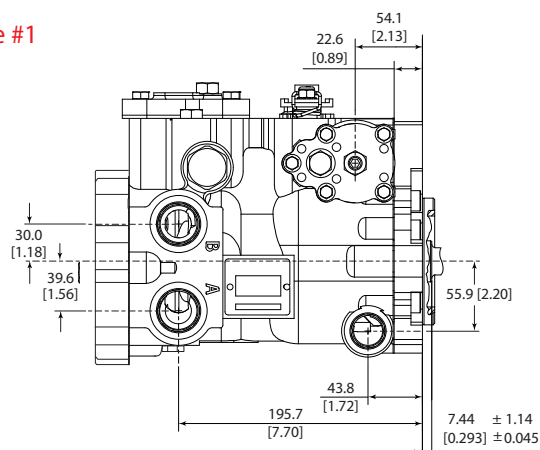
Remote filtration with or without charge pump



Left side view (with MDC, charge pump, and suction filtration)

Front view (with MDC)

Side #1



Bottom view (with MDC and suction filtration)

P100618

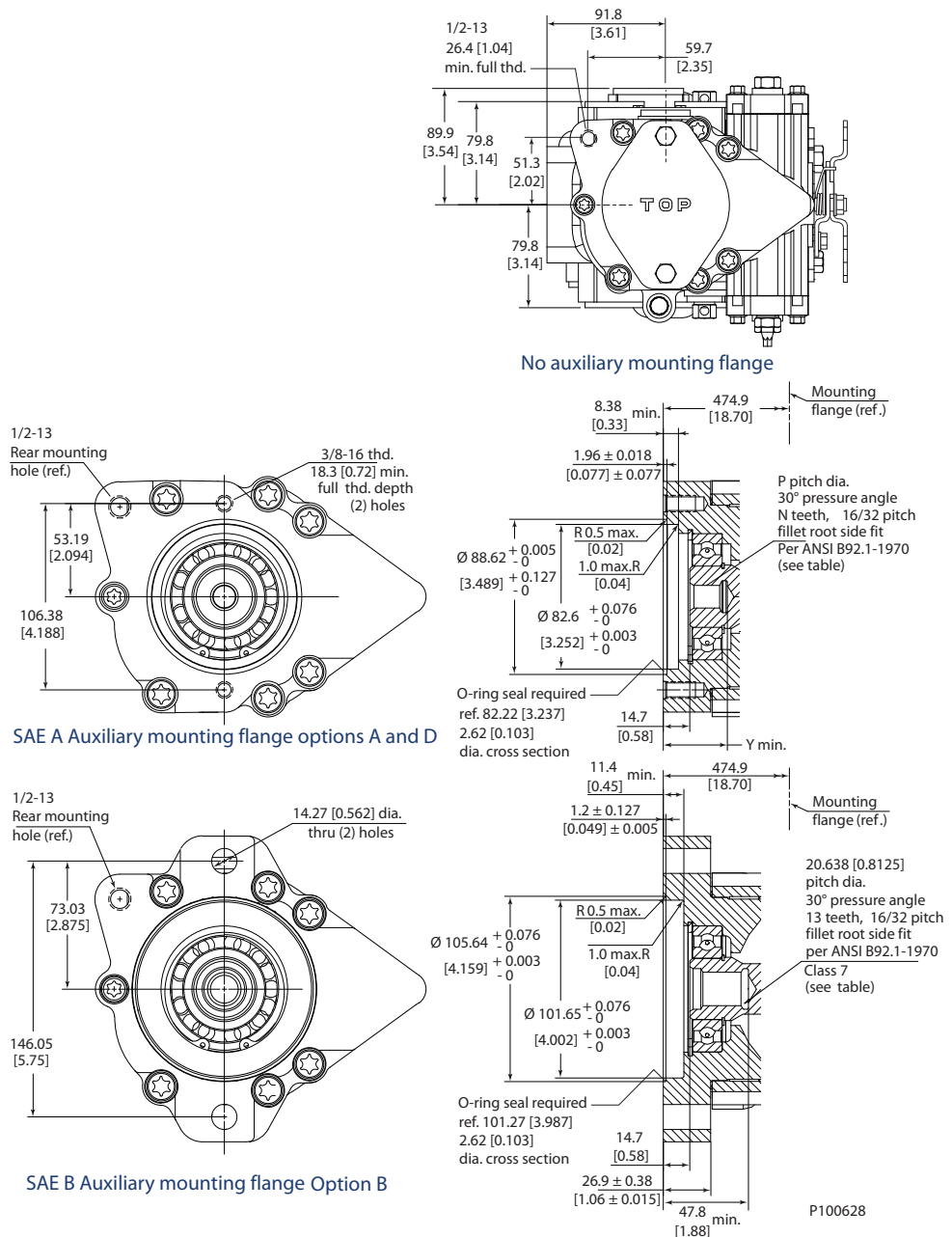
Contact Danfoss for individual dimension drawings.

M46 PV adjustable displacement limiter (option)

Shaft rotation	CW	CCW
Displacement limiter side	2	2
Limits flow out of port	B	A

Installation Drawings - Tandem Pump Dimensions

Auxiliary mounting flange

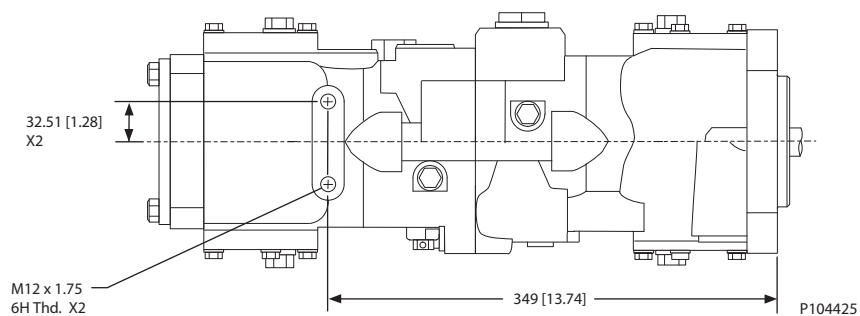


Auxiliary mounting flange and coupling options

Auxiliary mounting flange		Spline pitch dia. P	Number of teeth N	Minimum clearance Y
SAE A	Option A	14.30 [0.563]	9	34.8 [1.37]
SAE B	Option B	17.46 [0.688]	11	37.34 [1.47]

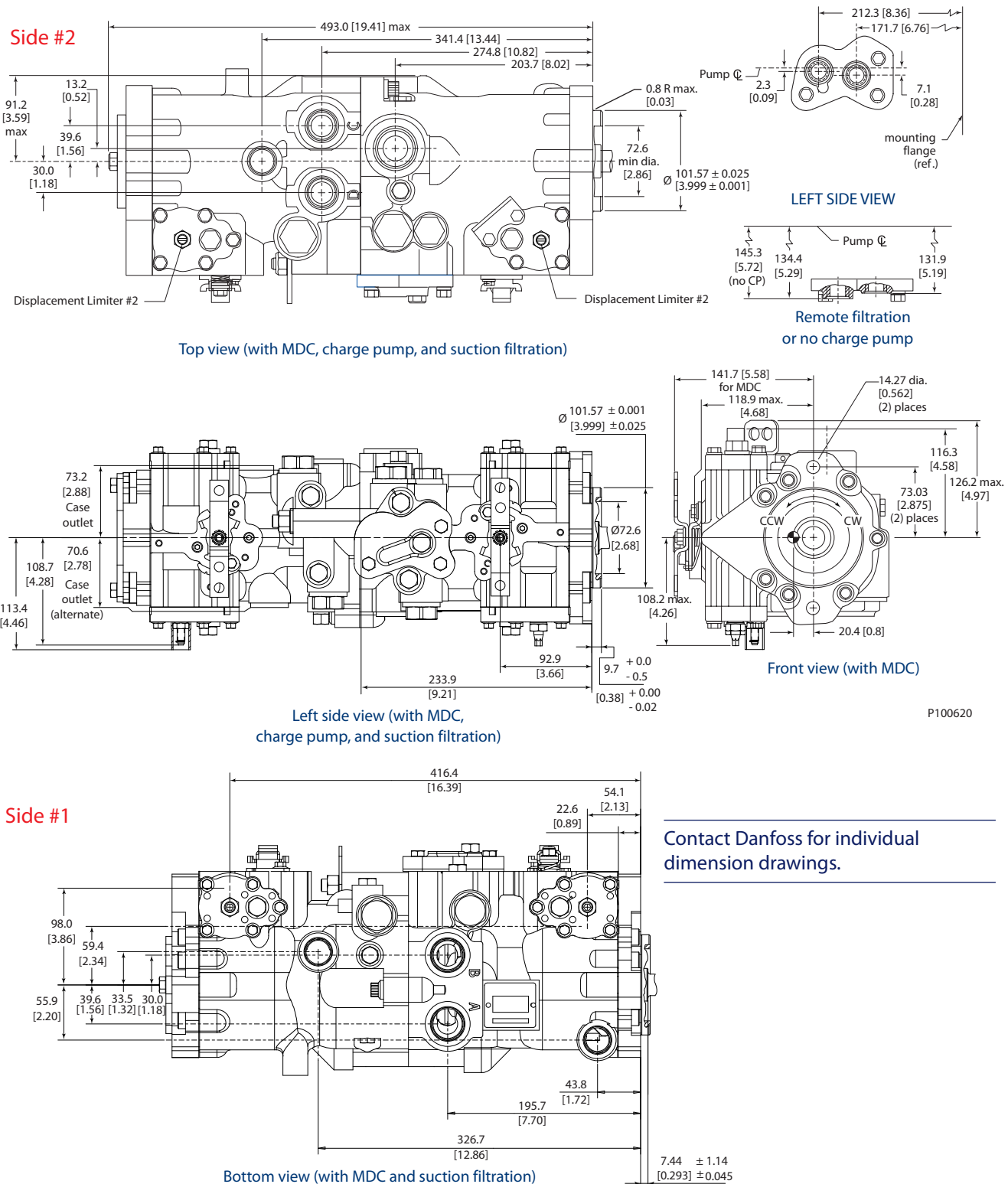
Installation Drawings - Tandem Pump Dimensions

Rear mounting boss



Installation Drawings - Tandem Pump Dimensions

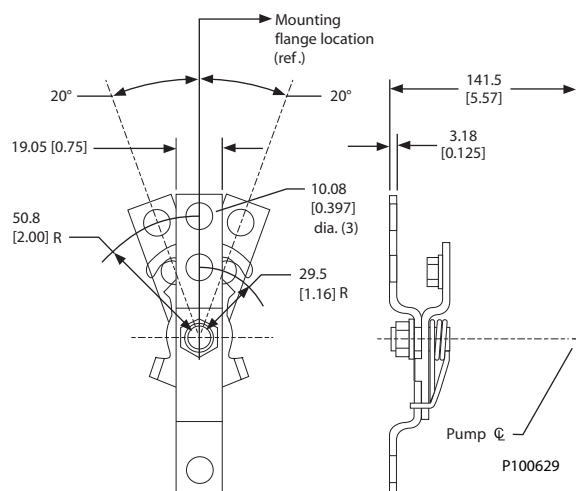
Pumps, filtration/charge pump options, MDC, displacement limiters



Control Options - Installation Drawings

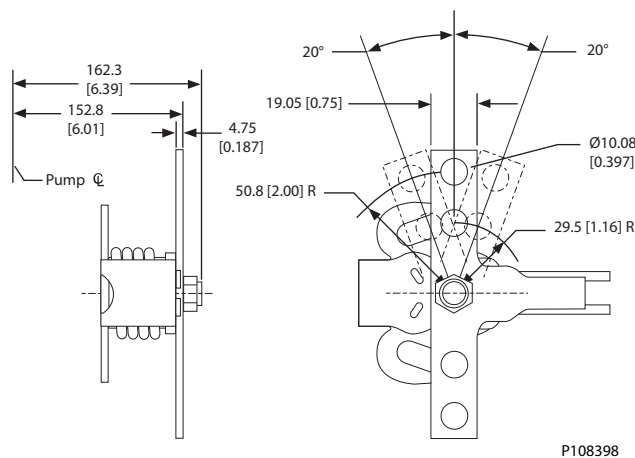
Control options, AC, AK

Three hole control handle with standard spring



Option GB

Control handle with heavy spring and heavy duty four hole handle

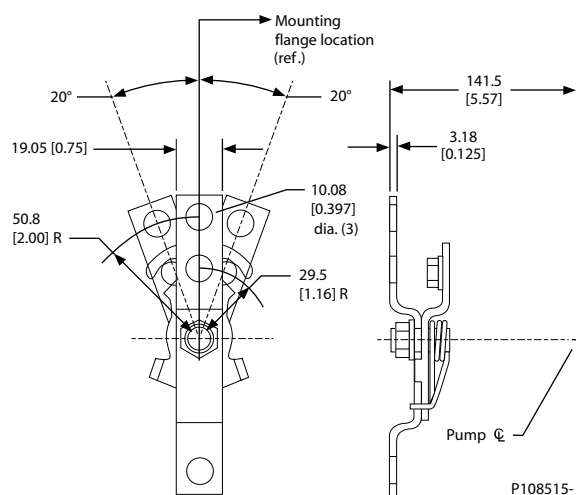


[Contact Danfoss for individual dimension drawings.](#)

Control Options - Installation Drawings

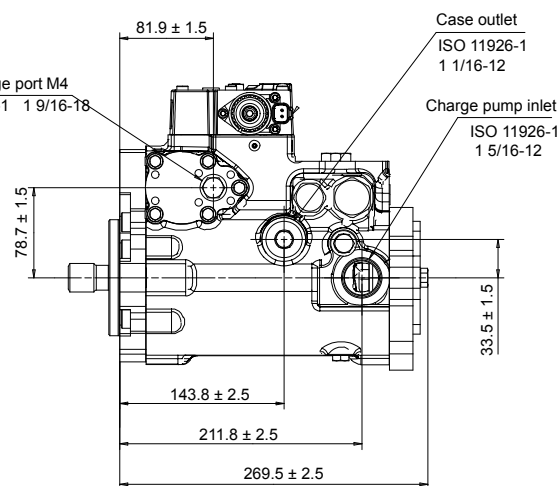
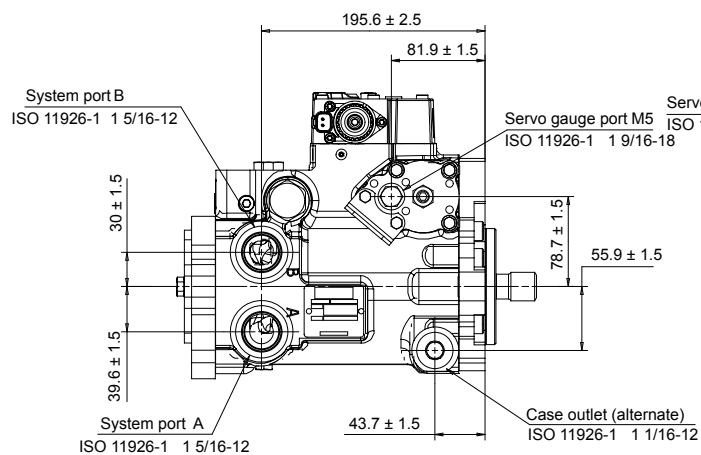
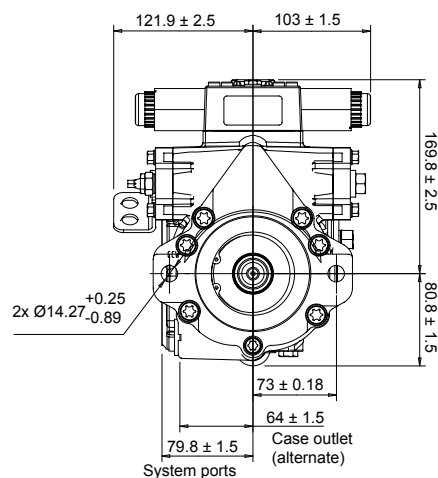
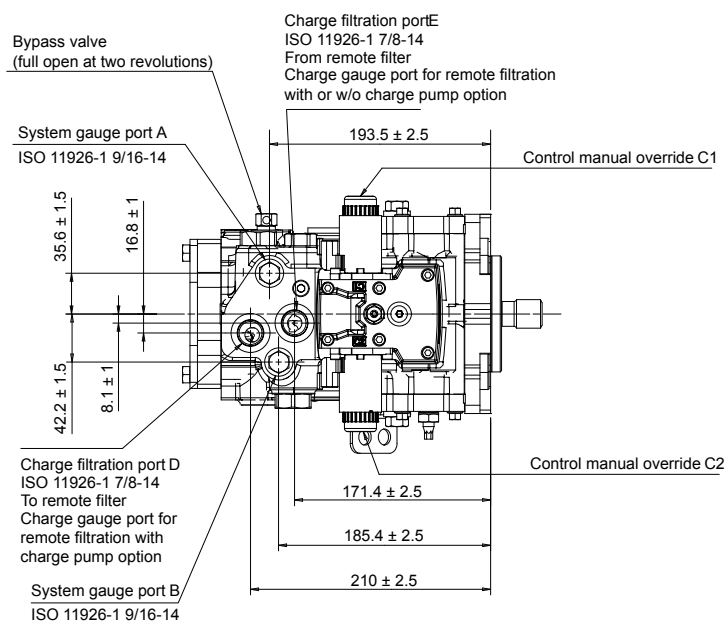
Options AB, AW

Two hole control handle with standard spring



Control Options - Installation Drawings

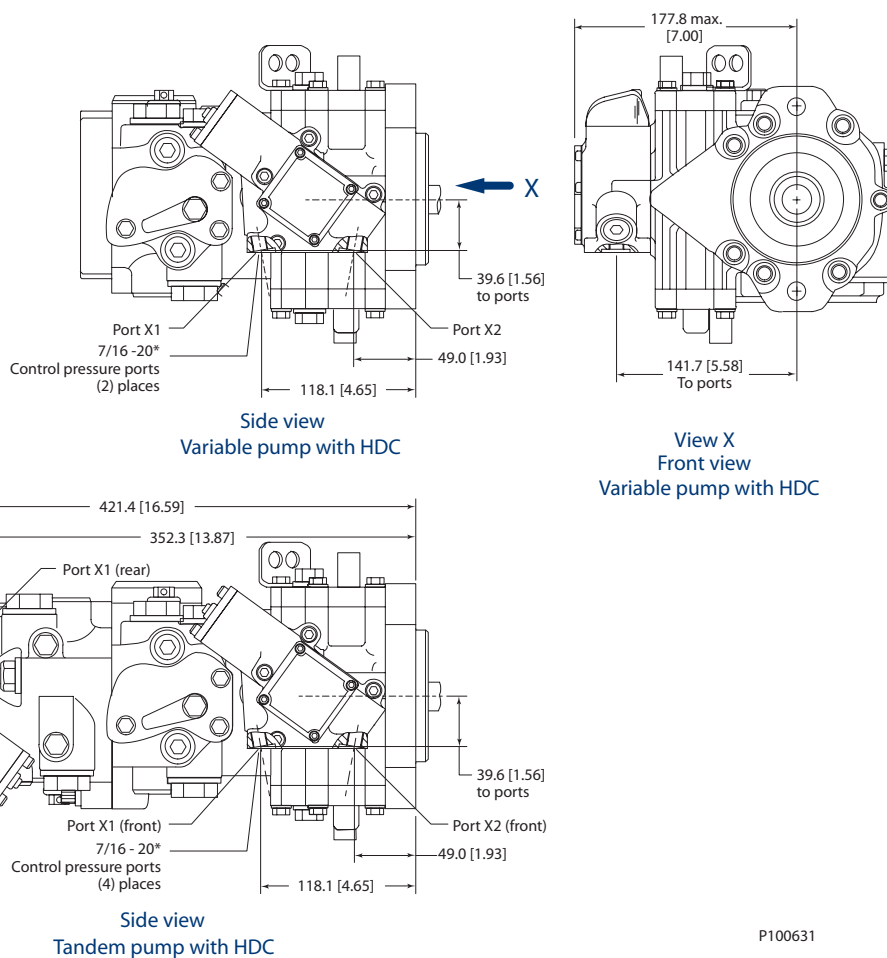
HC EDC Control



P108771-

Control Options - Installation Drawings

Hydraulic displacement control (HDC)

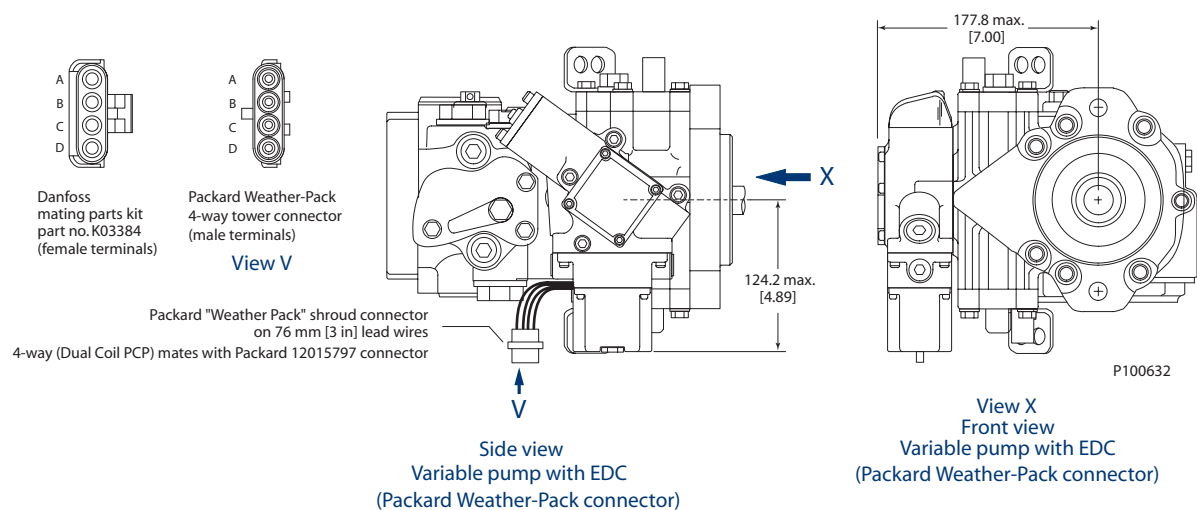


Contact Danfoss for individual dimension drawings.

Control Options - Installation Drawings

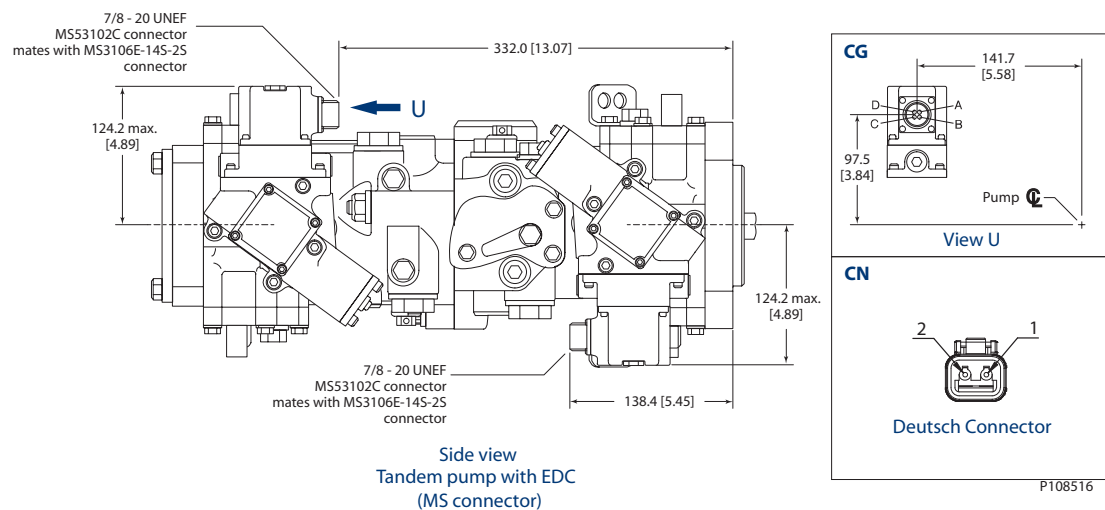
Option CE

Electronic displacement control (EDC)



Options CG, CN

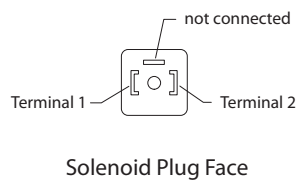
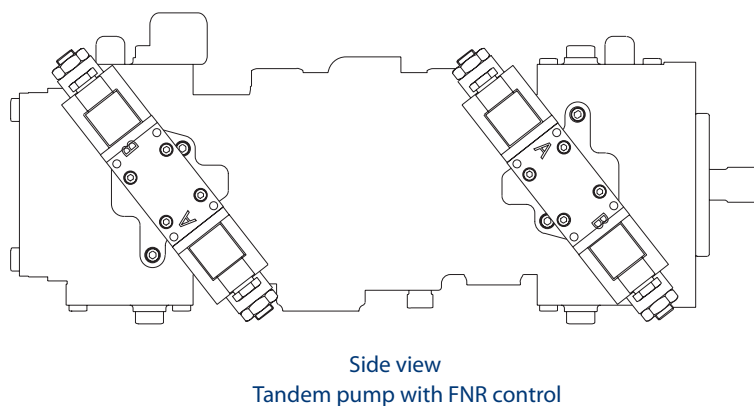
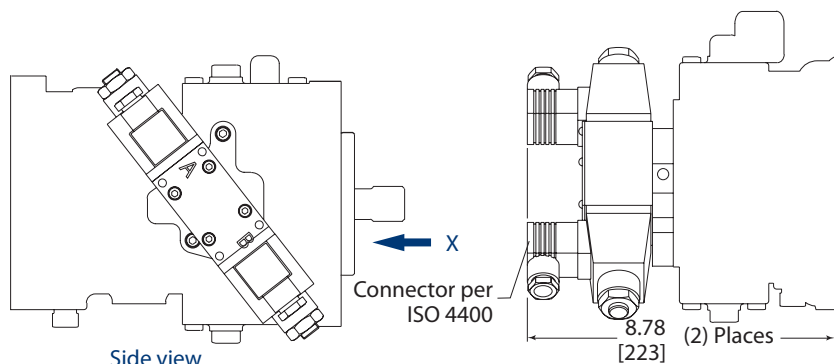
Electronic displacement control (EDC)



Control Options - Installation Drawings

Options DA, DB

Three-position electric displacement control (FNR)



P109487

Reference Literature

Literature

M46 systems may consist of a variety of pump, motor, valve and control combinations. Refer to the literature listed below for product information and specifications for M46 pumps and other Danfoss components.

M46 Pumps literature

- Series 40 M46 Single Pumps Service Manual **11026743**
- Series 40 M46 Tandem Pumps Service Manual **11029852**

Propel Systems related Literature

- Series 40 Motors Technical Information **520L0636**
- L&K Frame Motors Technical Information **520L0627**
- JS 1000, JS 6000 Joystick Grips Technical Information **520L0872**
- PLUS+1 Controller Family Technical Information **520L0719**

Hydraulic Systems Guidelines

- Hydraulic Fluids and Lubricants Technical Information **520L0463**
- Pressure and Speed Limits **BLN-9884**
- Design Guidelines for Hydraulic Fluid Cleanliness **520L0467**
- Experience with Biodegradable Hydraulic Fluids, Technical Information **520L465**
- Pressure and Speed Limits **BLN-9884**
- Selection of Driveline Components **BLN-9885**

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