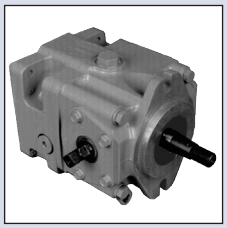
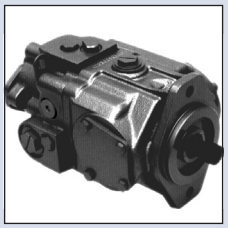
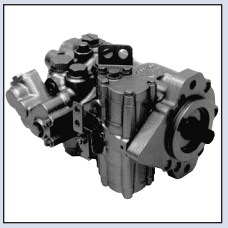
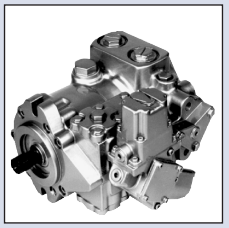
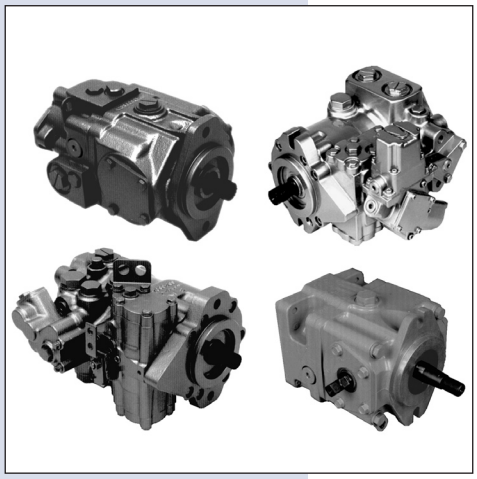
SAUER DANFOSS

Series 40 Axial Piston Pumps

Technical Information

HISTORY OF REVISIONS

Table of Revisions

Date	Page	Changed	Rev.
February 2010	last	Fix Osaka address	EI
June 2009	56	remove M25U outline drawing	EH
July 2008	62	add plug for Charge pressure construction port	EG
October 2007	31	identified A Pad and B Pad as M35 and M44	EF
July 2007	22	corrections to table - G factors for sample applications	ED
June 2006	11	corrections to maximum flow	EC
May 2006	21	Added an illustration to page 21	EB

SAUER DANFOSS

Series 40 Axial Piston Pumps
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SCHEMATICS

SERIES 40 FAMILY OF PUMPS AND MOTORS

Series 40 is a family of hydrostatic pumps and motors for medium power applications with maximum loads of 345 bar [5000 psi]. These pumps and motors can be applied together or combined with other products in a system to transfer and control hydraulic power.

Series 40 pump + motor transmissions provide an infinitely variable speed range between zero and maximum in both forward and reverse modes of operation. The pumps and motors each come in four frame sizes: M25, M35, M44, and M46.

Series 40 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.

Series 40 - M35, M44, and M46 pumps may include an integral charge pump to provide system replenishing and cooling fluid flow, as well as servo control fluid flow on M46 pumps. M25 pumps are designed to receive charge flow from an auxiliary circuit or from a gear pump mounted on the auxiliary mounting pad. Series 40 pumps feature a range of auxiliary mounting pads to accept auxiliary hydraulic pumps for use in complementary hydraulic systems.

Series 40 - M46 pumps offer proportional controls with either manual, hydraulic, or electronic actuation. An electric three-position control is also available. The M25, M35, and M44 pumps include a trunnion style direct displacement control.

Series 40 motors also use the parallel axial piston / slipper design in conjunction with a fixed or tiltable swashplate. The family includes M25, M35, M44 fixed motor units and M35, M44, M46 variable motor units. For complete technical information on Series 40 motors, refer to *Series 40 Motors Technical Information*, 520L0636.

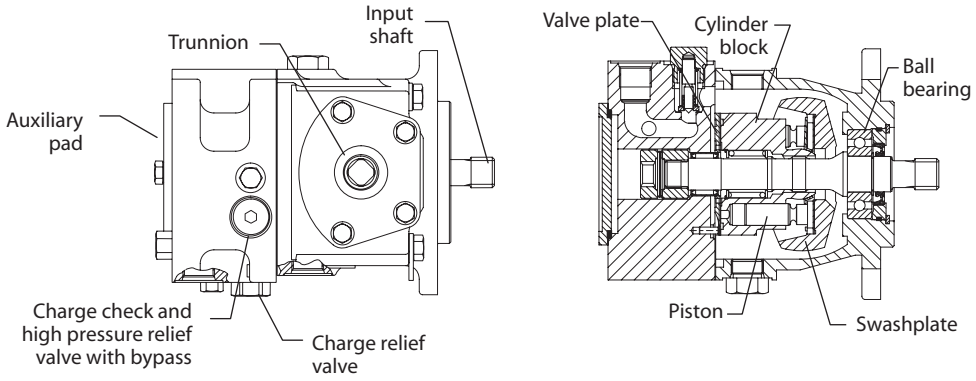
The M35 and M44 variable motors feature a trunnion style swashplate and direct displacement control. The M46 variable motors use a cradle swashplate design and a two-position hydraulic servo control.

The M46 variable motor is available in a cartridge flange version, which is designed to be compatible with CW and CT compact planetary gearboxes. This combination provides a short final drive length for applications with space limitations.

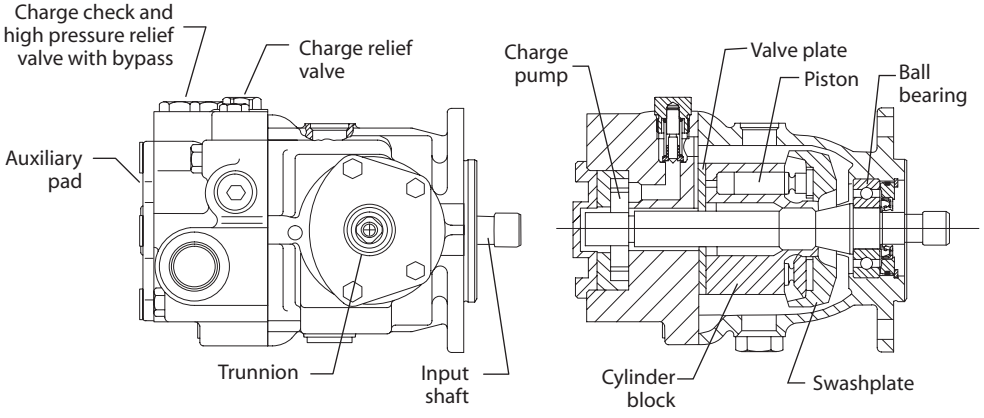
KEY FEATURES

- 4 sizes of variable displacement pumps
- 4 sizes of tandem pumps
- 3 sizes of variable displacement motors
- 3 sizes of fixed displacement motors
- Efficient axial piston design
- Complete family of control systems
- Proven reliability and performance
- Compact, lightweight
- Worldwide sales and service

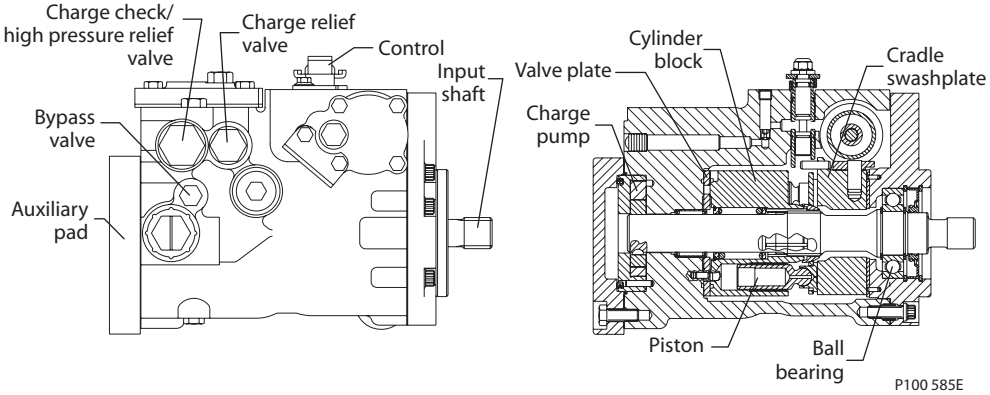
M25 VARIABLE PUMP



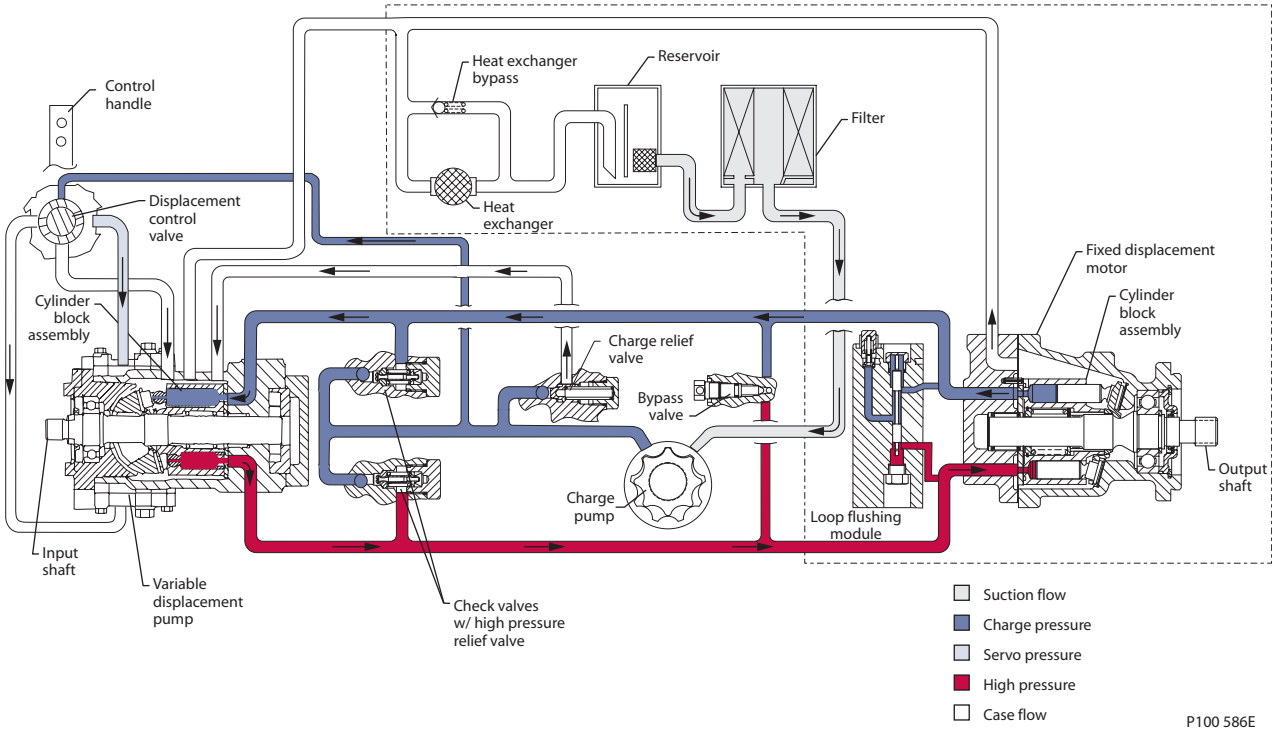
M35 VARIABLE PUMP (M44 SIMILAR)



M46 VARIABLE PUMP

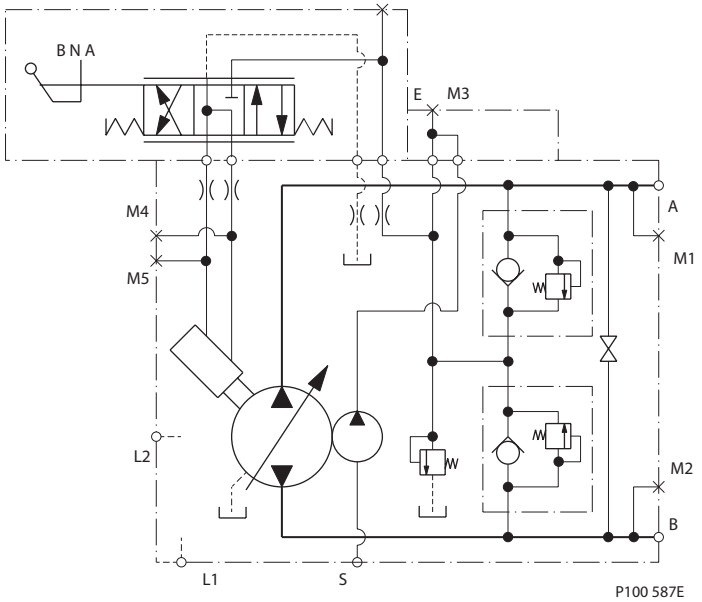


SYSTEM CIRCUIT DIAGRAM



A Series 40 - M46 variable pump is shown in a hydraulic circuit with a Series 40 - M35 fixed motor. The pump shown features manual displacement control. The circuit features suction filtration and heat exchanger.

M46 PUMP SCHEMATIC DIAGRAM



Technical Specifications

OVERVIEW

Specifications and operating parameters are shown below. For additional information, see *Operating parameters*, page 13, *System design parameters*, page 16, *Product coding*, page 23, *Features and options*, page 25 and *Control options*, page 41.

GENERAL

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

FEATURES

Model	**Unit**	**M25 PV**	**M35 PV**	**M44 PV**	**M46 PV**	**M25 PT**	**M35 PT**	**M44 PT**	**M46 PT**
Type of mounting		SAE B	SAE B	SAE B	SAE B	SAE B	SAE B	SAE B	SAE B
Port connections		Twin	Twin	Twin	Twin	Twin	Twin	Twin	Twin
Integral charge pump (std)	cm^3/rev [in^3/rev]	-	11.8 [0.72]	11.8 [0.72]	13.9 [0.85]	-	16.4 [1.00]	16.4 [1.00]	22.9 [1.40]
Charge relief valve setting	bar [psi]	14.0 [200]	14.0 [200]	14.0 [200]	19.5 [285]	14.0 [200]	14.0 [200]	14.0 [200]	19.5 [285]
System pressure regulation	bar [psi]	140-345 [2030-5000]							
Displacement limiters		-	-	-	Option	-	-	-	Option
Input shaft option		Splined, Tapered, or Straight Key							
Auxiliary mounting pad		SAE A	SAE A SAE B	SAE A SAE B	SAE A SAE B	SAE A	SAE A SAE B	SAE A SAE B	SAE A SAE B
Control options		DDC	DDC	DDC	MDC, HDC, EDC, FNR	DDC	DDC	DDC	MDC, HDC, EDC, FNR
Filtration configuration		Suction Filtration or Remote Charge Pressure Filtration							

SPECIFICATIONS

Model	**Unit**	**M25 PV**	**M35 PV**	**M44 PV**	**M46 PV**	**M25 PT**	**M35 PT**	**M44 PT**	**M46 PT**
Pump configuration		Single variable pump				Tandem variable pump			
Displacement	cm^3/rev	24.6	35.0	43.5	46.0	24.6 x 2	35.0 x 2	43.5 x 2	46.0 x 2
	[in^3/rev]	[1.50]	[2.14]	[2.65]	[2.81]	[1.50 x 2]	[2.14 x 2]	[2.65 x 2]	[2.81 x 2]
Weight	kg [lb]	19 [41.5]	25 [55]	25 [55]	33 [73]	24 [56]	45 [99]	45 [99]	59 [131]
Mass moment of inertia	kg•m^2	0.0018	0.0033	0.0032	0.0050	0.0037	0.0066	0.0064	0.0100
	[slug•ft^2]	[0.0014]	[0.0024]	[0.0023]	[0.0037]	[0.0028]	[0.0048]	[0.0047]	[0.0073]

OPERATING PARAMETERS

Model	Unit	M25 PV	M35 PV	M44 PV	M46 PV	M25 PT	M35 PT	M44 PT	M46 PT
Case pressure									
Continuous	bar [psi]	1.7 [25]							
Maximum	bar [psi]	5.2 [75]							
Speed limits									
Rated @ max angle	min^{-1} (rpm)	4000	3600	3300	4000	4000	3600	3300	4000
Maximim @ max angle	min^{-1} (rpm)	5000	4500	4100	4100	5000	4500	4100	4100
Minimum	min^{-1} (rpm)	500	500	500	500	500	500	500	500
System pressure									
Continuous	bar [psi]	210 [3000]							
Maximum	bar [psi]	345 [5000]							
Theoretical max flow at rated speed (per pump)	l/min [US gal/min]	100 [26.0]	126 [33.4]	145 [38.3]	184 [48.6]	100 [26.0]	126 [33.4]	145 [38.3]	184 [48.6]
Inlet pressure									
Continuous	bar absolute [in Hg vacuum]	0.8 [6.3]							
Maximum	bar absolute [in Hg vacuum]	0.7 [9.2]							

FLUID SPECIFICATIONS

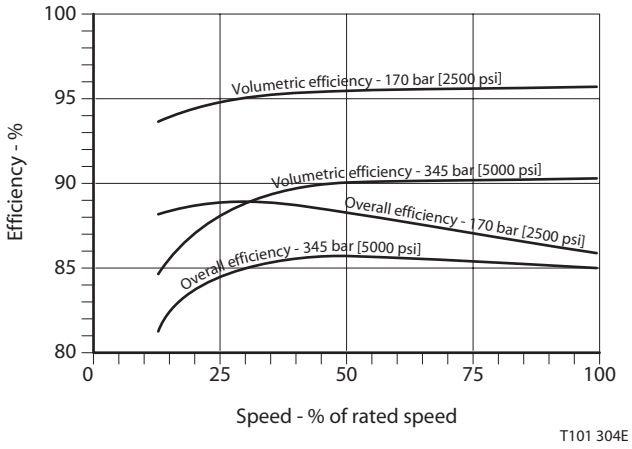
Ratings and data are based on operation with premium petroleum-based hydraulic fluids containing oxidation, rust, and foam inhibitors.

Parameter		Unit	Minimum	Continuous	Maximum
Viscosity		mm^2/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**		$\beta_{35\text{-}44}$=75 ($\beta_{10}\geq$1.5)		
	charge filtration		$\beta_{15\text{-}20}$=75 ($\beta_{10}\geq$10)		

PERFORMANCE

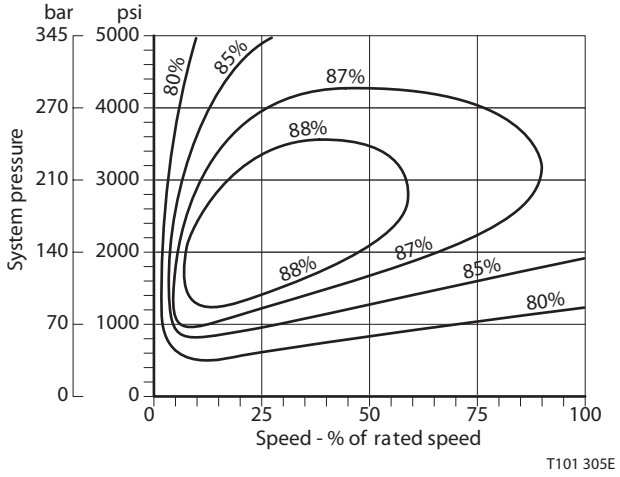
The following performance graph provides typical volumetric and overall efficiencies for Series 40 pumps. These efficiencies apply for all Series 40 pumps.

Pump performance as a function of operating speed



The performance map provides typical pump overall efficiencies at various operating parameters. These efficiencies also apply for all Series 40 pumps.

Pump performance as a function of operating speed and system pressure



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 Sauer-Danfoss publications: **520L0463**, *Hydraulic Fluids and Lubricants, Technical Information*, and **520L465**, *Experience with Biodegradable Hydraulic Fluids, Technical Information*.

VISCOSITY

Maintain fluid viscosity within the recommended range for maximum efficiency and bearing life. **Minimum viscosity** is acceptable only during brief occasions of maximum ambient temperature and severe duty cycle. **Maximum viscosity** is acceptable only at cold start: Limit speeds until the system warms up. See Sauer-Danfoss publications: **520L0463**, *Hydraulic Fluids and Lubricants, Technical Information*

Fluid viscosity limits

Condition	mm²/s (cSt)	SUS
Minimum	7	47
Continuous	12-60	70-278
Maximum	1600	7500

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 motor components. However, it may affect the ability of the motor to transmit power. **Maximum temperature** is based on material properties: Don't exceed it. Measure maximum temperature at the hottest point in the system. This is usually the case drain.

Temperature limits

Minimum (intermittent, cold start)	- 40° C [- 40° F]
Continuous	82.2° C [180° F]
Maximum	104.4° C [220° F]

Ensure fluid temperature and viscosity limits are concurrently satisfied.

CHARGE PRESSURE

All systems require a charge (positive pressure) in the low side of the system loop for proper lubrication and rotating group operation. Maintain low loop (charge) pressure at a minimum of 6 bar [87 psi] above case pressure. For more information, refer to *Charge Pump*, page 25.

CASE PRESSURE

Maintain case pressure within the limits shown in the table. Ensure housing is filled with hydraulic fluid.

Case pressure limits

Maximum (continuous)	1.7 bar [25 psi]
Intermittent (cold start)	5.2 bar [75 psi]

! 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.

PRESSURE RATINGS

The table, *Operating parameters*, page 11, gives maximum and continuous pressure ratings for each displacement. Not all displacements operate under the same pressure limits. Definitions of the operating pressure limits appear below.

System pressure is the differential pressure between system ports A and B. It is the dominant operating variable affecting hydraulic unit life. High system pressure, which results from high load, reduces expected life. Maintain system pressure at or below continuous working pressure during normal operation to achieve expected life.

Continuous working pressure is the average, regularly occurring operating pressure. Operate at or below continuous working pressure for satisfactory product life.

Maximum (peak) working pressure is the highest intermittent pressure allowed. Do not allow machine load to exceed maximum (peak) working pressure.

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

System pressure limits

Pressure Limits	bar	psi
Continuous	210	3000
Maximum	345	5000

SPEED RATINGS

The table, *Operating parameters*, page 11, gives rated and maximum speeds for each displacement. Not all displacements operate under the same speed limits. Definitions of these speed limits appear below.

Continuous speed is the maximum recommended operating speed at full power condition. Operating at or below this speed should yield satisfactory product life. Do not exceed maximum motor speed during unloaded, on-road travel over level ground.

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

⚠ 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 abs. (not more than 6.3 in. Hg vac.) is recommended. Normal pressure less than the **minimum inlet pressure** of 0.7 bar abs. (greater than 9.2 in. Hg vac.) indicates inadequate inlet design or a restricted filter. Pressures less than 0.7 bar abs. (greater than 9.2 in. Hg vac.) during cold start are possible, but should improve quickly as the fluid warms.

Inlet pressure

	bar absolute	in. Hg vacuum
Continuous	0.8	6
Minimum	0.7	9.2 (max)

THEORETICAL OUTPUT

The theoretical maximum flow at rated speed is a simple function of pump displacement and speed. This is a good gauge for sizing a companion motor. This does not take into account losses due to leakage or variations in displacement. Refer to *Performance*, page 12, for volumetric and overall efficiencies at various operating conditions.

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]
Δp	=	$p_O - p_i$ (system pressure)	bar [psi]
n	=	Speed	min^{-1} (rpm)
η_v	=	Volumetric efficiency	
η_m	=	Mechanical efficiency	
η_t	=	Overall efficiency ($\eta_v \cdot \eta_m$)	

FILTRATION

Ensure fluid entering pump is free of contaminants to prevent damage (including premature wear) to the system. Series 40 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 ingression rates
- Flow capacity
- Desired maintenance interval

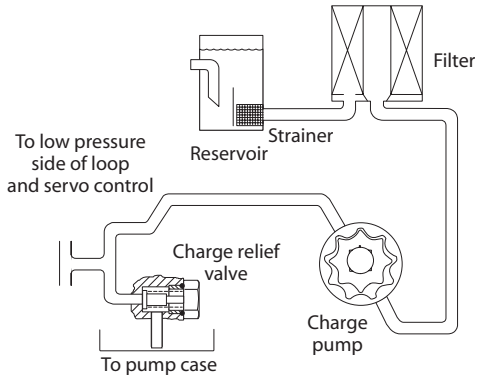
Locate filter either on the inlet (suction filtration) or discharge (charge pressure filtration) side of the charge pump. Series 40 pumps are available with provisions for either strategy.

Typically, a filter with a beta ratio of $\beta_{10} = 1.5$ to 2.0 is adequate. However, open circuit systems supplied from a common reservoir may have considerably higher requirements. Because each system is unique, only a thorough testing and evaluation program can fully validate the filtration system. For more information, see Sauer-Danfoss publication **520L0467**, *Design Guidelines for Hydraulic Fluid Cleanliness.*

Suction filtration

The suction filter is placed in the circuit between the reservoir and the inlet to the charge pump as shown in the accompanying illustration.

Suction filtration



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FILTRATION (continued)

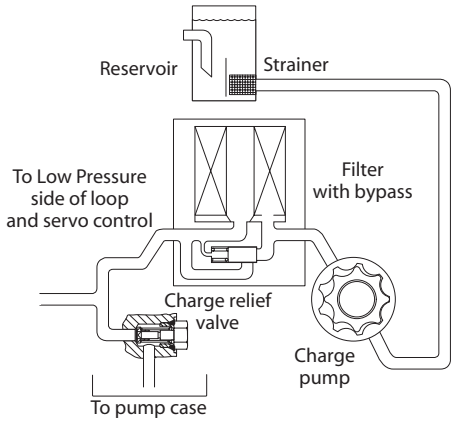
Charge filtration

Provision for charge pressure filtration is available on all Series 40 pumps. The pressure filter is remotely mounted in the circuit after the charge pump, as shown in the accompanying illustration.

Filters used in charge pressure filtration circuits must be rated to at least 34.5 bar [500 psi] pressure. A 100 - 125 µm screen located in the reservoir or in the charge inlet line is recommended when using charge pressure filtration.

A filter bypass valve is necessary to prevent filter damage and to avoid contaminants from being forced through the filter media by high pressure differentials across the filter. 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.

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

On tandem pumps, excess flow from the charge relief valve is routed into the housing of the front pump. In order to ensure adequate case flushing, it is recommended that the rear housing drain ports be used as the case drain.

M43/M44 tandem pumps with the option of opposing port endcaps do not follow the above rule.

BEARING LIFE AND EXTERNAL SHAFT LOADING

Bearing life is a function of speed, pressure and swashplate angle plus any external loads. Other life factors include oil type and viscosity.

In vehicle propulsion drives with no external loads, where the speed, pressure, and swashplate angle are often changing, normal bearing B10 (90% survival) life will exceed the hydraulic unit life.

In non-propel drives, such as conveyors or fan drives, the operating speed and pressure may be nearly constant leading to a distinctive duty cycle compared to that of a propulsion drive. In these types of applications, a bearing life review is recommended.

Series 40 pumps are designed with bearings that can accept some incidental external radial and thrust loads. However, any amount of external load will reduce the expected bearing life.

The allowable radial shaft loads are a function of the load position, the load orientation, and the operating pressures of the hydraulic unit. All external shaft loads have an effect on bearing life. In applications where external shaft loads cannot be avoided, the impact on bearing life can be minimized by orienting the load to the 90 or 270 degree position.

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 drawings on the next page .

The maximum allowable radial load is calculated as: $\mathbf{R_e = M_e / L}$

Avoid thrust loads in either direction.

If continuously applied external radial loads are 25% or more of the maximum allowable, or thrust loads are known to occur, contact your Sauer-Danfoss representative for an evaluation of unit bearing life. Optional high capacity bearings are available.

Tapered output shafts or *clamp-type* couplings are recommended for applications where radial shaft side loads are present.

Shaft loading parameters

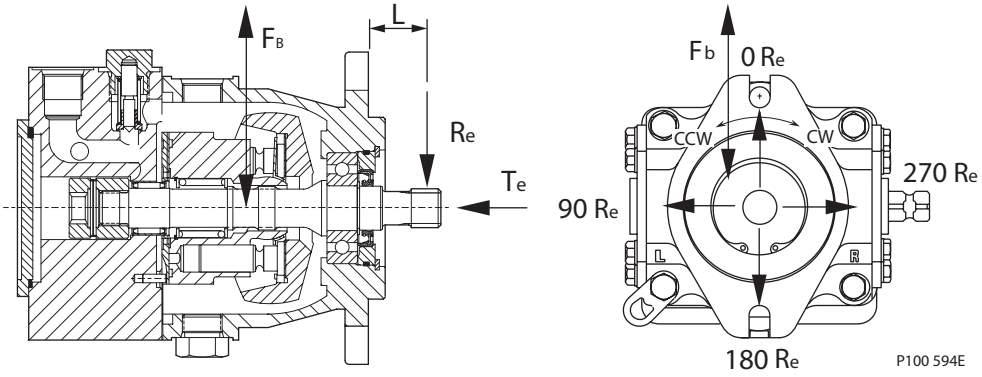
R_e	Maximum radial load
M_e	Maximum external moment
L	Distance from mounting flange to point of load
F_e	Force of cylinder block
T_e	Thrust load

Maximum external shaft moments

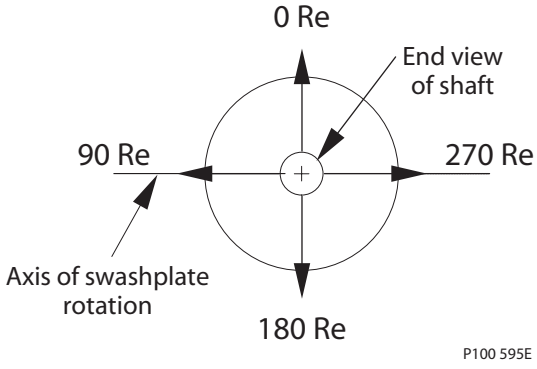
	M25	M35/44	M46
M_e/N•m [in•lbf]	101 [890]	121 [1075]	186 [1650]

BEARING LIFE AND EXTERNAL SHAFT LOADING (continued)

180° External radial shaft load



Direction of external shaft load



HYDRAULIC UNIT LIFE

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

Design the hydraulic system to a projected machine duty cycle. Know the expected percentages of time at various loads and speeds. Ask your Sauer-Danfoss representative to calculate an appropriate pressure based your hydraulic system design. If duty cycle data is not available, input power and pump displacement are used to calculate system pressure.

All pressure limits are differential pressures (referenced to charge pressure) and assume normal charge pressure.

Series 40 pumps will meet satisfactory life expectancy if applied within the parameters specified in this bulletin. For more detailed information on hydraulic unit life see BLN-9884, *Pressure and Speed Limits.*

MOUNTING FLANGE LOADS

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

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

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

Refer to *Installation drawings*, page 52, to find pump length (L). Refer to the table *Specifications*, page 10, to find pump weight (W). An exact measure of W will depend on the pump's features.

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.

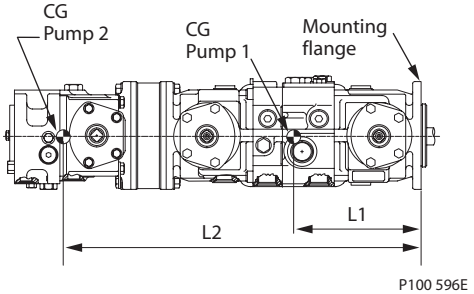
Overhung loading parameters

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 *n*th pump
L_n	Distance from mounting flange to center of gravity of *n*th pump

Allowable overhung parameters

Frame size	Continuous load moment (M_c)		Shock load moment (M_s)	
	N•m	[in•lbf]	N•m	[in•lbf]
M25 PV	361	[3200]	617	[5470]
M25 PT	361	[3200]	559	[4950]
M35 PV	517	[4600]	832	[7400]
M35 PT	517	[4600]	754	[6700]
M46 PV	517	[4600]	832	[7400]
M46 PT	517	[4600]	754	[6700]

Shaft loading parameters



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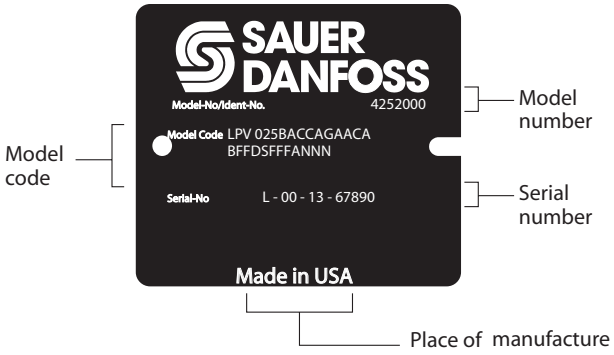
G-factors for sample applications

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.		

MODEL CODE

Series 40 variable pump

Name plate



Model code modules

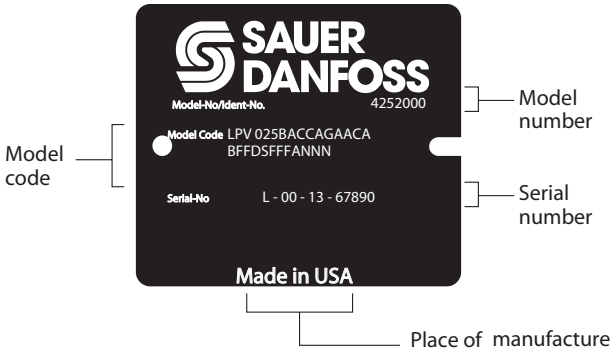
			Displacement				C	D	E	F	G	H	J											
M	P	V	0	2	5	C	B	A	A	R	A	G	N	N										
Product						Type																		
K	L	M		N		P	R		S	T														
A	A	A	A	A	B	A	A	B	H	A	N	N	N											

C: Swashplate group
D: Seal group
E: Input shaft
F: Rotation
G: Charge pump displacement
H: Charge pressure relief setting
J: Filtration
K: Displacement limiters
L: Bypass valve
M: System pressure protection
N: Control
P: Control handle position
R: Control orifice diameters
S: Auxiliary mounting pad
T: Special hardware

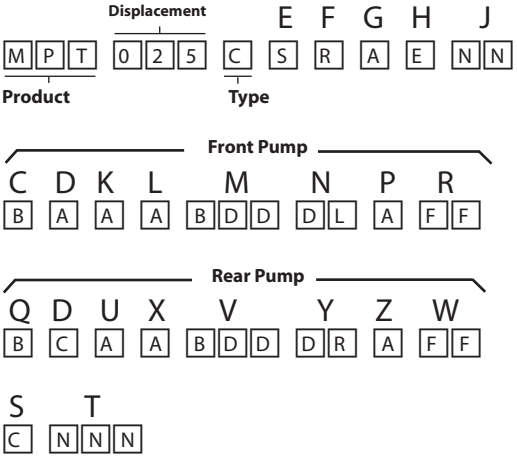
MODEL CODE (continued)

Series 40 tandem pump

Name plate



Model code modules



E: Input shaft
F: Rotation
G: Charge pump displacement
H: Charge pressure relief setting
J: Filtration
C & Q: Swashplate
D: Seal group
K & U: Displacement
L & X: Bypass valve
M & V: System pressure protection
N & Y: Control
P & Z: Control handle position
R & W: Control orifice
S: Auxiliary mounting flange
T: Special hardware

REVISED MODEL CODE

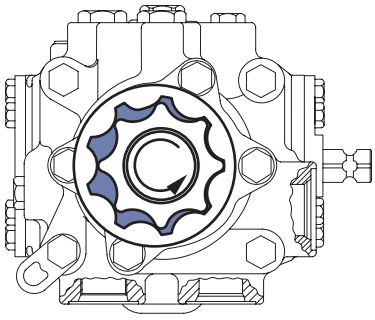
The model code is a modular description of a specific product and its options. To create an order code to include the specific options desired, see the *Series 40 Pump Model Code Supplement* or the *Series 40 Price Book*.

CHARGE PUMP

Charge flow is required on all Series 40 units applied in closed circuit installations 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 on M46 units, to provide flow and pressure for the control system.

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

Charge pump in series 40 - M35 PV



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All Series 40 pumps (except M25 pumps) may be equipped with integral charge pumps. These charge pump sizes have been selected to meet the needs of a majority of Series 40 applications.

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. In most Series 40 applications a general guideline is that the 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.

CHARGE PUMP (continued)

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

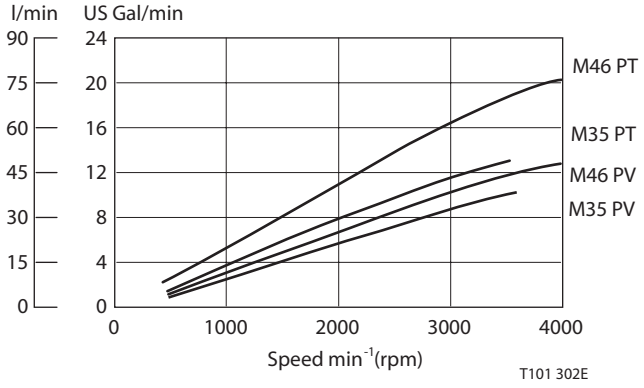
- Operation at low input speeds (below 1500 RPM)
- Shock loading
- Excessively long system lines
- Auxiliary flow requirements
- Use of low speed high torque motors

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 Sauer-Danfoss representative. A charge pump sizing worksheet is available in **BLN-9885**, *Selection of Driveline Components*.

M25 pumps do not allow for integral charge pumps. Other Series 40 pumps are also available without charge pumps. When an integral charge pump is not used, an external charge supply is required to ensure adequate charge pressure and cooling.

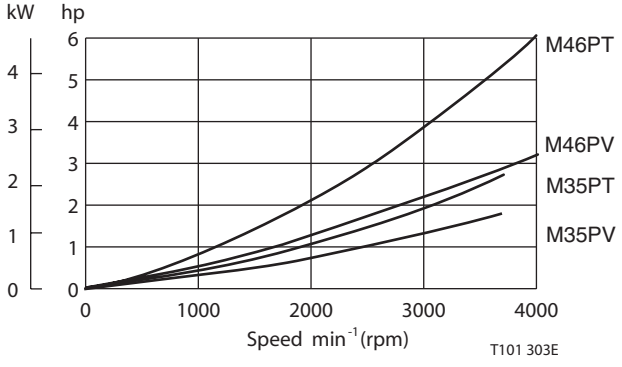
CHARGE PUMP OUTPUT FLOW

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



CHARGE PUMP POWER REQUIREMENTS

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



CHARGE RELIEF VALVE

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

The charge relief valve for the M25, M35, and M44 PV/PT is a flat poppet style valve. The M46 PV/PT uses a cone-style poppet valve.

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 of operation to maintain pump control performance.

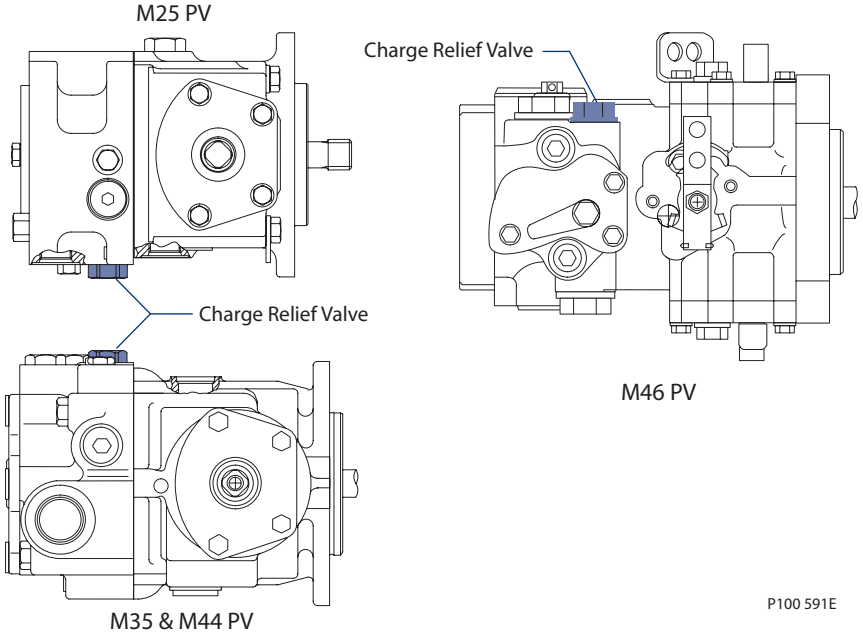
The charge relief valve is factory set. If necessary, it can be field adjusted with shims.

Charge relief valve specs

	M25	M35	M44	M46
Type	Flat poppet valve			Cone poppet valve
Available setting	7.5-14 bar [110-200 psi]			19.5-26.2 bar [285-380 psi]
Adjustment	Via shims inside of valve cartridge*			

*Shimming offers adustment over a limited range, a spring change may be required to make a larger adjustment.

Charge relief valve locations



CHECK / HIGH PRESSURE RELIEF VALVE

Charge check and high pressure relief valves maintain circuit pressure in the proper range. The check valves allow charge flow to replenish the low pressure side of the working loop. The high pressure relief valves provide pressure protection to the high pressure side of the working loop. There are two cartridge style valves to handle each side of the working loop with flow in either direction.

High pressure relief valves are available in a range of settings. You may specify individual port pressure settings . If high pressure relief valves are not desired, pumps may be equipped with charge circuit check valves only.

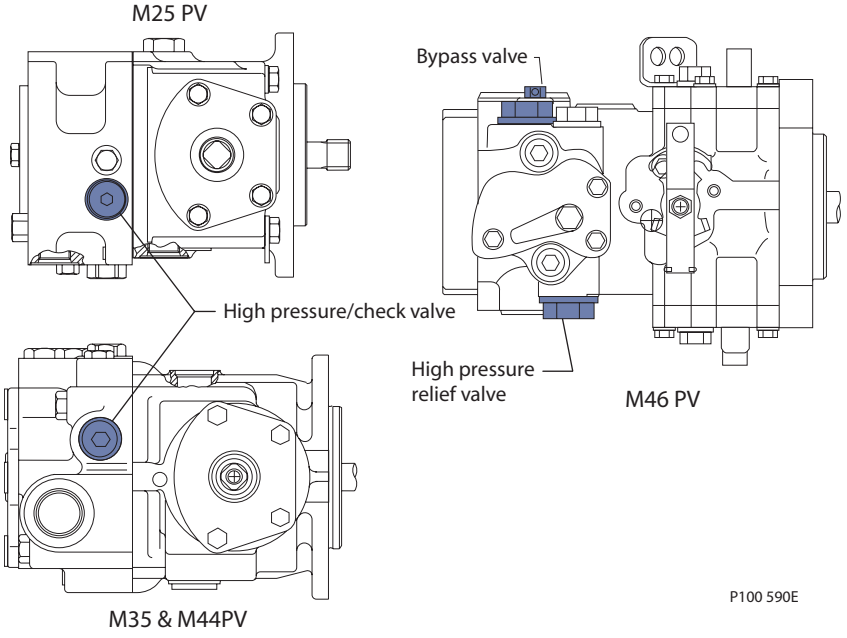
Caution

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.

Check/high 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



DISPLACEMENT LIMITERS

Series 40 - M46 PV or PT units are designed with optional mechanical displacement (stroke) limiters located in the servo piston. You can limit maximum displacement of the pump to a certain per-cent of its maximum displacement to near zero in either direction.

Displacement limits are fixed physical stops inside the pump and are not externally adjustable. It is possible to configure an M46 pump with an externally adjustable displacement limiter screw on one side only. The screw is located on the side of the servo piston opposite the neutral adjustment screw.

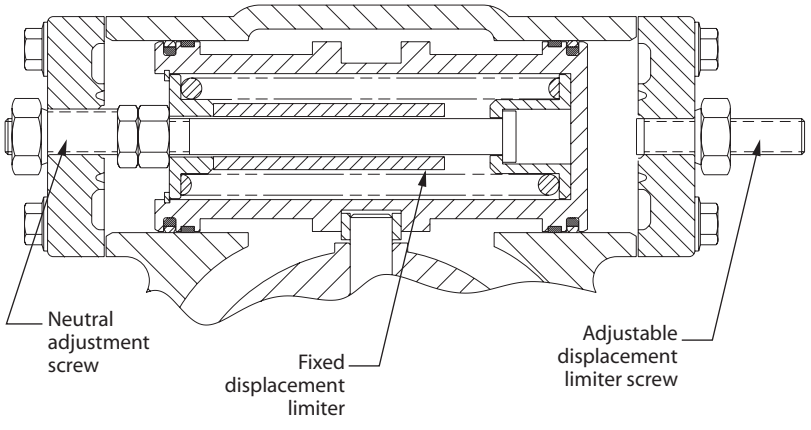
⚠ Warning

Take care in adjusting displacement limiters to avoid an undesirable condition of output flow or speed. Retorque 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 cm^3/rev [0.24 in^3/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. An anti-tamper seal sleeve is provided.

Series 40 - M25, M35, and M44 pumps do not have displacement limiters.

M46 Displacement limiter



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AUXILIARY MOUNTING PADS AND AUXILIARY PUMPS

Auxiliary mounting pads are available on all Series 40 pumps. A sealed cover is included as standard equipment on all mounting pads.

An O-ring seals the auxiliary pump mounting flange to the pad. The drive coupling is lubricated 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 on page 33.
- 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*, p. 22, for additional information.

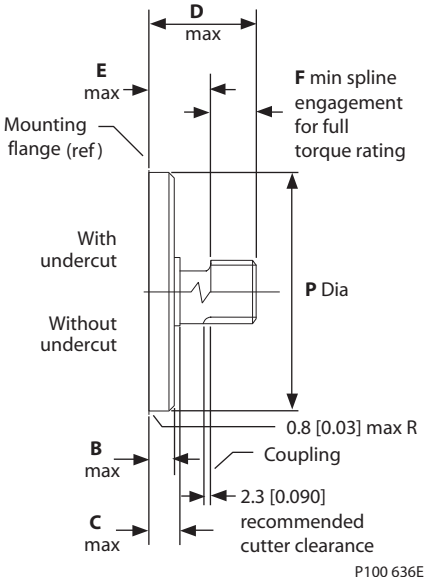
Auxiliary mounting pad specs

Internal spline size	Pad size	Torque rating			Availability			
			N•m	[in • lbf]	M25	M35	M44	M46
9T 16/32P	SAE A	Continuous:	51	[450]	m	m	m	m
		Max:	107	[950]				
11T 16/32P	SAE A	Continuous:	90	[800]	m	m	m	m
		Max:	147	[1300]				
13T 16/32P	SAE B	Continuous:	124	[1100]	—	m	m	m
		Max:	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.

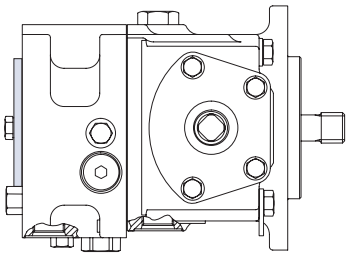
Auxiliary pump mating dimensions mm [in.]

Pad size	P	B	C	D	E	F
SAE A	82.55 [32.50]	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]

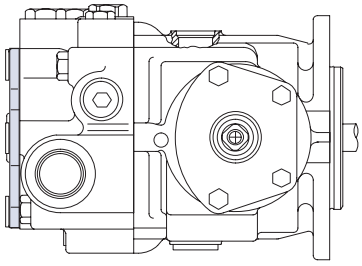


AUXILLIARY MOUNTING PADS AND AUXILIARY PUMPS (continued)

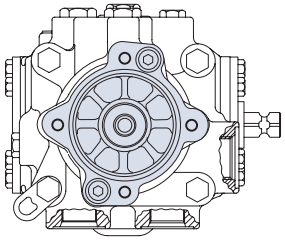
Auxiliary mounting pads on Series 40 pumps



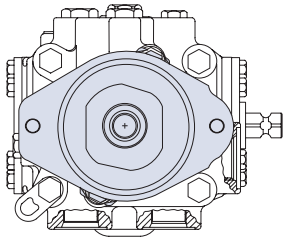
M25 PV



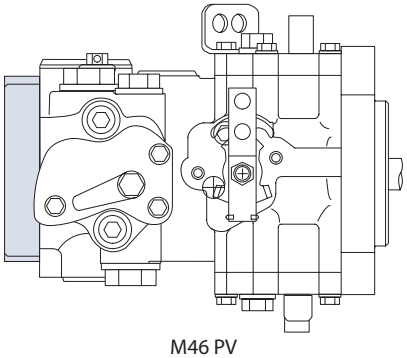
M35 & M44 PV



A Pad
M35 & M44 PV



B Pad
M35 & M44 PV



M46 PV

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SHAFT OPTIONS

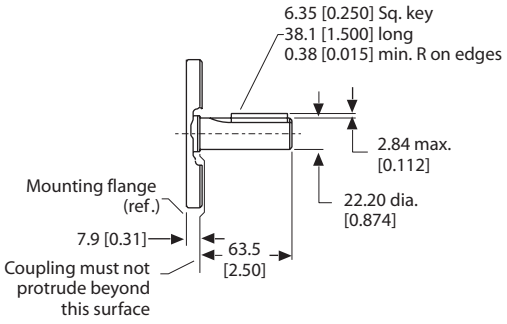
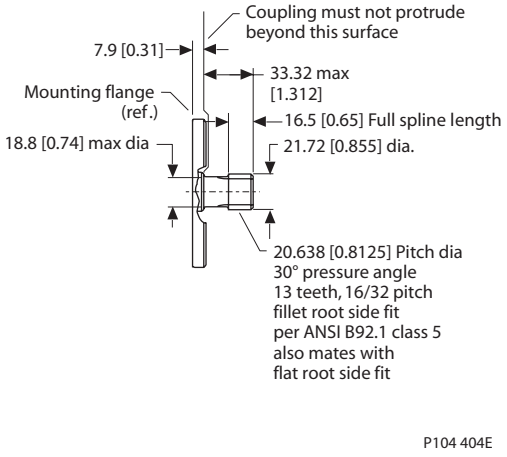
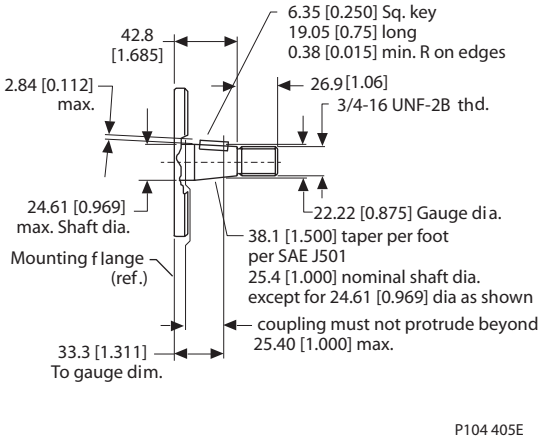
Series 40 pumps are available with a variety of splined, straight keyed, and tapered shaft ends. Nominal shaft sizes and torque ratings are shown in the table on the next page.

Torque ratings assume no external radial loading. **Continuous torque** ratings for splined shafts are based on splined tooth wear, and assume the mating spline has a minimum hardness of R_C 55 and full spline depth with good lubrication.

Maximum torque ratings are based on shaft torsional strength and assume a maximum of 200,000 load reversals.

Recommended mating splines for Series 40 splined output shafts should be in accordance with ANSIB92.1 Class 5. Sauer-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 Sauer-Danfoss representative for availability.

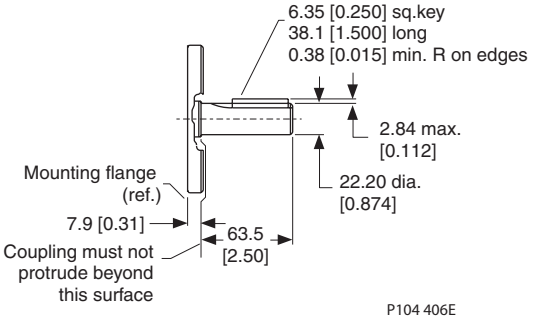
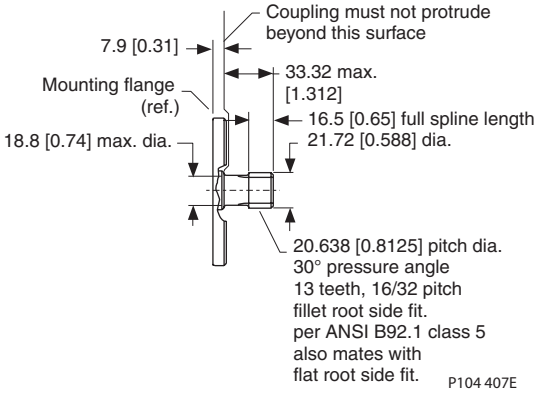
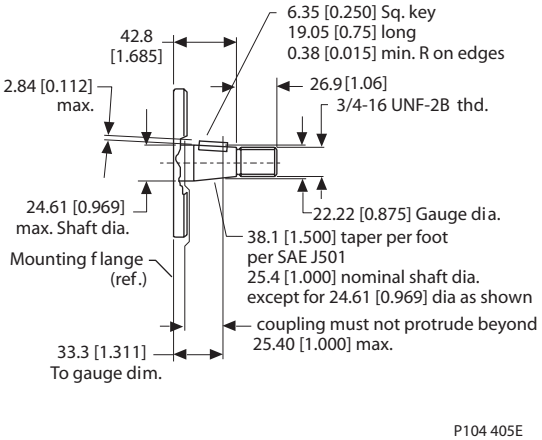
M25 VARIABLE PUMP

Code	Description	Torque rating		Drawing
		Maximum torque rating N•m [lbf•in]	Continuous torque rating N•m [lbf•in]	
Y	Ø 22.20 mm [0.874 in] Straight keyed	**140 [1240]**	—	
A	13-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**140 [1240]**	**85 [750]**	
C	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501)	**140 [1240]**	—	

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

Dimensions in mm [in]

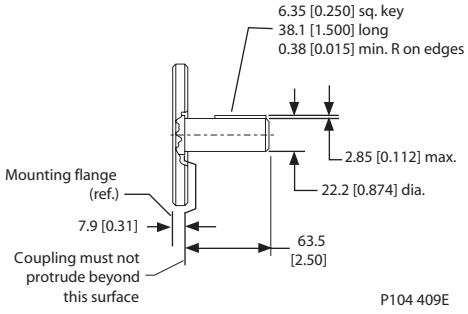
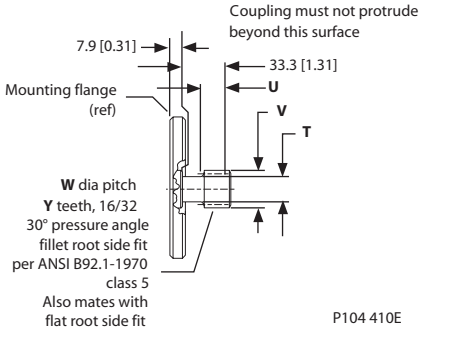
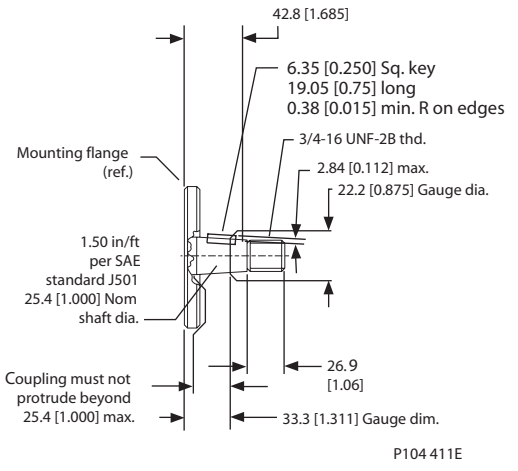
M25 TANDEM PUMP

Code	Description	Torque rating		Drawing
		Maximum torque rating N•m [lbf•in]	Continuous torque rating N•m [lbf•in]	
Y	Ø 22.20 mm [0.874 in] Straight keyed	**140 [1240]**	—	
A	13-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**140 [1240]**	**85 [750]**	
C	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501)	**140 [1240]**	—	

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

Dimensions in mm [in]

M35/44 VARIABLE PUMP

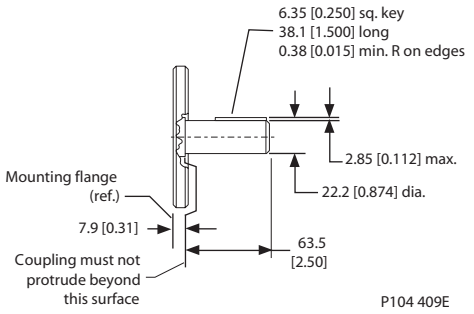
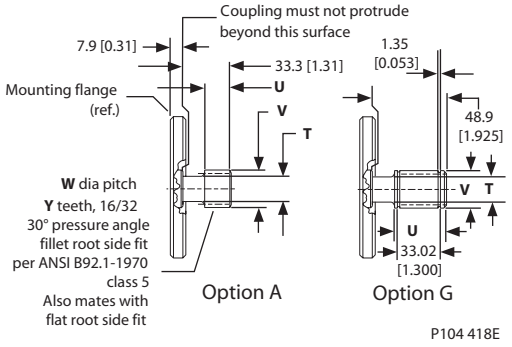
<table>
<tr><th rowspan="2">Code</th><th rowspan="2">Description</th><th colspan="2">Torque rating</th><th rowspan="2">Drawing</th></tr>
<tr><th>Maximum torque rating
N•m [lbf•in]</th><th>Continuous torque rating
N•m [lbf•in]</th></tr>
<tr><td>Y</td><td>Ø 22.20 mm [0.874 in]
Straight keyed</td><td>226 [2000]</td><td>—</td><td rowspan="2"> 
</td></tr>
<tr><td>A</td><td>13-tooth
16/32 pitch
(ANSI B92.1 1970 - Class 5)</td><td>126 [2000]</td><td>124 [1100]</td></tr>
<tr><td>G</td><td>15-tooth
16/32 pitch
(ANSI B92.1 1970 - Class 5)</td><td>362 [3200]</td><td>153 [1350]</td><td> 
</td></tr>
<tr><td>N</td><td>Ø 25.4 mm [1.000 in]
1:8 taper (SAE J501)</td><td>497 [4400]</td><td>—</td><td> 
</td></tr>
</table>

Shaft option	Shaft dia. T	Full spline U	Major dia. V	Pitch dia. W	No. teeth Y
G	21.97 [0.865]	18.5 [0.73]	24.89 [0.9800	23.812 [0.9375]	15
A	18.8 [.074]	16.50.65	21.72 [0.855]	20.638 [0.8125]	13

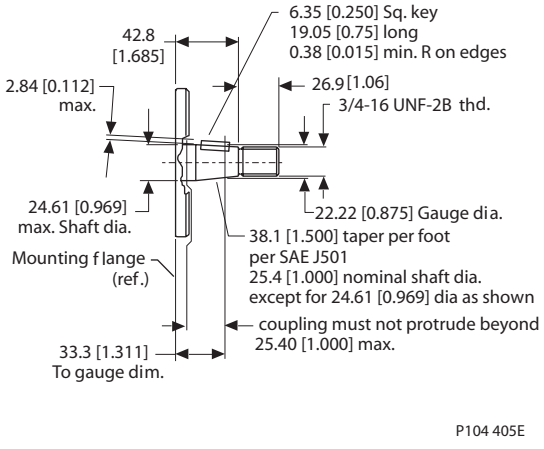
Other shaft options may exist. Contact your Sauer-Danfoss representative for availability and for specific installation drawings.

Dimensions in mm [in]

M35/44 TANDEM PUMP

Code	Description	Torque rating		Drawing
		Maximum torque rating N•m [lbf•in]	Continuous torque rating N•m [lbf•in]	
Y	Ø 22.20 mm [0.874 in] Straight keyed	**226 [2000]**	—	
A	15-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**362 [3200]**	**153 [1350]**	
G	15-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**362 [3200]**	**153 [1350]**	

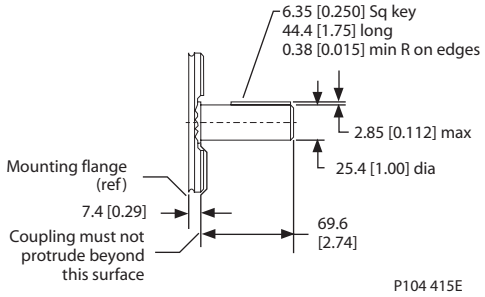
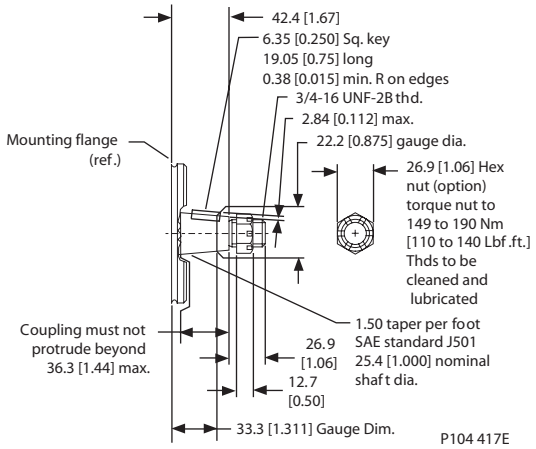
Shaft option	Shaft dia. T	Full spline U	Major dia. V	Pitch dia. W	No. teeth Y
G	21.97 [0.865]	39.4 [1.55]	24.89 [0.9800]	23.812 [0.9375]	15
A	21.97 [0.865]	18.5 [0.73]	24.89 [0.9800]	23.812 [0.9375]	15

N	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501)	**497 [4400]**	—	

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

Dimensions in mm [in]

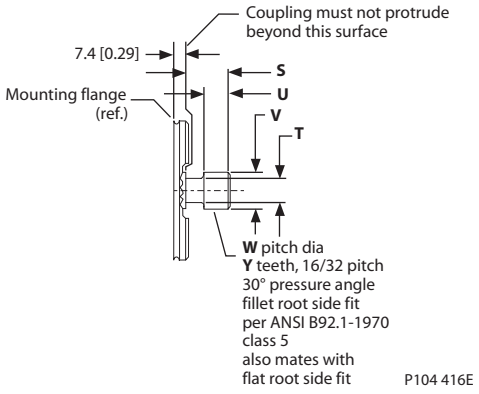
M46 VARIABLE PUMP

Code	Description	Torque rating		Drawing
		Maximum torque rating N•m [lbf•in]	Continuous torque rating N•m [lbf•in]	
V **W**	Ø 25.37 mm [0.999 in] Straight keyed	**362 [3200]**	—	
N **P** **R** **S**	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501)	**497 [4400]**	—	

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

Dimensions in mm [in]

M46 VARIABLE PUMP

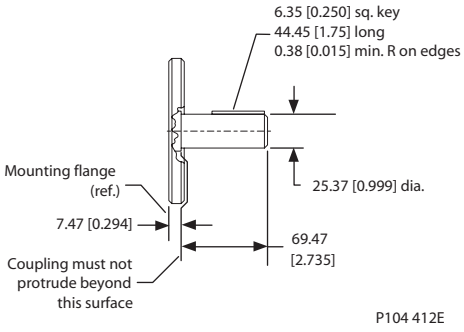
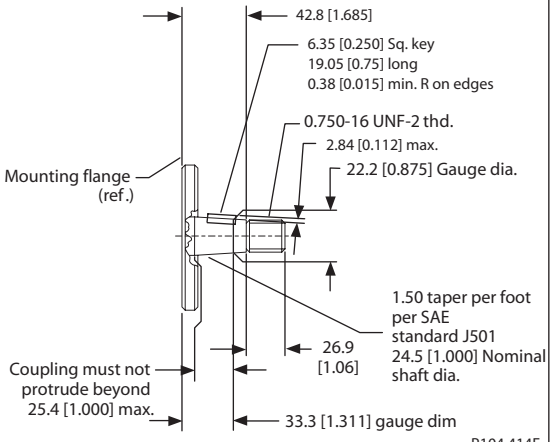
Code	Description	Torque rating		Drawing
		Maximum torque rating N•m [lbf•in]	Continuous torque rating N•m [lbf•in]	
G H J	13-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**226 [2000]**	**124 [1100]**	
K A B D E X Z	15-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**362 [3200]**	**153 [1350]**	

Shaft option	Length	Shaft dia.	Full spline	Major dia.	Pitch dia.	No. teeth
	S	T	U	V	W	Y
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
A, B & D	32.9 [1.297]	20.3 [0.80]	16.26 [0.64]	21.72 [0.8550]	20.64 [0.8125]	13
E, & X,	54.74 [2.155]	22.3 [0.88]	39.88 [1.57]	24.89 [0.9800]	23.81 [0.9375]	15
Z	51.82 [2.040	22.3 [0.88]	36.83 [1.45]	24.89 [0.9800]	23.81 [0.9375]	15

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

Dimensions in mm [in]

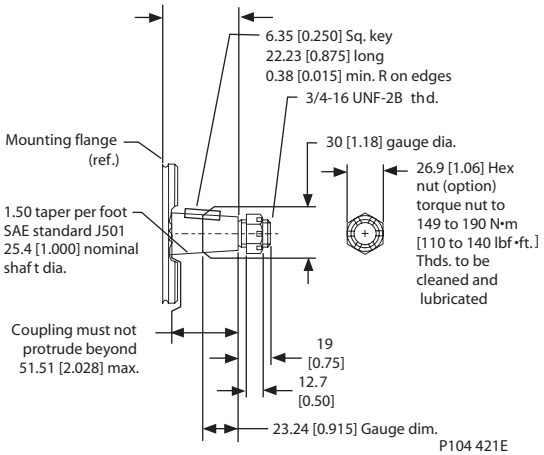
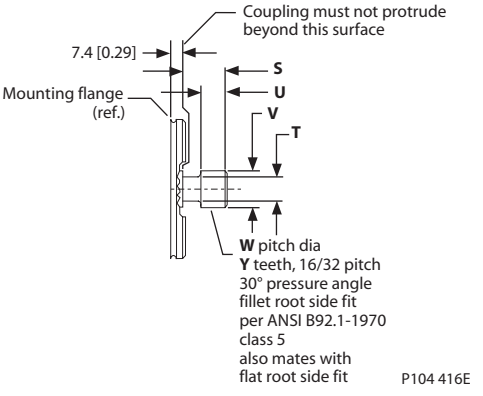
M46 TANDEM PUMP

Code	Description	Torque rating		Drawing
		Maximum torque rating N•m [lbf•in]	Continuous torque rating N•m [lbf•in]	
J	Ø 25.37 mm [0.999 in] Straight keyed	**362 [3200]**	—	
C	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501)	**497 [4400]**		

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

Dimensions in mm [in]

M46 TANDEM PUMP

Code	Description	Torque rating		Drawing
		Maximum torque rating N•m [lbf•in]	Continuous torque rating N•m [lbf•in]	
T	Ø 25.4 mm [1.000 in] 1:8 taper (SAE J501)	**497 [4400]**	—	
A **B**	15-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**362 [3200]**	**153 [1350]**	
	19-tooth 16/32 pitch (ANSI B92.1 1970 - Class 5)	**734 [3500]**	**305 [2700]**	

Shaft option	Max. coupling engagement	Shaft dia.	Full spline	Major dia.	Pitch dia.	No teeth
	S	T	U	V	W	Y
A	37.7 [1.49]	22.4 [0.88]	23.4 [0.92]	24.89 [0.980]	20.638 [0.9375]	15
B	37.7 [1.49]	28.7 [1.13]	24.1 [0.95]	31.24 [1.230]	30.163 [1.1875]	19

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

Dimensions in mm [in]

DIRECT DISPLACEMENT CONTROL (DDC) M25, M35/44 VARIABLE PUMPS

The Direct Displacement Control (DDC) can be located on either side of a Series 40 - M25, M35, or M44 pump. It provides a simple, positive method of control. Movement of the control shaft causes a proportional swashplate movement, thus varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

Some applications (generally vehicle propel) require a provision for non-linear control input to reduce control sensitivity near neutral. Damping or frictional forces may be necessary to produce desirable control feel.

Neutral position is not factory set, nor is there any internal neutral return mechanism. The application must include provisions for all control linkage and neutral return fuctionality.

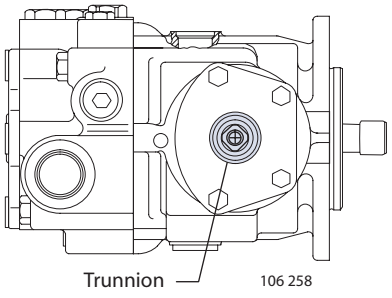
With no external forces applied to the swashplate trunnion, internal hydraulic forces may not return the swashplate to the neutral position under all conditions of operation.

The DDC is available on variable pumps and tandem pumps.

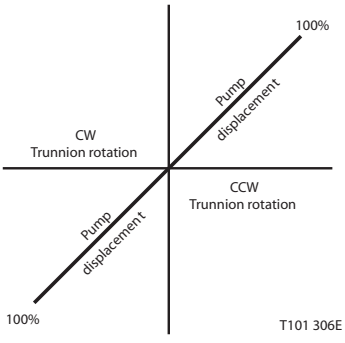
External control handle requirements

Maximum allowable trunnion torque is 79.1 N•m [700 in•lbf] for M25, M35, and M44. Minimum torque necessary to hold the swashplate at a zero angle for neutral is 2.3 N•m [20 in•lbf]. Maximum trunnion angle is 15° for M25 and 16° for M35 and M44.

DDC on Left Side of M35 Pump



Pump Displacement vs Swashplate Rotation



DDC input specs

Max torque	Nm [in•lbf]	79.1	[700]
Min torque	Nm [in•lbf]	2.3	[20]
Max angle		M25: 15°	M35/44: 16°

Pump flow direction

Input shaft rotation		CW				CCW			
Trunnion location		Right		Left		Right		Left	
Trunnion rotation		CW	CCW	CW	CCW	CW	CCW	CW	CCW
PV or front PV	Port A Flow	Out	In	In	Out	In	Out	Out	In
	Fort B Flow	In	Out	Out	In	Out	In	In	Out
Rear PT	Port C (A) Fow	In	Out	Out	In	Out	In	In	Out
	Port D (B) Flow	Out	In	In	Out	In	Out	Out	In

MANUAL DISPLACEMENT CONTROL (MDC) M46 VARIABLE PUMP

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.

Features:

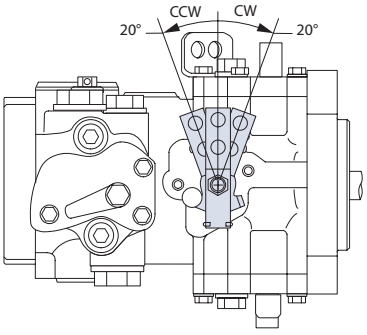
- The MDC is a high gain control: with only a small movement of the control handle (input signal) the control valve moves to a full open position porting maximum flow to the servo cylinder. This is a high response control system with low input forces.
- Mechanical feedback senses swashplate reactions to load.
- Precision parts provide repeatable, accurate displacement settings with a given input signal.
- To facilitate self centering, both ends of the double-acting servo piston are drained to case when a mechanical input signal is not present. The servo piston is coupled to a spring centering mechanism.

Benefits:

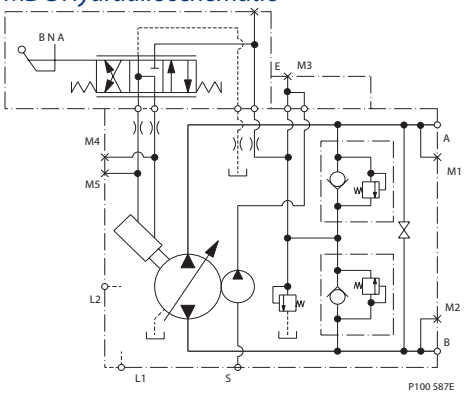
- Simple-low cost design.
- Pump output is maintained regardless of load.
- Pump will return to neutral after prime mover shuts down.
- Pump returns to neutral if external control linkage becomes disconnected from the control handle or if there is a loss of charge pressure.

MANUAL DISPLACEMENT CONTROL (MDC) (continued)

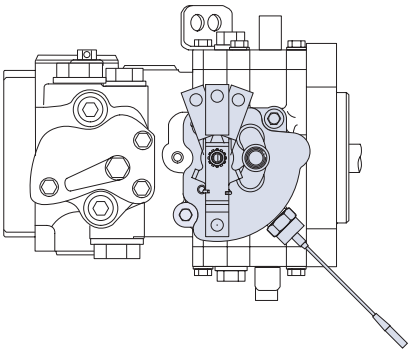
MDC on M46 PV



MDC Hydraulic schematic



MDC with NSS M46 PV



P100 598
(Handle up* option shown)

Pump flow direction with MDC control

		Input Shaft Rotation			
		CW		CCW	
PV or Front PT	Handle Rotation	CW	CCW	CW	CCW
	Port A Flow	Out	In	In	Out
	Port B Flow	In	Out	Out	In
Rear PT	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.

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.) Test system pressure to determine the proper orifice sizes for the desired response.

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	6.4 [0.050]	0.5	0.4

*Contact Sauer-Danfoss for special orifice combinations.

MANUAL DISPLACEMENT CONTROL (MDC) M46 VARIABLE PUMP (continued)

External control handle requirements

Rotation of the control handle to reach full pump displacement is 20°. Maximum handle rotation is 25°. There is a neutral deadband of ±1.5° (±3.0° with NSS option). A nominal control handle torque of 1.2 N•m [11 in•lbf] is required to begin handle rotation (1°) and 1.7 N•m [15 in•lbf] is required to reach full stroke (20° handle rotation). An optional high rate return spring is available which requires 2.5 N•m [22 in•lbf] and 3.4 N•m [30 in•lbs] to reach 1° and 20° respectively. The maximum allowable handle input torque is 17 N•m [150 in•lbf].

Handle direction

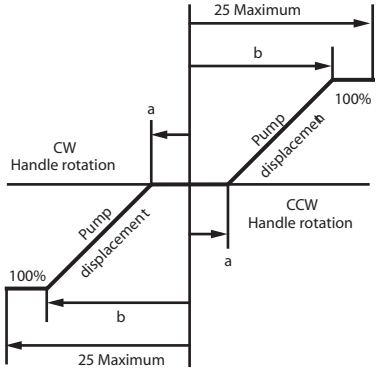
The MDC handle can be configured in either the up or down positions. The up position is shown on the previous page. The down position is oriented 180° of the up position.

Neutral start switch (NSS)

This safety feature is an option to prevent start-up when the pump is not in neutral. It provides an electrical switch contact which is closed when the control handle is in its neutral (0°) position. The switch contact will open when the control handle is rotated 1.5 to 2° clockwise (CW) or counterclockwise (CCW) from neutral. The switch is rated at 5 amperes inductive load at 12 or 24 Vdc. The NSS should be wired in series with the engine starting circuit and is intended to verify the neutral position of the pump before allowing the engine to start.

This switch is available with screw terminals (no connector) or with a Packard Weather-Pack™ 2-way sealed connector.

Pump displacement vs control lever rotation



MDC signal required for swashplate position

Handle configuration	Swashplate position (ref. above chart)	
	Swashplate movement begins (point A) degrees	Full displacement reached (pont B) degrees
Standard	1.5°	20°
with NSS	3.0°	20°

NSS specifications

Switch position on neutral	Closed
Neutral play	± 1.5°~2°
VDC	12 or 24
Rated current (A)	5
Connector type	Screw or Weather-Pack™

HYDRAULIC DISPLACEMENT CONTROL (HDC) M46 VARIABLE PUMP

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 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.

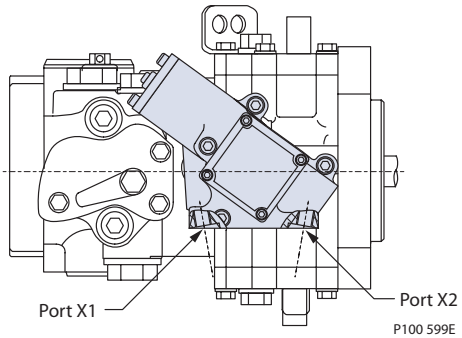
Features

- 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.

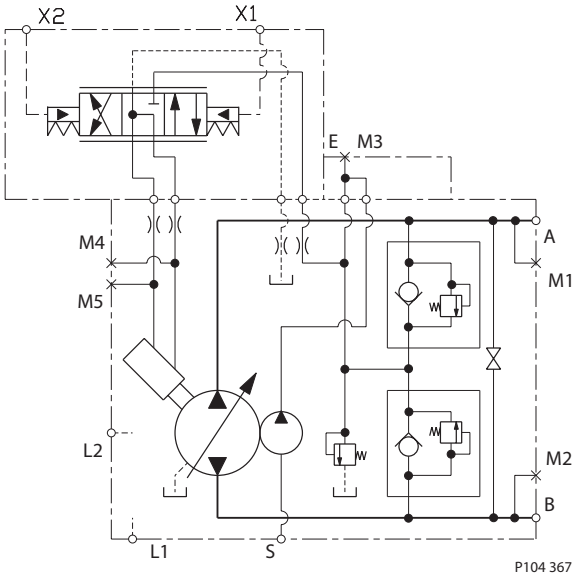
Benefits

- 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.

HDC on M46 PV



HDC Hydraulic Schematic



HYDRAULIC DISPLACEMENT CONTROL (HDC) M46 VARIABLE PUMP (continued)

Pump flow direction with HDC control

		Input Shaft Rotation			
		CW		CCW	
PV or front PT	Higher pressure into control port:	X1	X2	X1	X2
	Port A flow	Out	In	In	Out
	Port B flow	In	Out	Out	In
Rear PT	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.					

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 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 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

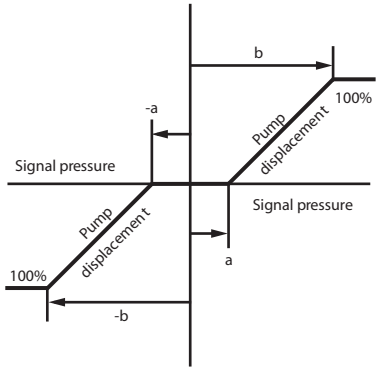
The HDC can be tailored to respond to a higher signal pressure. Optional heavy spring packs are available that operate in the 3 to 14 bar [44 to 200 psi] range and the 5 to 15 bar [70 to 220 psi] range.

HDC response time

Orifice diameter* mm [in]		Average response time (seconds)	
		Acceleration	Deceleration
0.9	[0.037]	1.6	1.3
1.4	[0.055]	0.9	0.7
None		0.4	0.3

*Contact Sauer-Danfoss for special orifice combinations

Pump displacement vs hydraulic signal



HYDRAULIC DISPLACEMENT CONTROL (HDC) M46 VARIABLE PUMP (continued)

HDC Signal requirement for swashplate position

Configuration	Swashplate position (ref above chart)			
	Swashplate movement begins (point A)		Full displacement reached (point B)	
	bar	[psid]	bar	[psid]
Standard	1.3±0.5	[19±7]	11.7±1.1	[170±16]
Option	3.0±0.7	[44±10]	14.0±1.4	[200±20]
Option	5.0±0.7	[70±10]	15.0±1.4	[220±20]

HDC Input specs

Max. input pressure bar [psi]	27.5 [400]

ELECTRICAL DISPLACEMENT CONTROL (EDC) M46 VARIABLE PUMP

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.

Features::

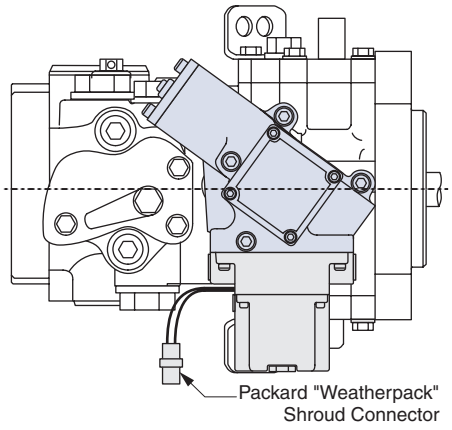
- The EDC is a high gain control: with only a small change in the input current, the servo valve moves to a full open position thus porting maximum flow to the servo cylinder.
- Oil filled PCP valve case lengthens control life by preventing moisture ingression and dampening component vibrations.
- Internal 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.

ELECTRICAL DISPLACEMENT CONTROL (EDC) M46 VARIABLE PUMPS (continued)

EDC on M46 PV



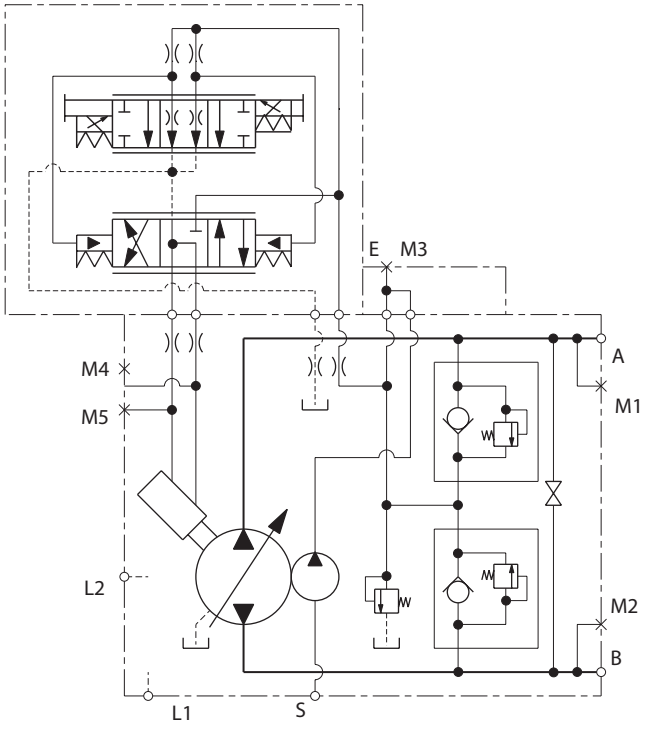
Pump flow direction with EDC control

		Input shaft rotation			
		CW		CCW	
PV or front PT	Positive signal to pin:	A	B	A	B
	Port A Flow	Out	In	In	Out
	Port B Flow	In	Out	Out	In
Rear PT	Positive signal to pin:	A	B	A	B
	Port C flow	In	Out	Out	In
	Port D flow	Out	In	In	Out
High servo gauge port		M4	M5	M4	M5

EDC Signal required for swash

Coil configuration	Swashplate position (ref about chart)	
	Swashplate movement begins (point A) mA	Full displacement reach (point B) mA
Single coil	16 ± 5	90 ± 12
Dual coil in series	1.5 ± 3	65 ± 9
Dual coil in parallel	23 ± 6	132 ± 18

EDC Hydraulic Schematic



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ELECTRICAL DISPLACEMENT CONTROL (EDC) M46 VARIABLE PUMPS (continued)

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 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 required pump command current signal is 16 mA (nominal) threshold and a maximum of 90 mA (nominal) to provide full pump displacement with a 12 VDC source. The maximum command current must be less than 250 mA to prevent damage to the input coil.

Electrical displacement control options

The standard EDC is a single coil, Packard Weather-Pack™ connector device, with an oil filled case. Options include:

- Dual coil - A dual coil control allows utilization of two command sources, the resulting signal being the algebraic sum of the two. Dual coils allow operation of a machine from either the operator's station or the ground.
- MS connectors - MS connectors provide a mechanical, threaded retention interface between the connector halves. Most military applications require MS connectors.

For further information refer to Sauer-Danfoss publication **95-8988**.

EDC response time

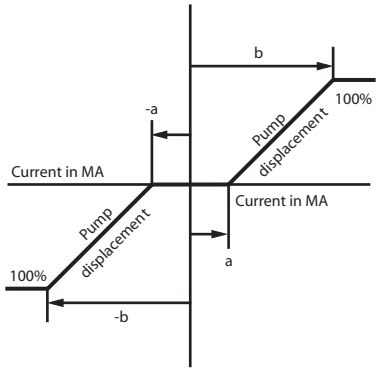
Orifice diameter* mm [in]		Average response time (seconds)	
		Acceleration	Deceleration
0.9	[0.037]	1.6	1.3
1.4	[0.055]	0.9	0.7
None		0.4	0.3

*Contact Sauer-Danfoss for special orifice combinations.

EDC Input specs

Coil resistance Ohms @24°C [75°F]	23 Ohms
Max input current mA	250
Coils	Single or dual
Connectors	Weather-Pack™ or MS

Pump displacement vs electrical signal



THREE-POSITION ELECTRICAL CONTROL (FNR)

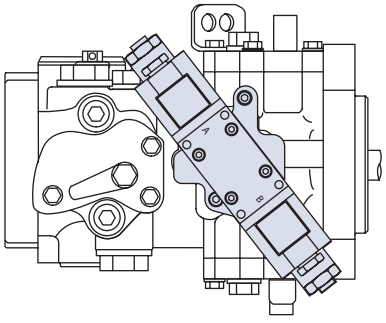
The three-position Forward-Neutral-Reverse (FNR) is a two stage control that uses a solenoid operated 3-position, 4-way valve to move pump displacement from neutral to maximum displacement in either direction.

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 on next page.)

Features and benefits

- Electric control.
- If voltage is lost, the control returns pump to neutral.
- Simple, low-cost design.
- Ideal for applications that do not require proportional control.

FNR Control on M46 PV

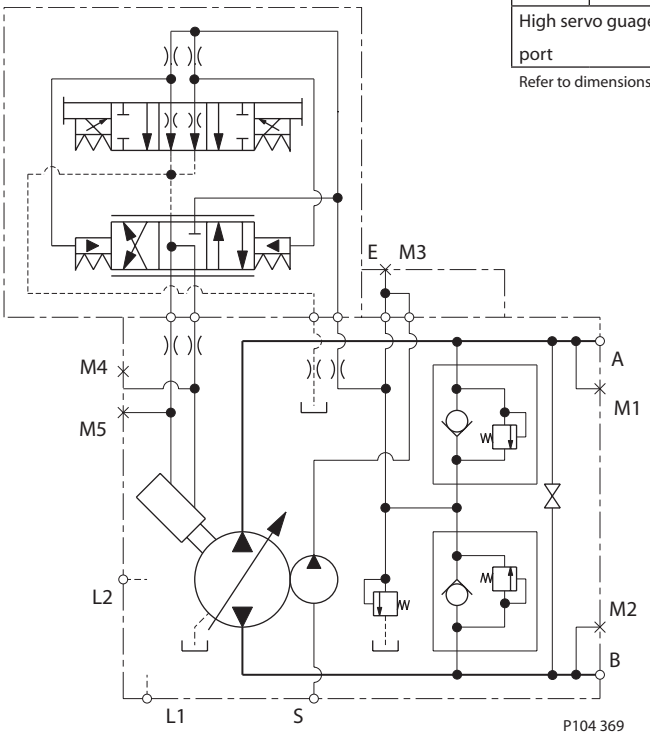


Pump flow direction with FNR control

		Input shaft rotation			
		CW		CCW	
PV or front PT	Solenoid energized:	A	B	A	B
	Port A flow	Out	In	In	Out
	Port B flow	In	Out	Out	In
Rear PT	Solenoid energized	A	B	A	B
	Port C flow	In	Out	Out	In
	Port D flow	Out	In	In	Out
High servo guage port		M4	M5	M4	M5

Refer to dimensions for solenoid and port locations

FNR Hydraulic schematic



THREE POSITION ELECTRICAL CONTROL (FNR) (continued)

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 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 or with a Packard Weather-Pack™ 2-way sealed connector.

FNR response time

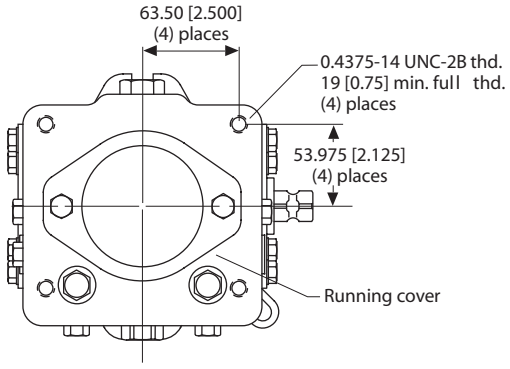
Orifice diameter mm [in]		Average response time (seconds)	
		Acceleration	Deceleration
0.9	[0.037]	1.3	0.9
1.4	[0.055]	0.5	0.4
None		0.1	0.1

FNR input specifications

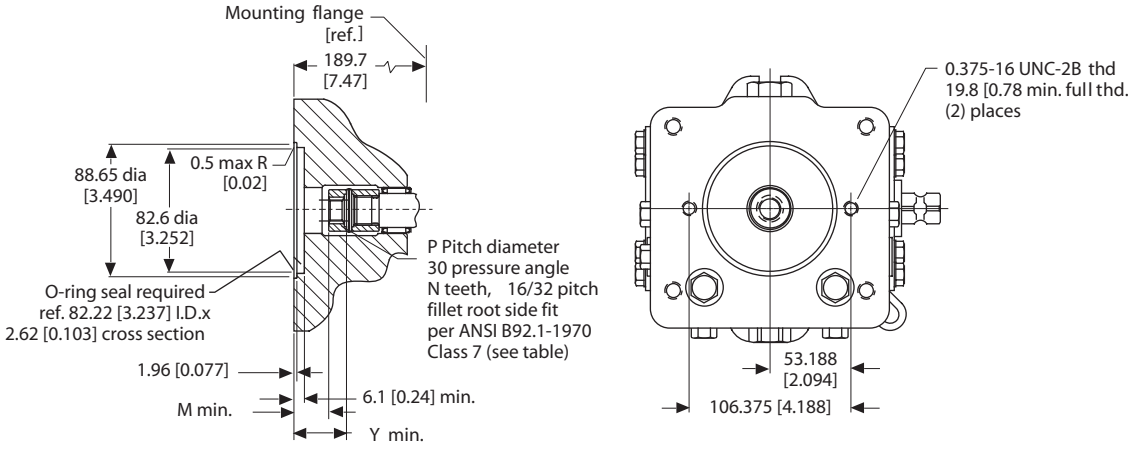
VDC	12 or 24
Max power	30 W
Connectors	DIN 43650 or Weather-Pack™

M25 VARIABLE PUMP DIMENSIONS

Auxiliary mounting flange



Running cover



SAE A Auxiliary mounting flange

P100 603E

M25PV Auxiliary flange coupling options

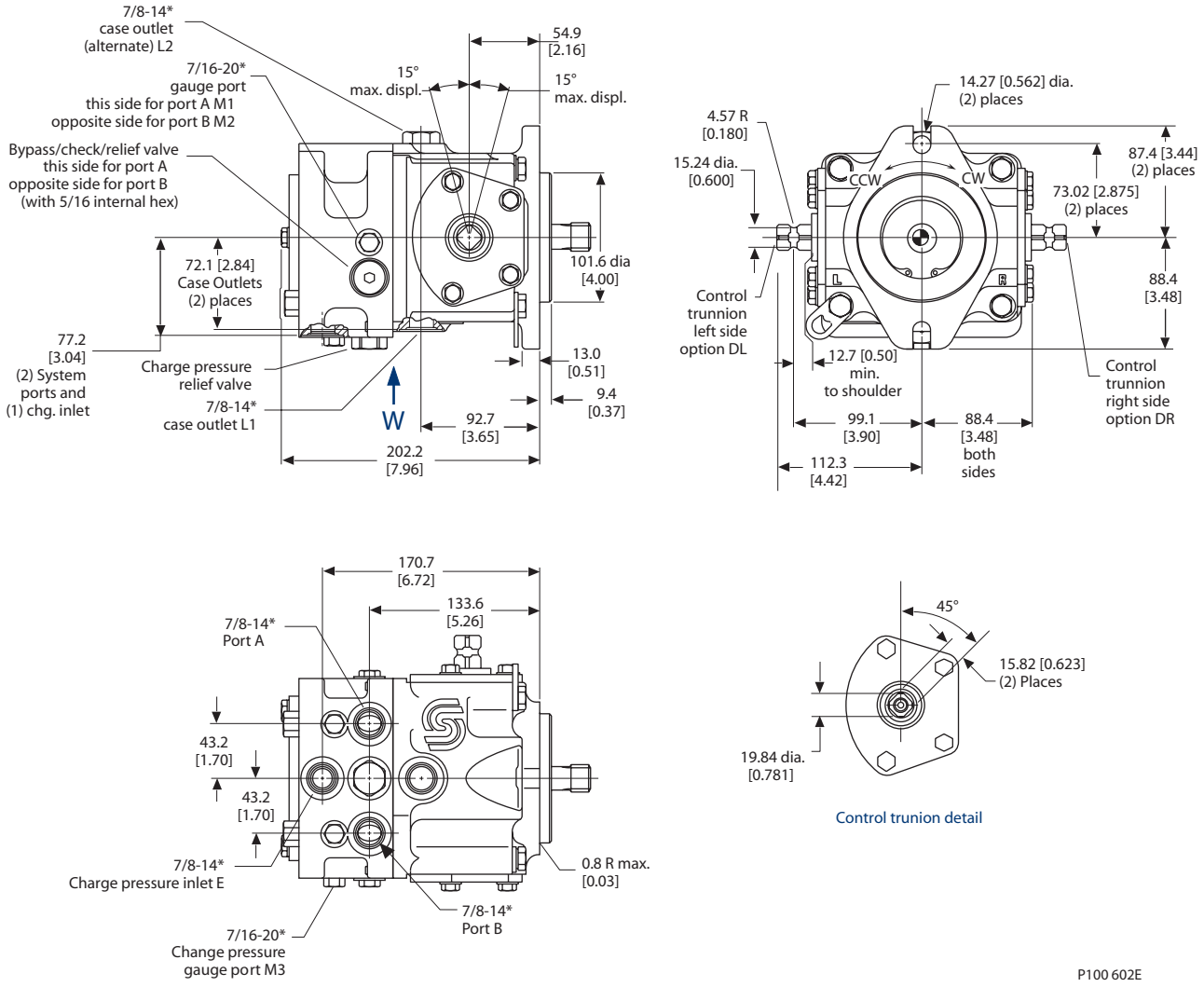
Auxiliary mounting flange		Spline pitch dia. P	Number of teeth N	Shaft clearance Y	Coupling clearance M
SAE A	Option A	14.30 [0.563]	9	34.5 [1.36]	22.6 [0.89]
SAE A	Option D	17.46 [0.688]	11	39.6 [1.56]	25.9 [1.02]

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

M25 VARIABLE PUMP DIMENSIONS (continued)

Pump and control

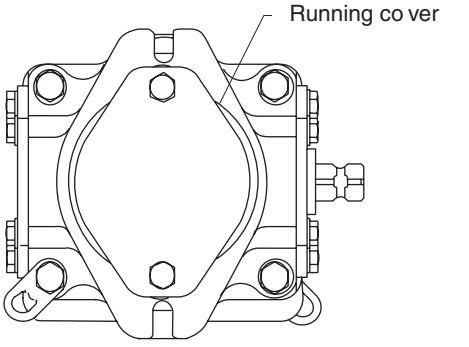


*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

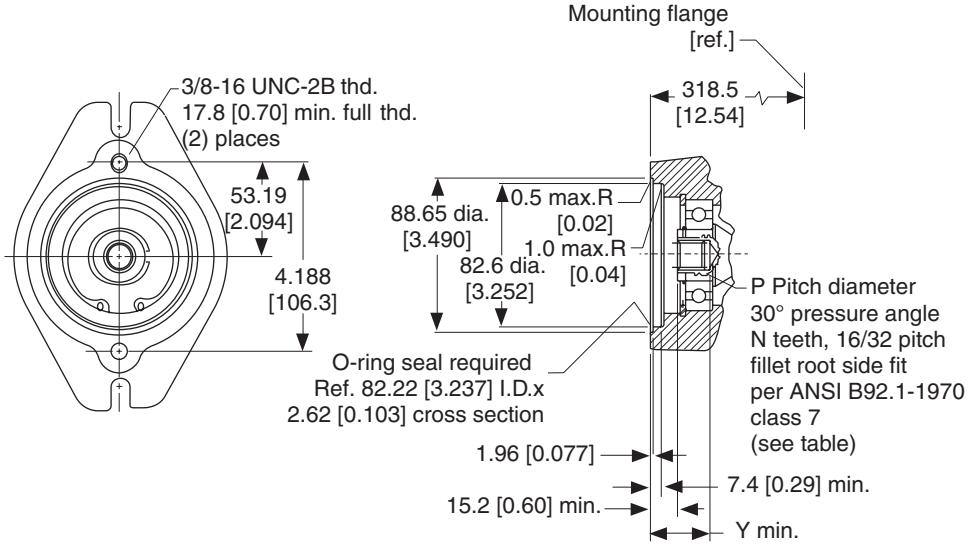
Dimensions in mm [in]

M25 TANDEM PUMP DIMENSIONS

Auxiliary mounting flange



Running cover



SAE A Auxiliary mounting flange

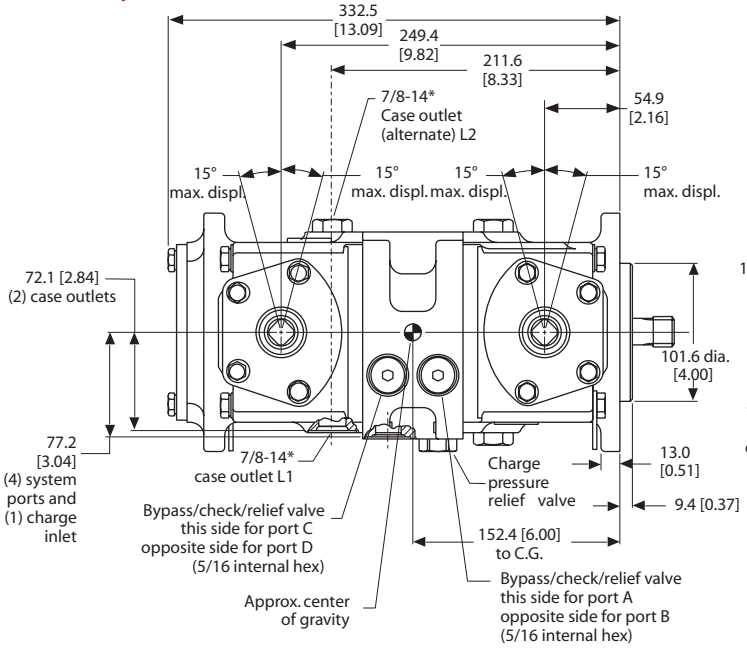
P100 612E

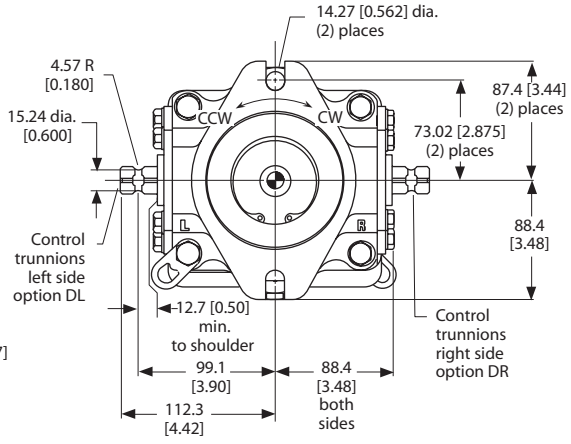
*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

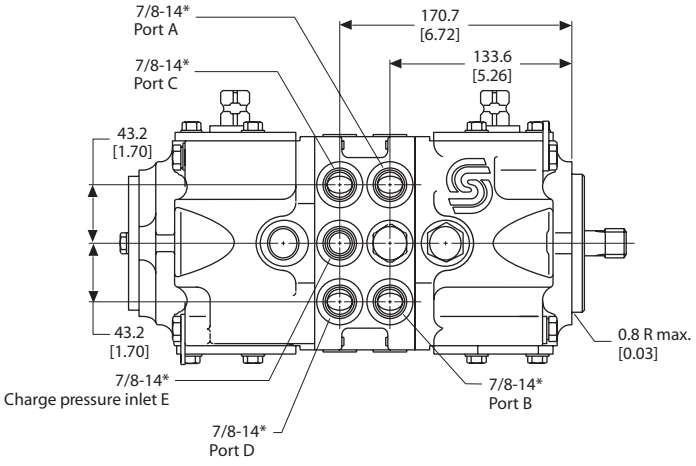
Dimensions in mm [in]

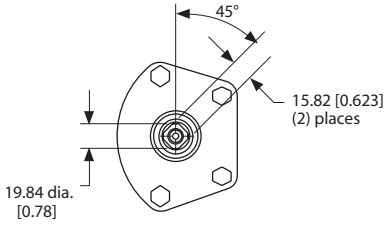
M25 TANDEM PUMP DIMENSIONS (continued)

Pump and control









Control trunion detail

P100 611E

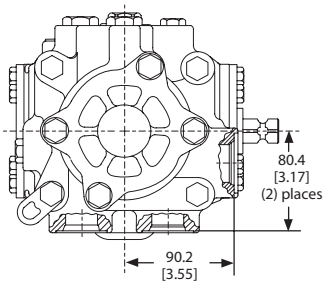
*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

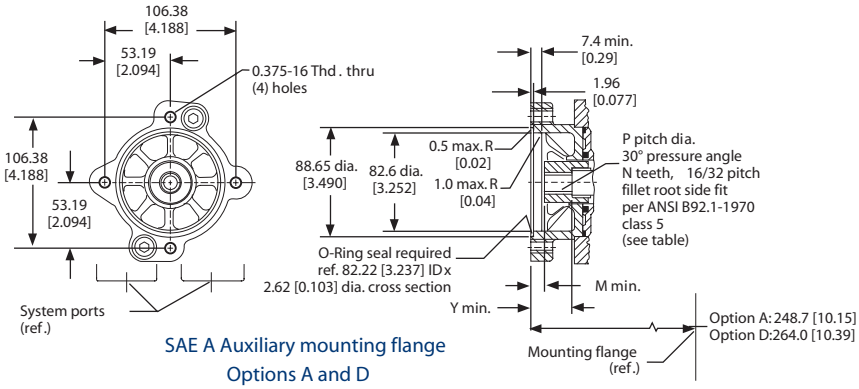
Notes

M35/44 VARIABLE PUMP DIMENSIONS

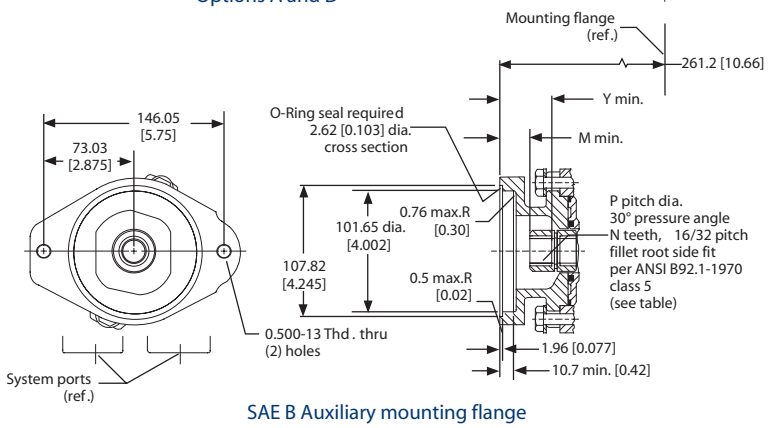
Auxiliary mounting flange



RUNNING COVER



SAE A Auxiliary mounting flange
Options A and D



SAE B Auxiliary mounting flange
Option B

P100 615E

M35/44 PV Auxiliary mounting flange and coupling option

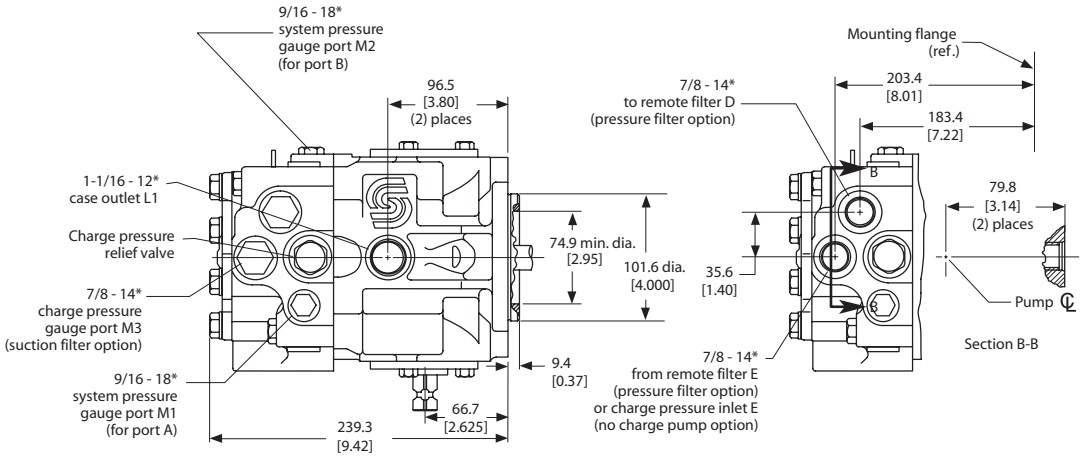
Auxiliary mounting flange		Spline pitch dia. P	No. teeth N	Shaft clearance Y	Coupling clearance M
SAE A	Option A	14.30 [0.563]	9	33.0 [1.30]	9.1 [0.36]
SAE A	Option D	17.46 [0.688]	11	39.1 [1.54]	9.1 [0.36]
SAE B	Option B	20.72 [0.813]	13	42.9 [1.69]	22.3 [0.91]

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

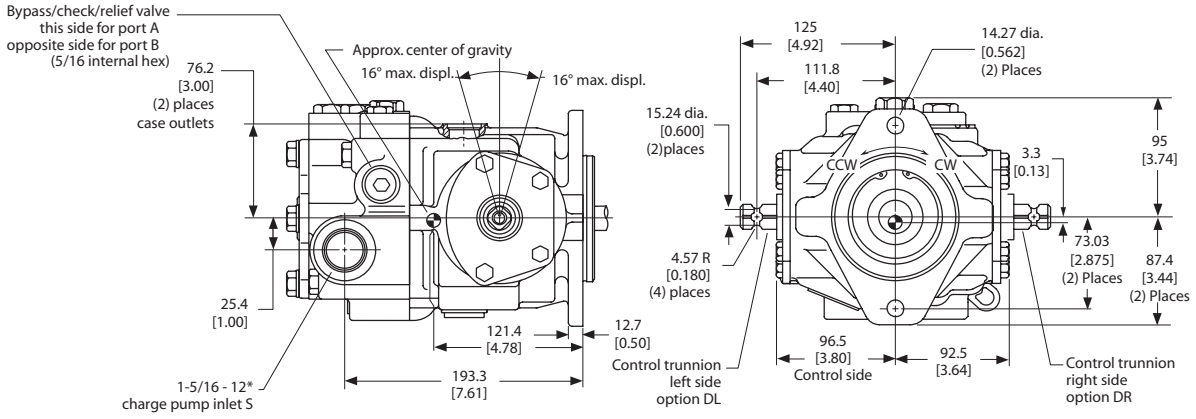
M35/44 VARIABLE PUMP DIMENSIONS (continued)

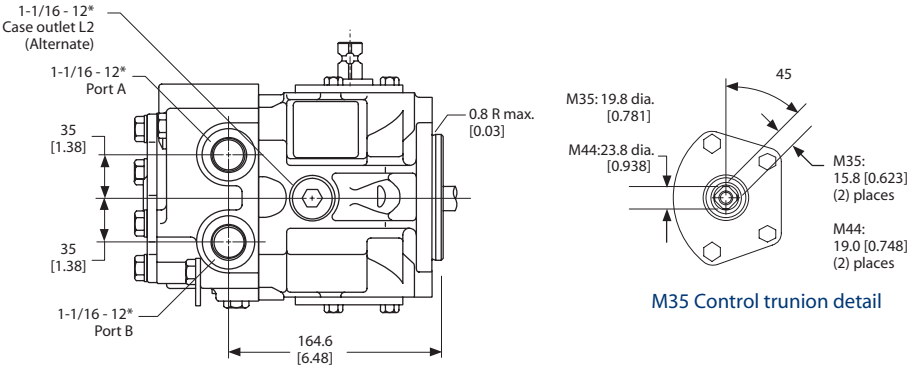
Pump, filtration/charge pump option, control



Top view
Suction filtration

Top view
Remote filtration or less charge pump





M35 Control trunion detail

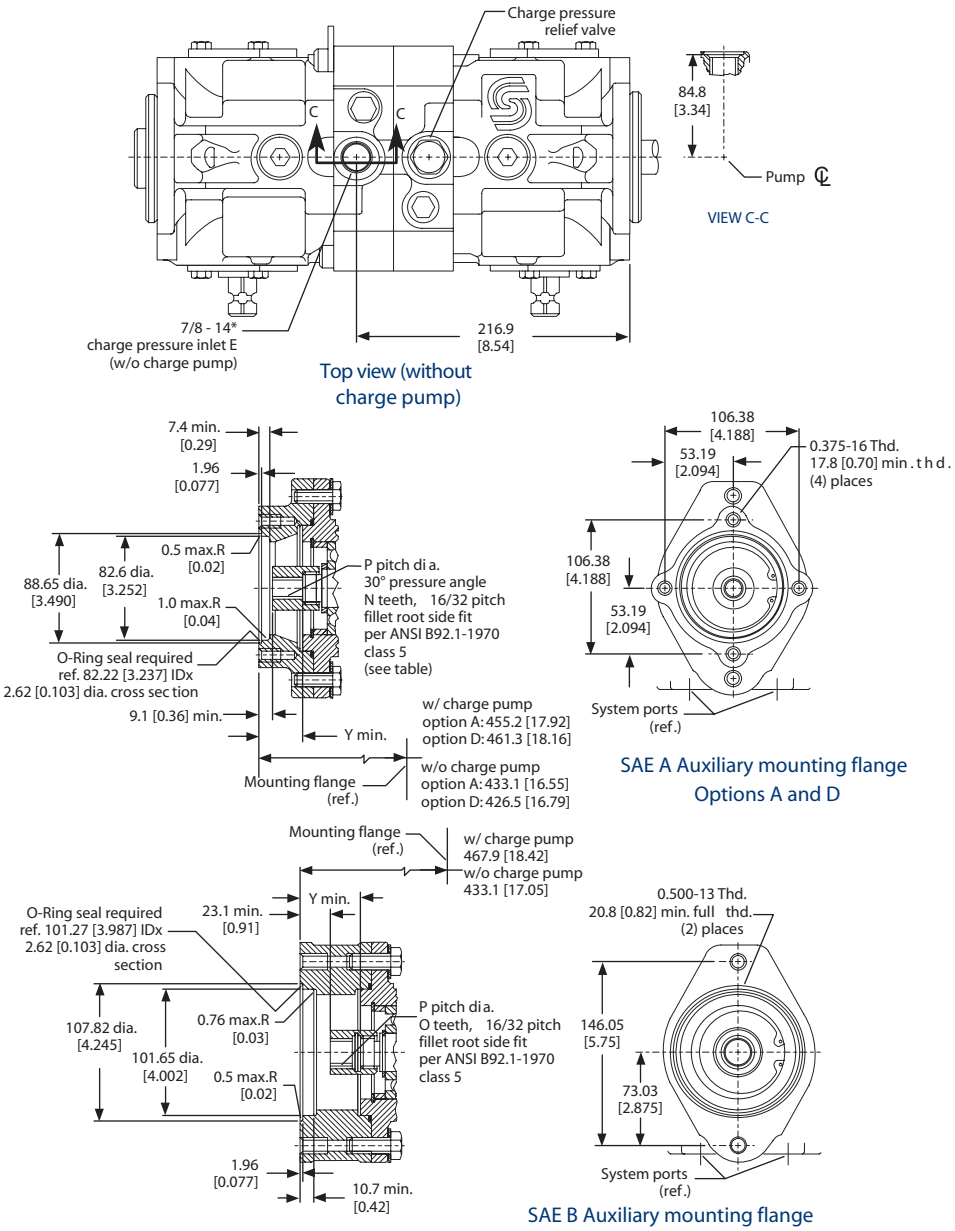
P104 614E

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

M35/44 TANDEM PUMP DIMENSIONS

Charge pump options, auxiliary mounting flanges



M35/44 PT Auxiliary mounting flange and coupling options

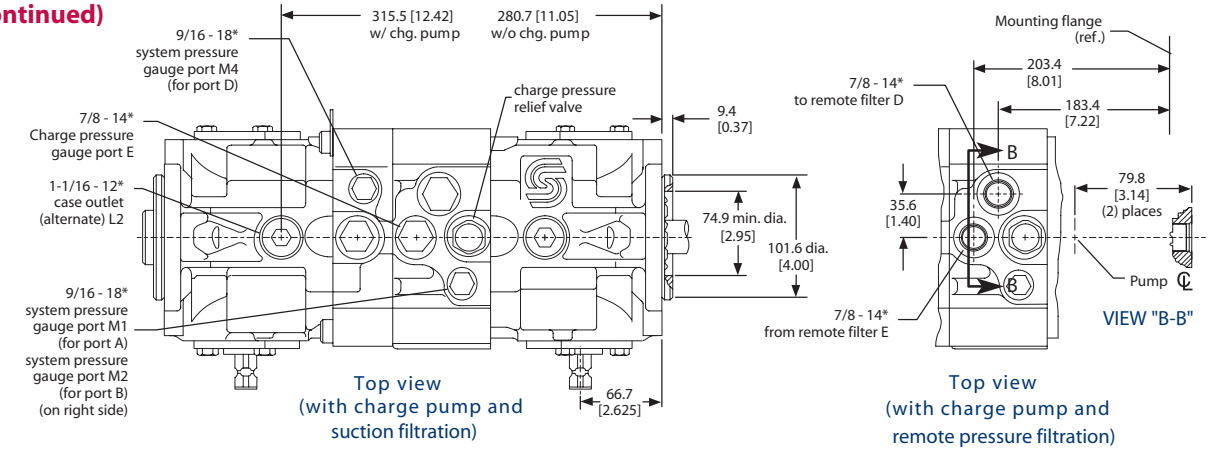
Auxiliary mounting flange		Spline pitch dia. P	No. teeth N	Shaft clearance Y	Coupling clearance M
SAE A	Option A	14.30 [.563]	9	33.0 [1.30]	9.1 [0.36]
SAE A	Option D	17.46 [.688]	11	39.1 [1.54]	9.1 [.36]
SAE B	Option B	20.72 [0.813]	13	42.9 [1.69]	22.3 [0.91]

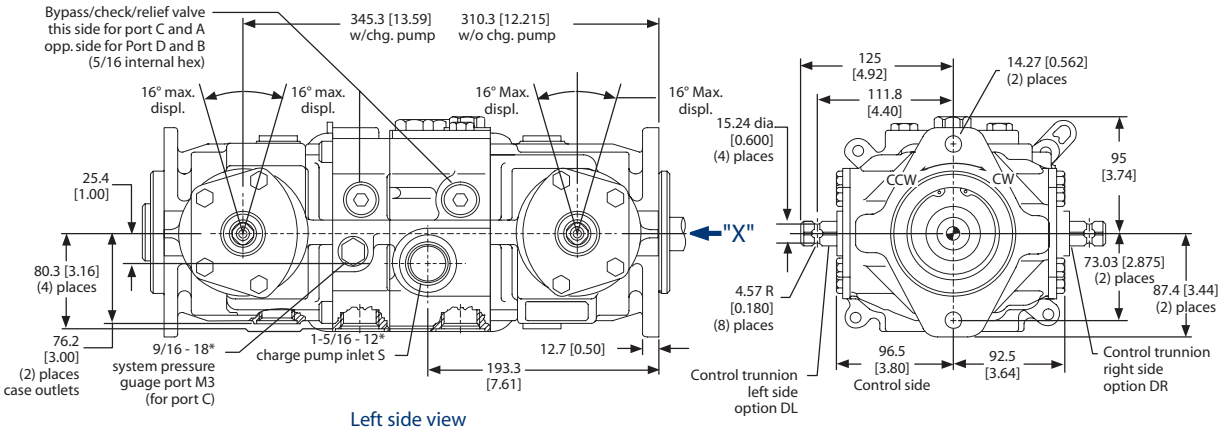
*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

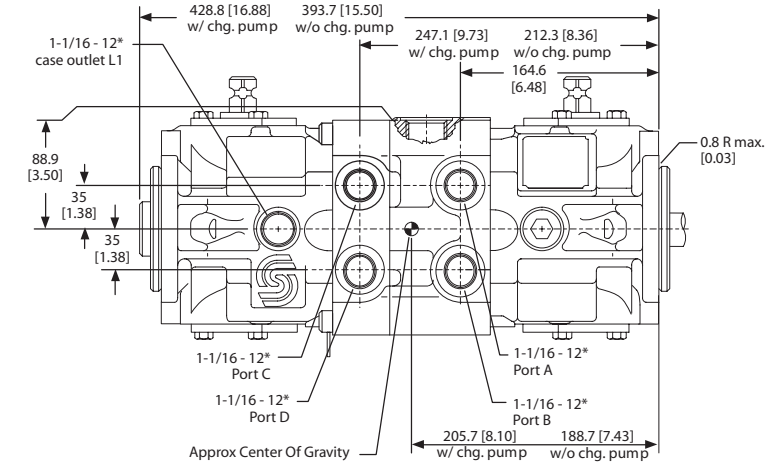
Dimensions in mm [in]

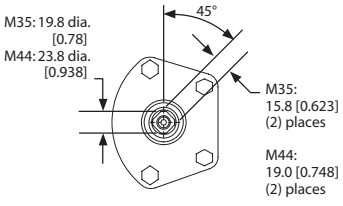
M35/44 TANDEM PUMP DIMENSIONS (continued)

Pumps, filtration/charge pump options, control









M35 Control trunion detail

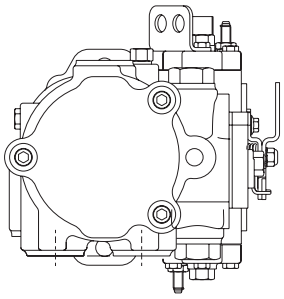
P100 616E

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

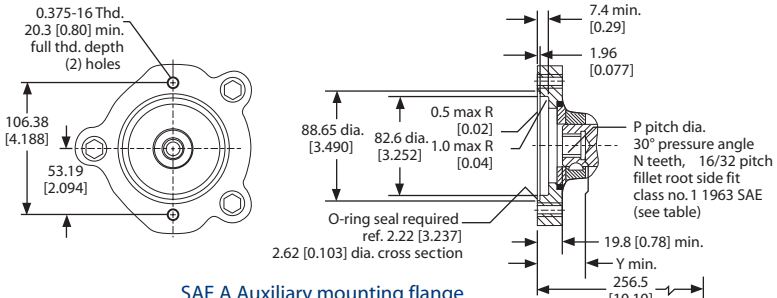
Dimensions in mm [in]

M46 VARIABLE PUMP DIMENSIONS

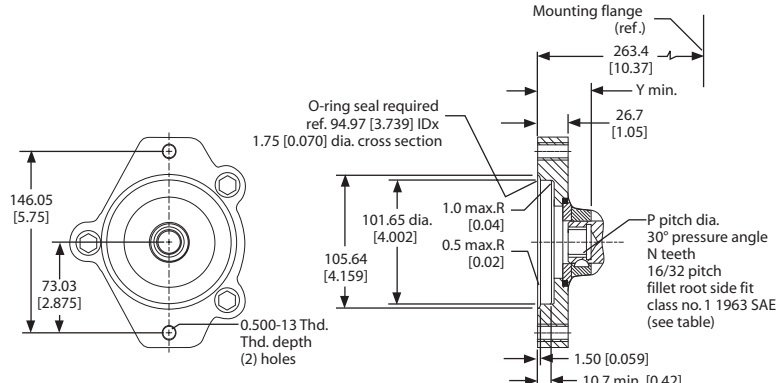
Auxiliary mounting flanges



Rear view (no pads shown)



SAE A Auxiliary mounting flange
Options A and D



SAE B Auxiliary mounting flange
Option B

P100 619E

M46 PV auxiliary mounting flange and coupling options

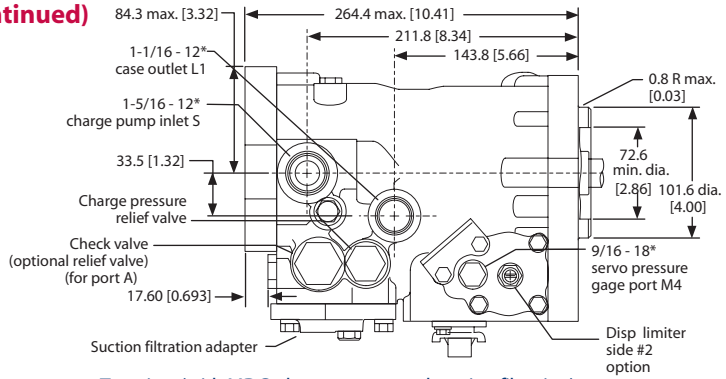
Auxiliary mounting flange		Spline pitch dia. P	Number of teeth N	Minimum clearance Y
SAE A	Option A	14.30 [0.563]	9	36.6 [1.44]
SAE A	Option D	17.46 [0.688]	11	42.4 [1.67]
SAE B	Option B	20.72 [0.813]	13	46.0 [1.81]

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

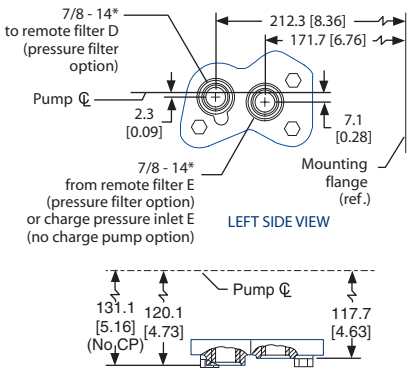
Dimensions in mm [in]

M46 VARIABLE PUMP DIMENSIONS (continued)

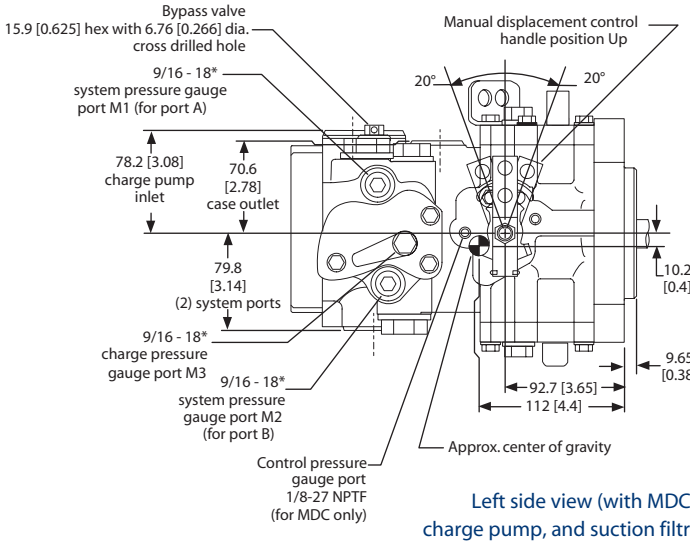
Pump, filtration/charge pump options, MDC, displacement limiter



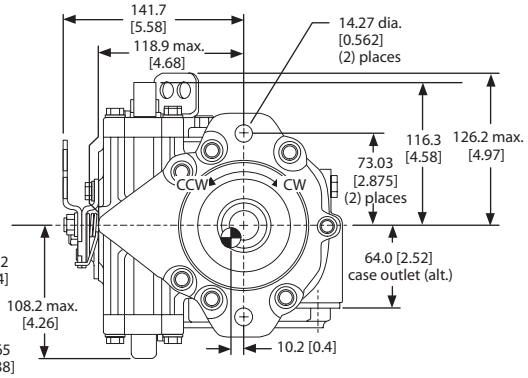
Top view (with MDC, charge pump, and suction filtration)



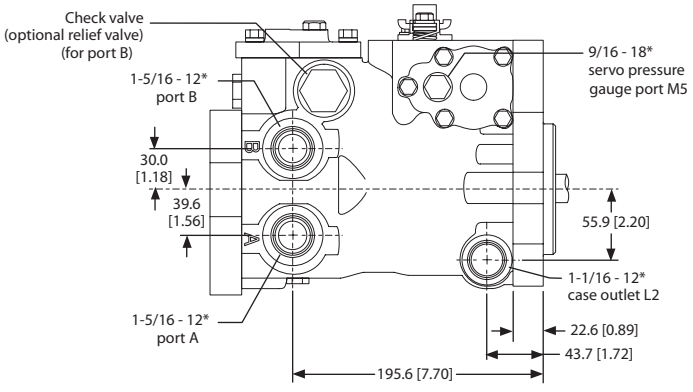
Remote filtration with or without charge pump



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



Front view (with MDC)



Bottom view (with MDC and suction filtration)

P100 618E

M46 PV adjustable displacement limiter (option)

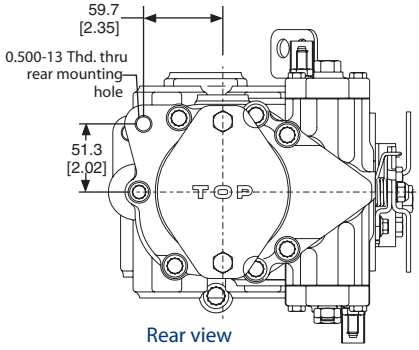
Shaft rotation	CW	CCW
Displacement limiter side	2	2
Limits flow out of port	B	A

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

M46 TANDEM PUMP DIMENSIONS

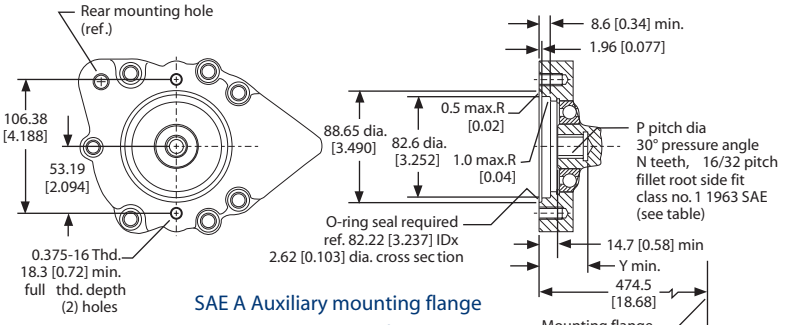
Auxiliary mounting flange



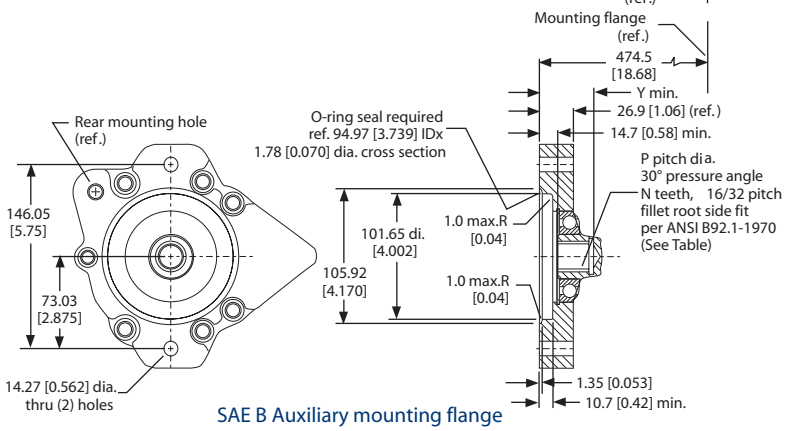
Rear view
no auxiliary mounting flange

M46 PT 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	35.6 [1.40]
SAE A	Option D	17.46 [0.688]	11	38.1 [1.50]
SAE B	Option B	20.72 [0.813]	13	47.5 [1.87]



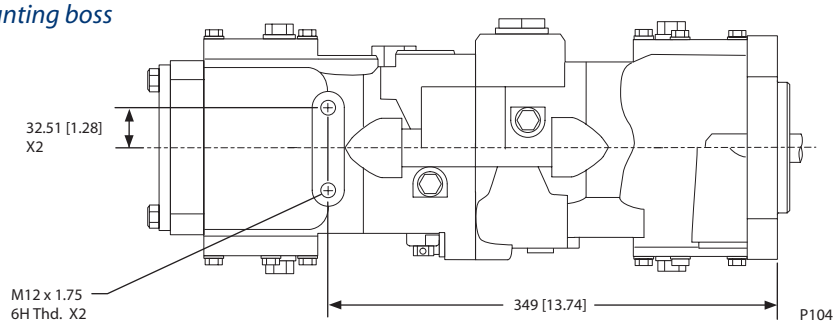
SAE A Auxiliary mounting flange
options A and D



SAE B Auxiliary mounting flange
Option B

P100 628E

Rear mounting boss



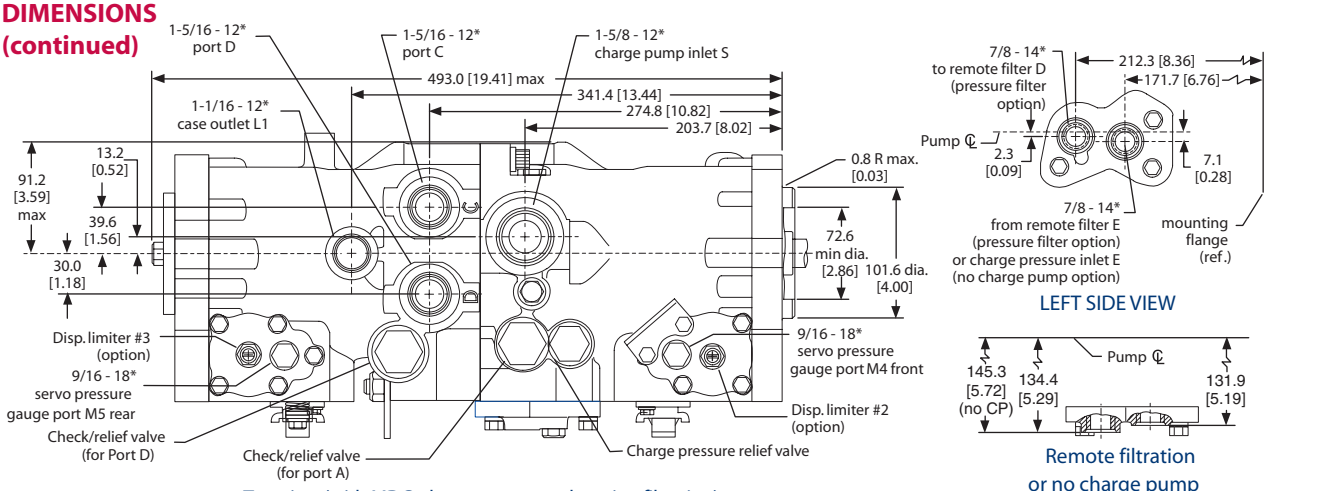
P104 425E

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

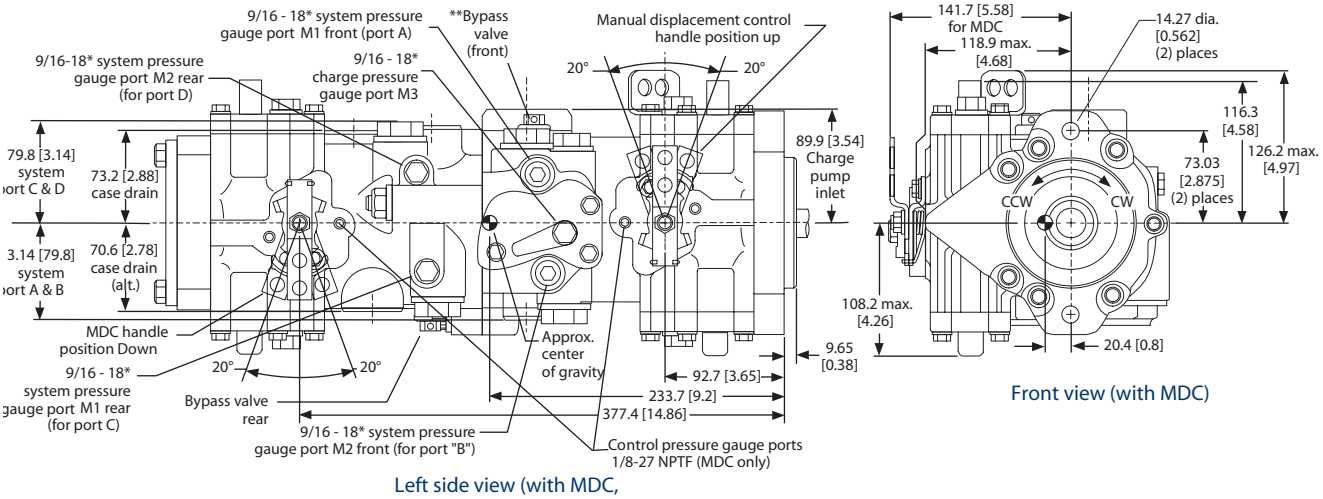
Dimensions in mm [in]

M46 TANDEM PUMP DIMENSIONS (continued)

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

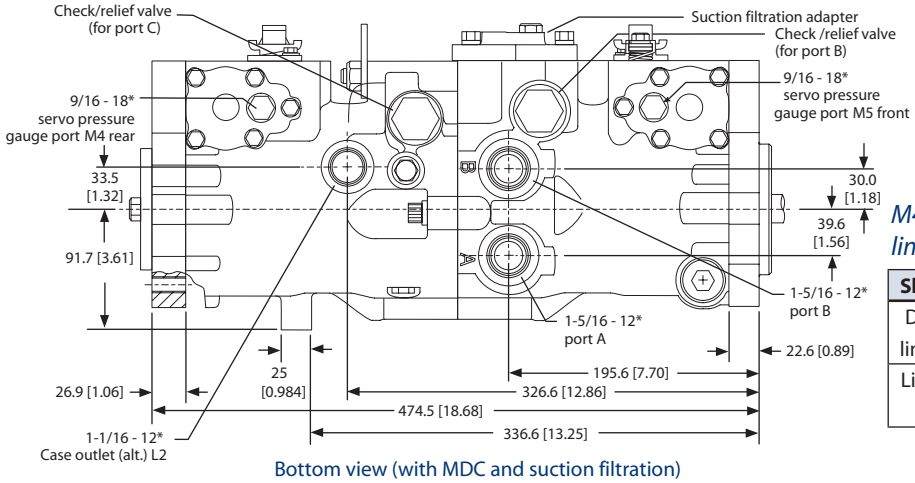


Top view (with MDC, charge pump, and suction filtration)



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

P100 620E



Bottom view (with MDC and suction filtration)

M46 PT adjustable displacement limiters (option)

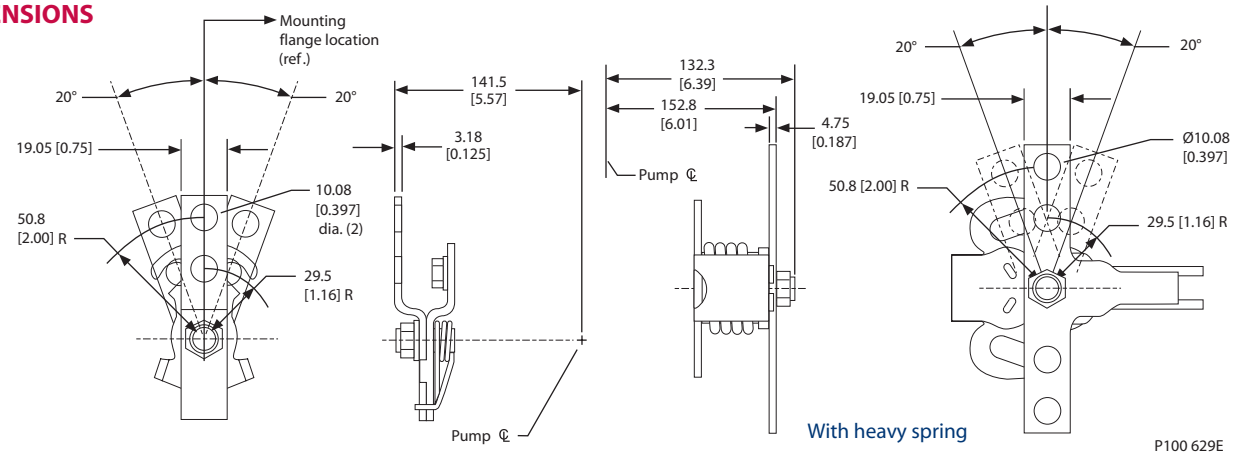
Shaft rotation	CW		CCW	
Displacement limiter number	2	3	2	3
Limits flow out of port	B	D	A	C

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

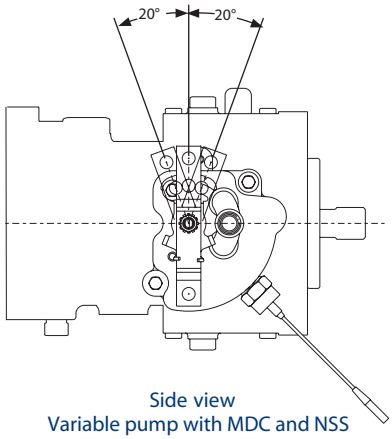
Dimensions in mm [in]

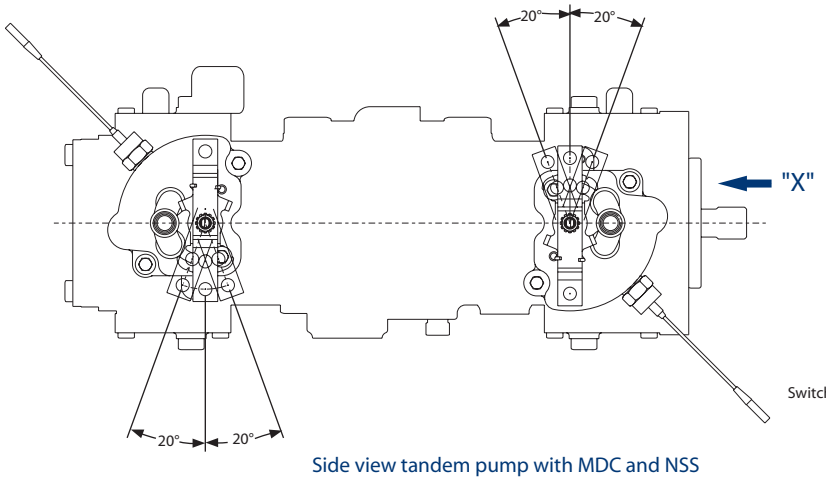
M46 CONTROL MODULE DIMENSIONS

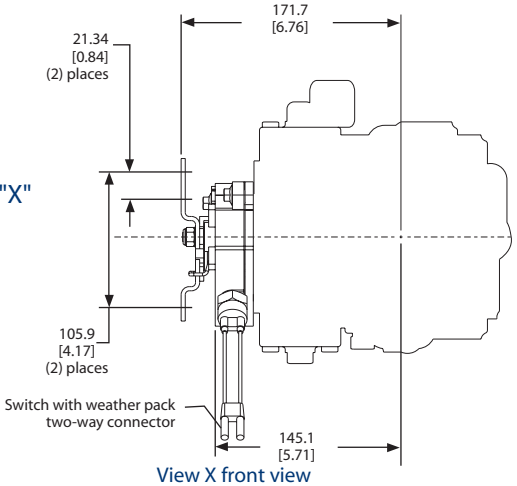
M46 PV/PT manual displacement control handle



M46 PV/PT manual displacement control with neutral start switch





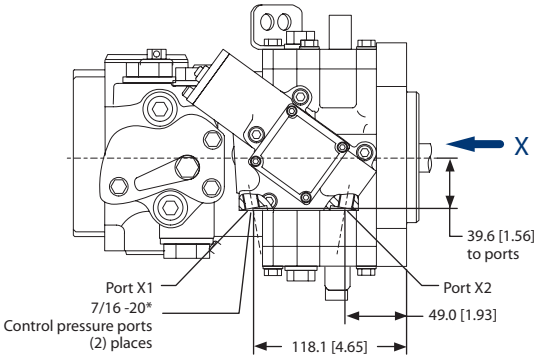


*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

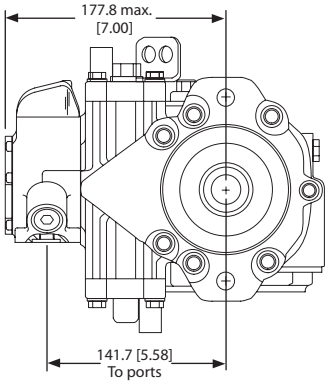
Dimensions in mm [in]

M46 CONTROL MODULE DIMENSIONS (continued)

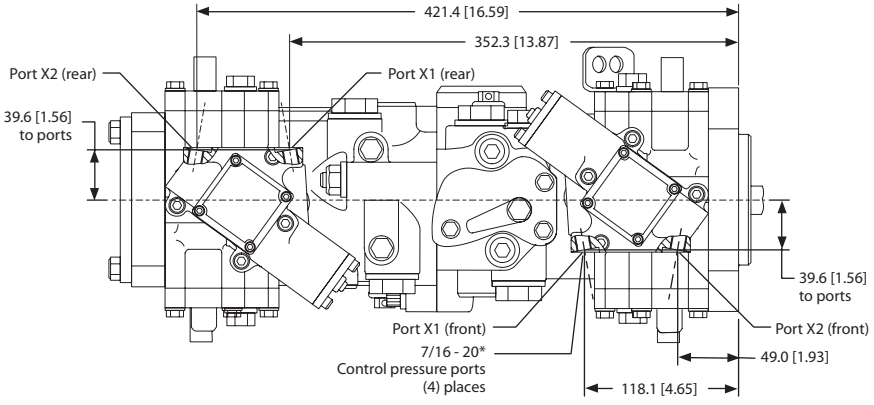
M46 PV/PT hydraulic displacement control



Side view
Variable pump with HDC



View X
Front view
Variable pump with HDC



Side view
Tandem pump with HDC

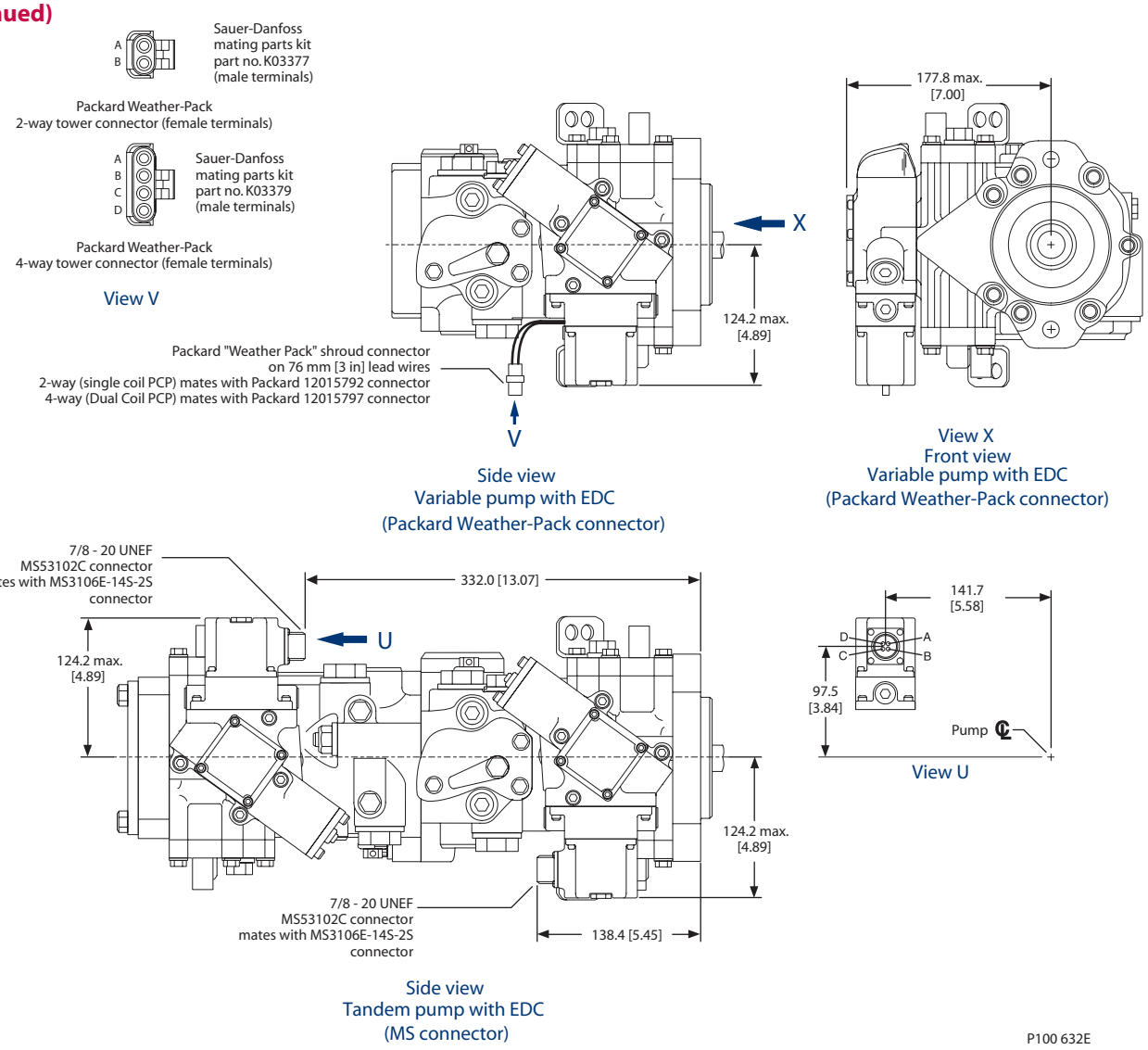
P100 631E

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

M46 CONTROL MODULE DIMENSIONS (continued)

M46 PV/PT electronic displacement control

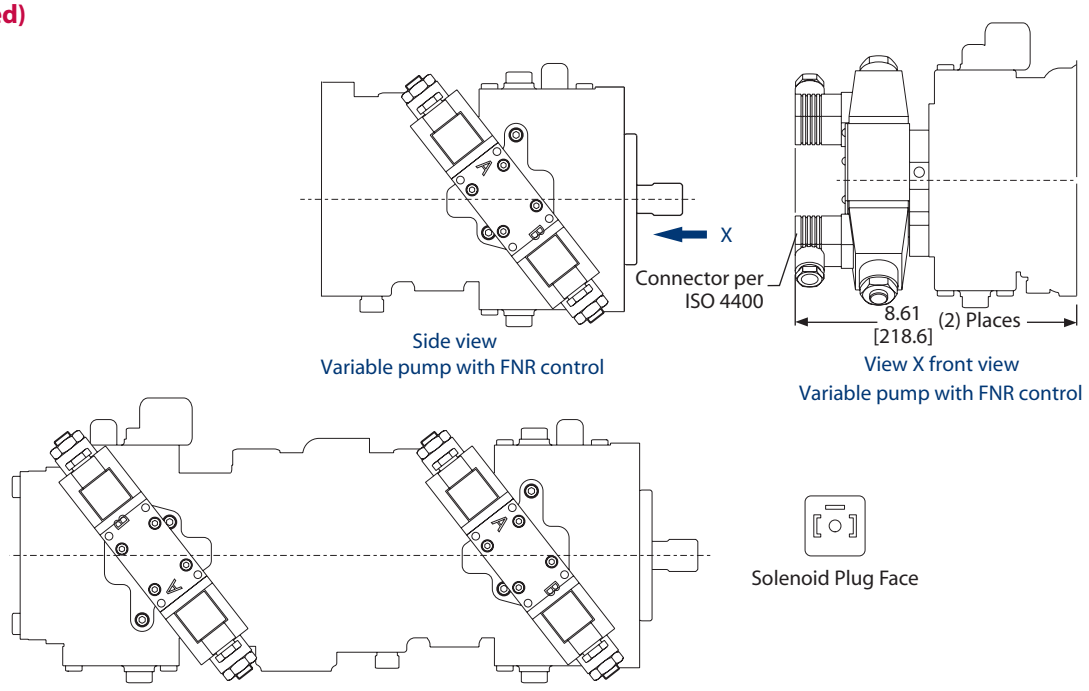


*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

M46 CONTROL MODULE DIMENSIONS (continued)

M46 PV/PT three-position electic displacement control (FNR)



Side view
Variable pump with FNR control

View X front view
Variable pump with FNR control

Side view
Tandem pump with FNR control

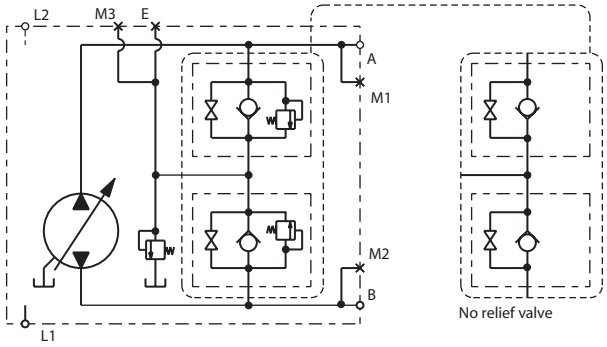
P100 635E

*All ports are SAE straight thread o-ring ports per SAE J514, unless otherwise specified.
Shaft rotation is determined by viewing pump from input shaft end.
Contact your SAUER-DANFOSS representative for specific installation drawings.

Dimensions in mm [in]

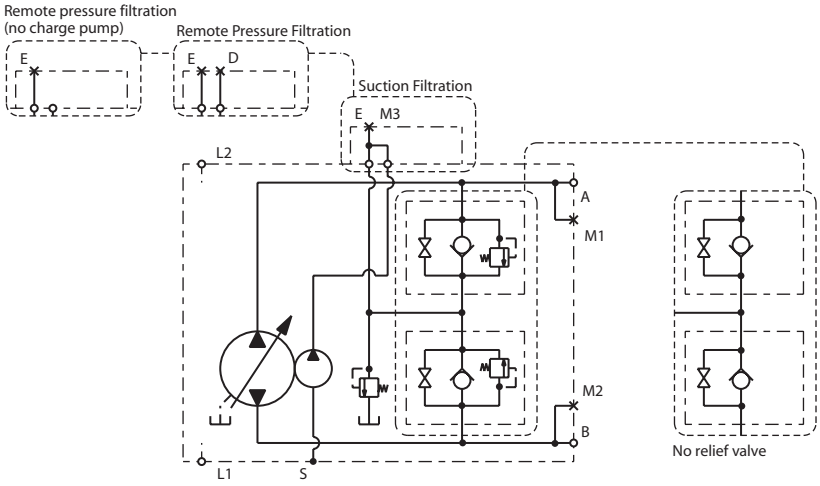
SERIES 40 PVARIABLE PUMP SCHEMATICS

M25 PV



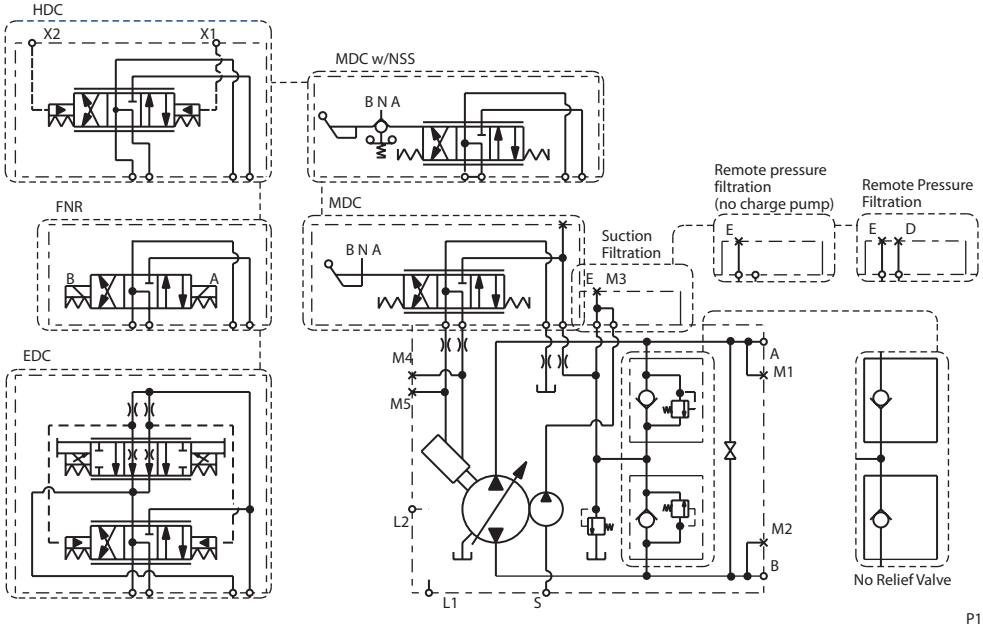
P100 637E

M35/44 PV



P100 638E

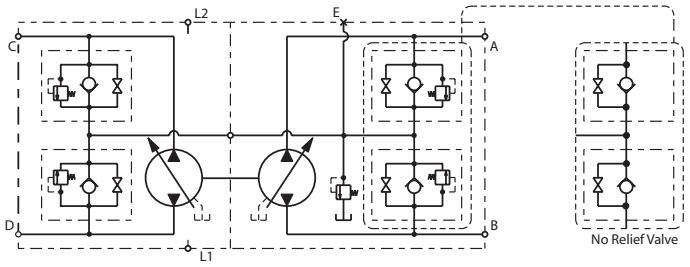
M46 PV



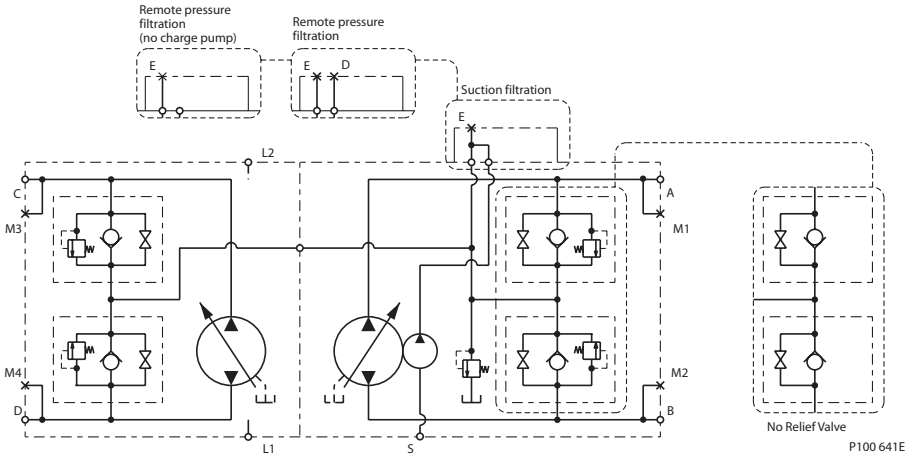
P100 639E

SERIES 40 TANDEM PUMP SCHEMATICS

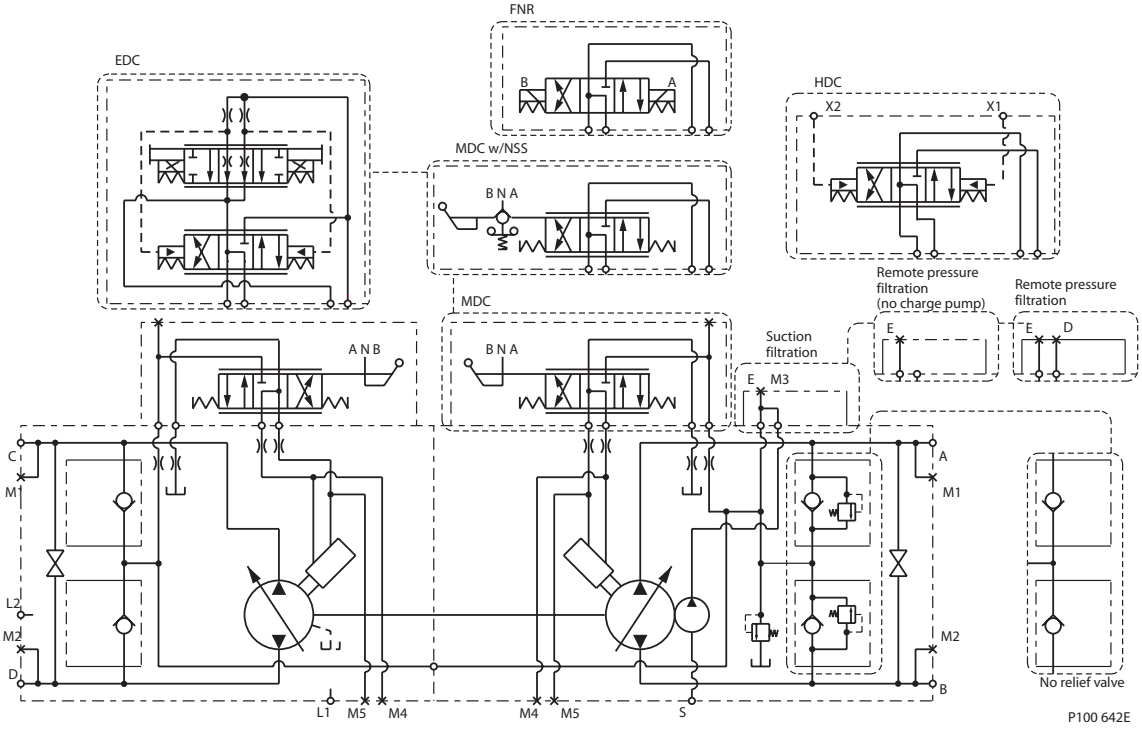
M25 PT



M35/44 PT



M46 PT



Notes

SAUER DANFOSS

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Proportional valves

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Sauer-Danfoss serves markets such as agriculture, construction, road building, material handling, municipal, forestry, turf care, and many others.

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520L0635 • Rev EI • February 2010