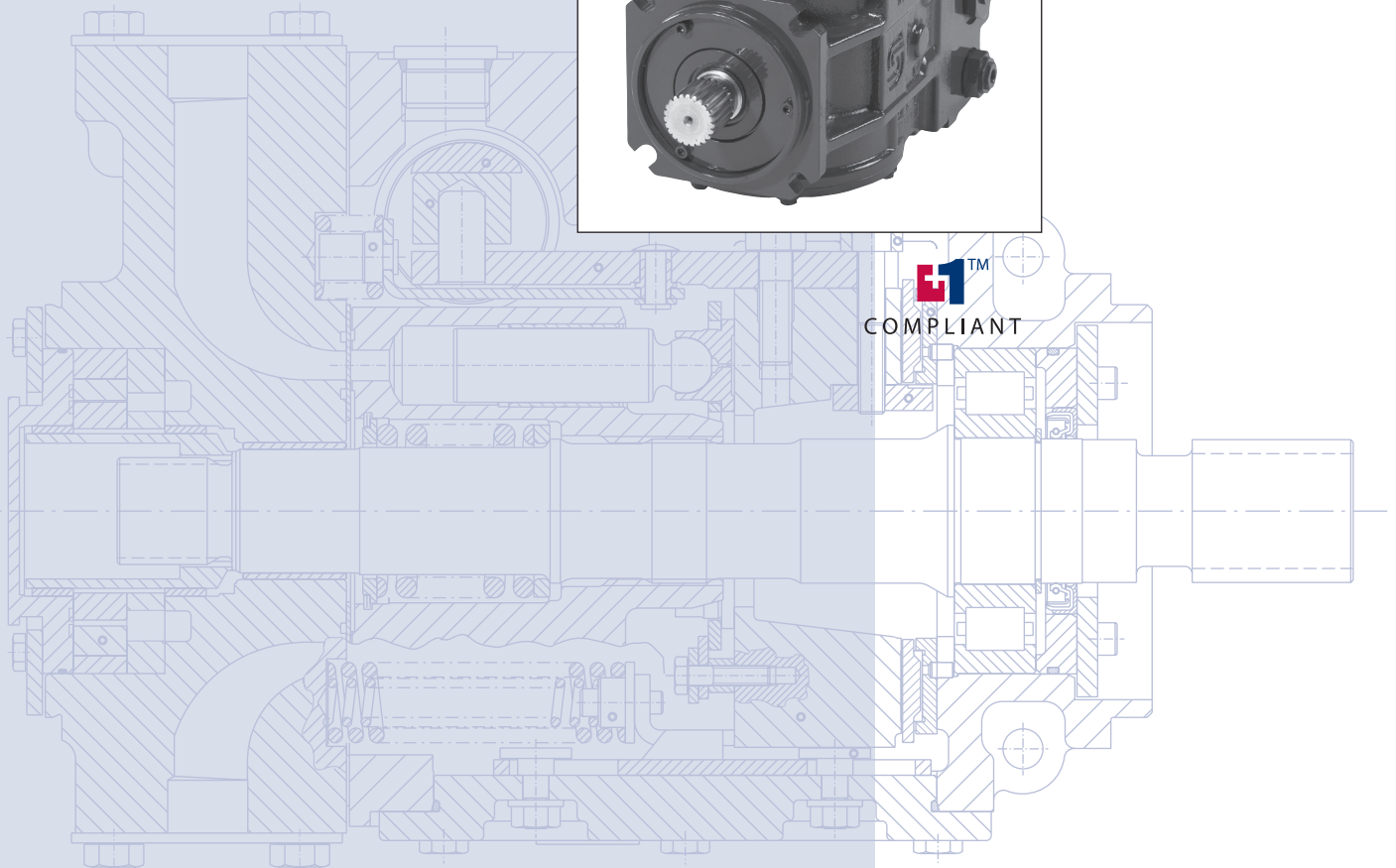
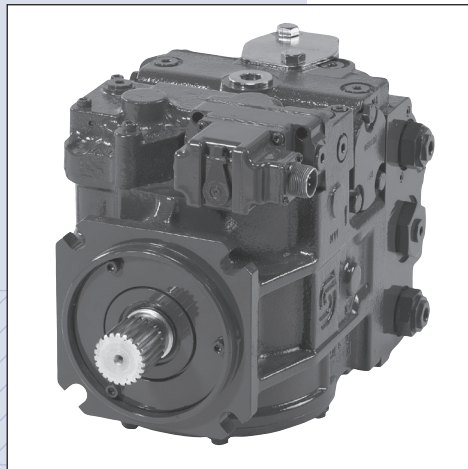
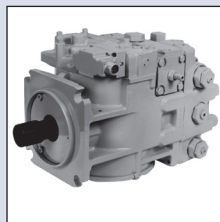




Series 90 Axial Piston Pumps

Technical Information



 TM
COMPLIANT

HISTORY OF REVISIONS

Table of Revisions

Date	Page	Changed	Rev.
August 2008	8	130 frame size case drain port changed to 1 5/16-12	FC
July 2007	Various	Minor edits and dimension changes	FB
March 2004	-	Revision F	F

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**SERIES 90 FAMILY OF
PUMPS AND MOTORS**

Series 90 hydrostatic pumps and motors can be applied together or combined with other products in a system to transfer and control hydraulic power. They are intended for closed circuit applications.

Series 90 variable displacement pumps are compact, high power density units. All models utilize 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 oil from the pump and thus reverses the direction of rotation of the motor output.

Series 90 pumps include an integral charge pump to provide system replenishing and cooling oil flow, as well as control fluid flow. They also feature a range of auxiliary mounting pads to accept auxiliary hydraulic pumps for use in complementary hydraulic systems. A complete family of control options is available to suit a variety of control systems (mechanical, hydraulic, electric).

Series 90 motors also use the parallel axial piston/slipper design in conjunction with a fixed or tiltable swashplate. They can intake/discharge fluid through either port; they are bidirectional. They also include an optional loop flushing feature that provides additional cooling and cleaning of fluid in the working loop.

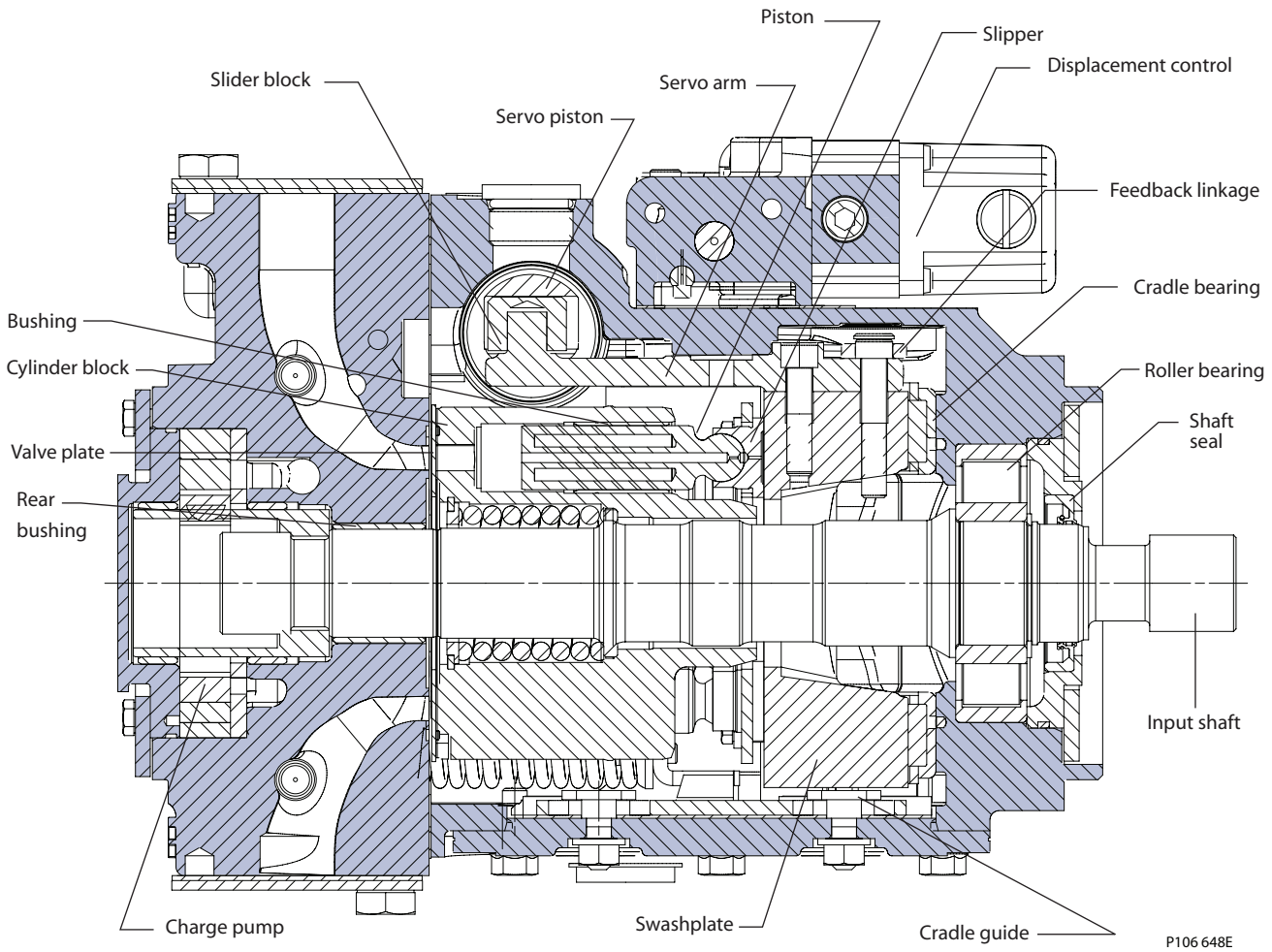
- Series 90 – advanced technology today
- Seven sizes of variable displacement pumps
- Five sizes of fixed displacement motors
- One variable displacement motor
- SAE and cartridge mount configurations
- Efficient axial piston design
- Proven reliability and performance
- Compact, lightweight
- Worldwide sales and service
- Plus+1™ compliant controls and sensors

**PLUS+1 COMPLIANT
CONTROLS AND
SENSORS**

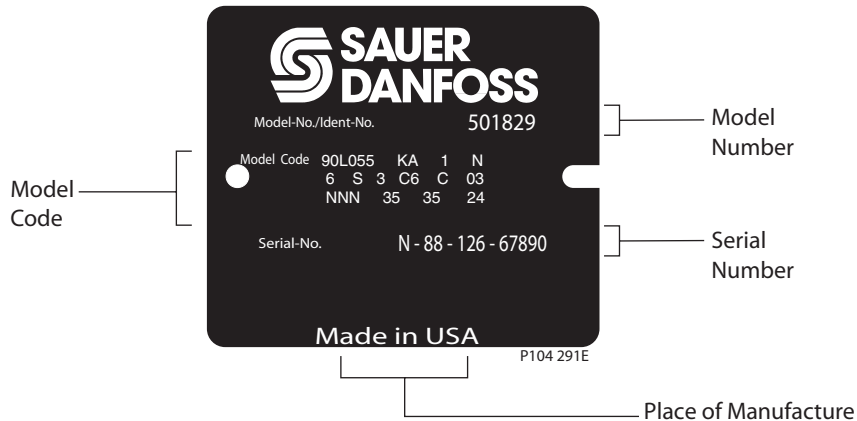
Series 90 controls and sensors are PLUS+1™ compliant. PLUS+1 compliance means our controls and sensors are directly compatible with the PLUS+1 machine control architecture. Adding Series 90 pumps to your application using PLUS+1 GUIDE software is as easy as drag-and-drop. Software development that used to take months can now be done in just a few hours. For more information on PLUS+1 GUIDE, visit www.sauer-danfoss.com/plus1.

DESIGN

Series 90 pump cross-section

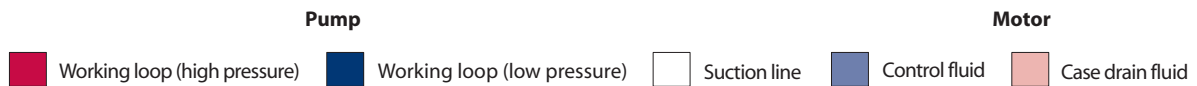
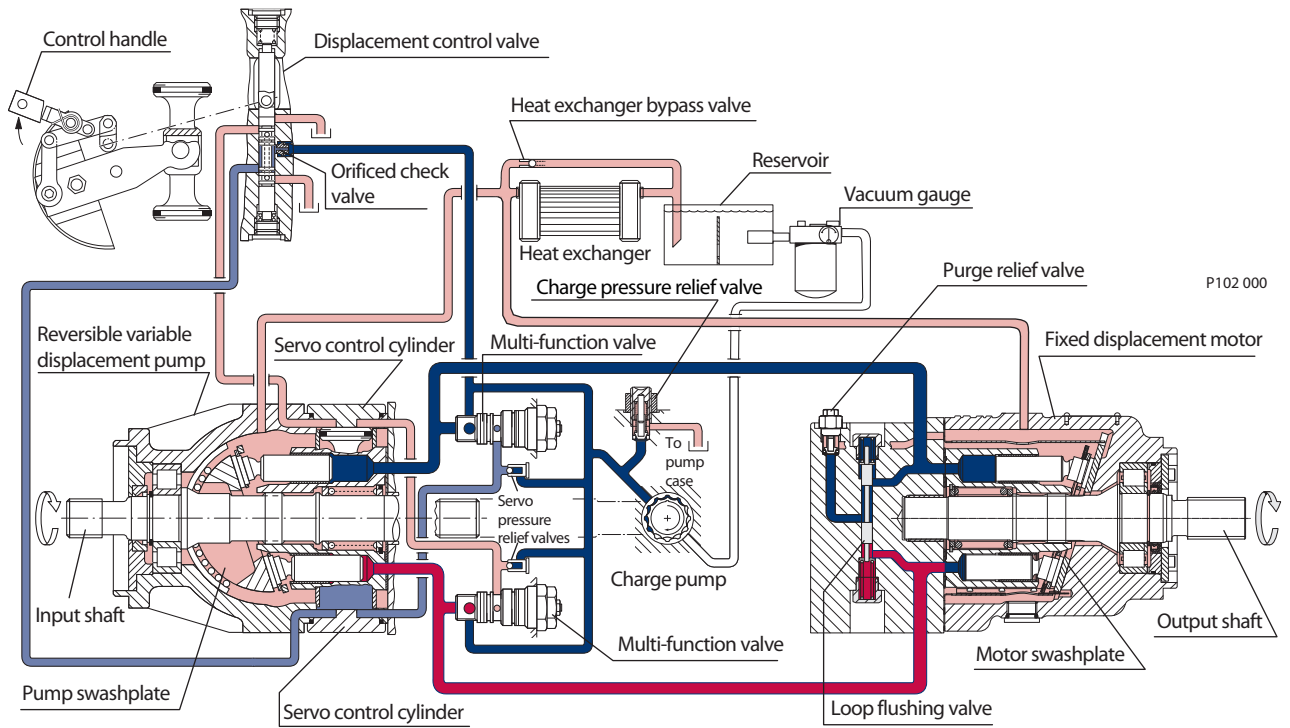


Name plate

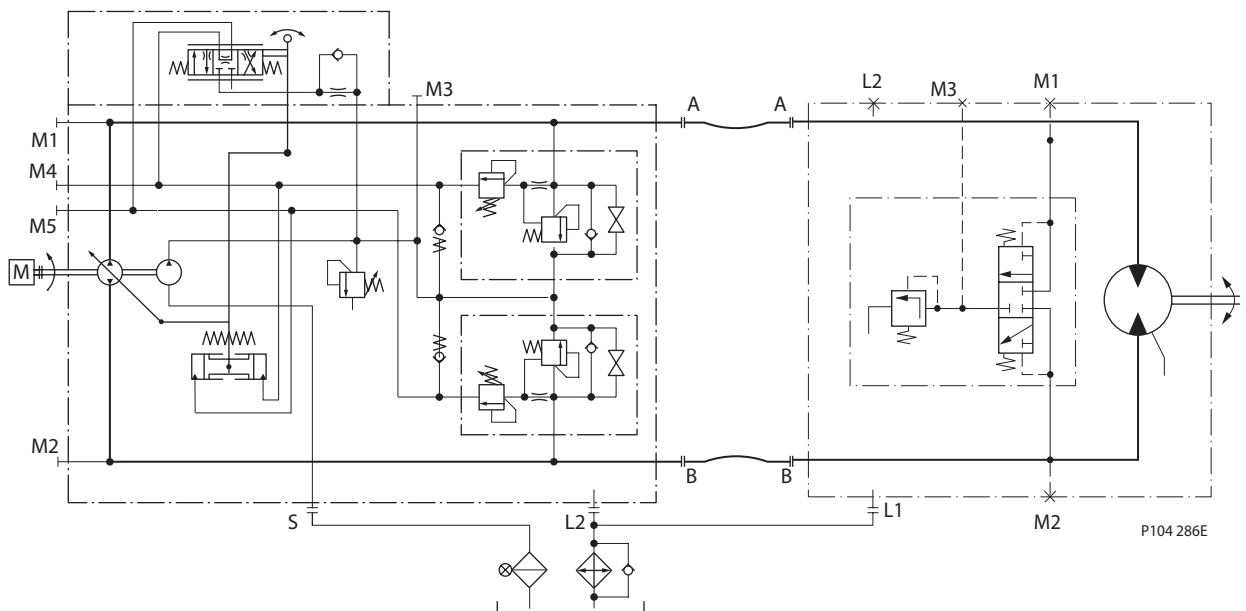


PICTORIAL CIRCUIT DIAGRAM

This configuration shows a hydrostatic transmission using a Series 90 axial piston variable displacement pump and a Series 90 fixed displacement motor.



SYSTEM SCHEMATIC



FEATURES AND OPTIONS

Feature	Unit	Frame						
		042	055	075	100	130	180	250
Displacement	cm ³ /rev [in ³]/rev	42 [2.56]	55 [3.35]	75 [4.59]	100 [6.10]	130 [7.93]	180 [10.98]	250 [15.25]
Flow at rated speed (theoretical)	l/min [US gal/min]	176 [46]	215 [57]	270 [71]	330 [87]	403 [106]	468 [124]	575 [160]
Torque at maximum displacement (theoretical)	N•m/bar [lbf•in/1000 psi]	0.67 [410]	0.88 [530]	1.19 [730]	1.59 [970]	2.07 [1260]	2.87 [1750]	3.97 [2433]
Mass moment of inertia of rotating components	kg•m ² [slug•ft ²]	0.0023 [0.0017]	0.0060 [0.0044]	0.0096 [0.0071]	0.0150 [0.0111]	0.0023 [0.0170]	0.0380 [0.0280]	0.0650 [0.0479]
Weight (with control opt. MA)	kg [lb]	34 [75]	40 [88]	49 [108]	68 [150]	88 [195]	136 [300]	154 [340]
Mounting (per SAE J744)		B	C	C	C	D	E	E
Rotation		Clockwise or Counterclockwise						
Main ports: 4-bolt split-flange (per SAE J518 code 62)	mm [in]	19.05 [0.75]	25.4 [1.0]	25.4 [1.0]	25.4 [1.0]	31.75 [1.25]	31.75 [1.25]	38.1 [1.5]
Main port configuration		Radial	Radial or axial			Radial		
Case drain ports (SAE O-ring boss)	UNF thread (in.)	0.875–14	1.0625–12	1.0625–12	1.0625–12	1.3125–12	1.625–12	1.625–12
Other ports		SAE O-ring boss. See <i>Installation drawings</i> , page 34.						
Shafts		Splined, straight keyed, and tapered shafts available. See <i>Shafts</i> , page 15.						
Auxiliary mounting		SAE-A, B, C			SAE-A, B, C, D		SAE-A, B, C, D, E	
Installation position		Installation is recommended with control on the top or side. Consult your Sauer-Danfoss representative for nonconformance guidelines. The housing must remain filled with hydraulic fluid.						

OPERATING PARAMETERS

Parameter	Unit	Frame						
		042	055	075	100	130	180	250
Input speed								
Minimum	min ⁻¹ (rpm)	500	500	500	500	500	500	500
Continuous		4200	3900	3600	3300	3100	2600	2300
Maximum		4600	4250	3950	3650	3400	2850	2500
System pressure								
Rated	bar [psi]	420 [6000]						
Maximum		450 [6500]						
Minimum low loop		10 [150]						
Inlet pressure (charge inlet)								
Minimum (continuous)	bar (abs.)	0.7 [9]						
Minimum (cold start)	[in. Hg vac.]	0.2 [24]						
Case pressure								
Continuous	bar [psi]	3 [40]						
Maximum (cold start)		5 [75]						

FLUID SPECIFICATIONS

Viscosity mm ² /sec (cSt) [SUS]	
Minimum	7 [49]
Continuous	12-80 [70-370]
Maximum	1600 [7500]
Temperature °C [°F]	
Minimum	-40 [-40]
Continuous	104 [220]
Maximum	115 [240]
Filtration	
Cleanliness	18/13 or better per ISO 4406
Efficiency (suction filtration)	$\beta_{35-45}=75$ ($\beta_{10} \geq 2$)
Efficiency (charge filtration)	$\beta_{15-20}=75$ ($\beta_{10} \geq 10$)
Recommended inlet screen size	100-125 μm [0.0039-0.0049 in]

OVERVIEW

Maintain operating parameters within prescribed limits during all operating conditions. This section defines operating limits given in the table *Operating parameters*, page 8.

INPUT SPEED

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

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

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

Consult *Pressure and speed limits*, BLN-9984, when determining speed limits for a particular application.

Warning

Unintended vehicle or machine movement hazard.

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

SYSTEM PRESSURE

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

Continuous pressure is the average, regularly occurring operating pressure. Operating at or below this pressure should yield satisfactory product life.

Maximum pressure is the highest intermittent pressure allowed. Maximum machine load should never exceed this pressure. For all applications, the load should move below this pressure.

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

CASE PRESSURE

Under normal operating conditions, the maximum continuous case pressure must not exceed 3 bar (44 psi). Maximum allowable intermittent case pressure during cold start must not exceed 5 bar (73 psi). Size drain plumbing accordingly.

Caution

Possible component damage or leakage

Operation with case pressure in excess of these limits may damage seals, gaskets, and/or housings, causing external leakage. Performance may also be affected since charge and system pressure are additive to case pressure.

HYDRAULIC FLUIDS

Ratings and data are based on operating with hydraulic fluids containing oxidation, rust and foam inhibitors. These fluids must possess good thermal and hydrolytic stability to prevent wear, erosion, and corrosion of pump components. Never mix hydraulic fluids of different types.

Fire resistant fluids are also suitable at modified operating conditions. Please see Sauer-Danfoss publication 520L0463 for more information. Refer to publication 520L0465 for information relating to biodegradable fluids.

Suitable Hydraulic fluids:

- Hydraulic fluids per DIN 51 524, 2-HLP,
- Hydraulic fluids per DIN 51 524, 3-HVLP,
- API CD, CE and CF engine fluids per SAE J183,
- M2C33F or G automatic transmission fluids (ATF),
- Dexron II (ATF), which meets the Allison C3- and Caterpillar TO-2 test,
- Agricultural multi purpose oil (STOU),
- Premium turbine oils.

TEMPERATURE AND VISCOSITY

Temperature and viscosity requirements must be concurrently satisfied. The data shown in the table *Fluid specifications*, page 9, assume petroleum-based fluids are used.

The high temperature limits apply at the hottest point in the transmission, which is normally the motor case drain. The system should generally be run at or below the **rated temperature**. The **maximum temperature** is based on material properties and should never be exceeded.

Cold oil will generally not affect the durability of the transmission components, but it may affect the ability of oil to flow and transmit power; therefore temperatures should remain 16 °C [30 °F] above the pour point of the hydraulic fluid. The **minimum temperature** relates to the physical properties of component materials.

For maximum unit efficiency and bearing life the fluid viscosity should remain in the **recommended operating range**. The **minimum viscosity** should be encountered only during brief occasions of maximum ambient temperature and severe duty cycle operation. The **maximum viscosity** should be encountered only at cold start.

Heat exchangers should be sized to keep the fluid within these limits. Testing to verify that these temperature limits are not exceeded is recommended.

FLUID AND FILTRATION

To prevent premature wear, it is imperative that only clean fluid enter the hydrostatic transmission circuit. A filter capable of controlling the fluid cleanliness to ISO 4406 class 22/18/13 (SAE J1165) or better under normal operating conditions is recommended.

The filter may be located either on the inlet (suction filtration) or discharge (charge pressure filtration) side of the charge pump. The selection of a filter depends on a number of factors including the contaminant ingress rate, the generation of contaminants in the system, the required fluid cleanliness, and the desired maintenance interval. Filters are selected to meet the above requirements using rating parameters of efficiency and capacity.

Filter efficiency may be measured with a Beta ratio¹ (β_x). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a β -ratio within the range of $\beta_{35-45} = 75$ ($\beta_{10} \geq 2$) or better has been found to be satisfactory. For some open circuit systems, and closed circuits with cylinders being supplied from the same reservoir, a considerably higher filter efficiency is recommended. This also applies to systems with gears or clutches using a common reservoir. For these systems, a charge pressure or return filtration system with a filter β -ratio in the range of $\beta_{15-20} = 75$ ($\beta_{10} \geq 10$) or better is typically required.

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

CHARGE PRESSURE

The charge pressure setting listed in the model code is based on the charge flow across the charge pressure relief valve at fluid temperature of 50 °C [120 °F].

INDEPENDENT BRAKING SYSTEM

Warning

Unintended vehicle or machine movement hazard.

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

RESERVOIR

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

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

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

**RESERVOIR
 (continued)**

Locate the reservoir outlet (charge pump inlet) above the bottom of the reservoir to take advantage of gravity separation and prevent large foreign particles from entering the charge inlet line. A 125 µm screen over the outlet port is recommended. Position the reservoir inlet (fluid return) to discharge below the normal fluid level, toward the interior of the tank. A baffle (or baffles) will further promote de-aeration and reduce surging of the fluid.

CASE DRAIN

A case drain line must be connected to one of the case outlets (L1 or L2) to return internal leakage to the system reservoir. The higher of the two case outlets should be used to promote complete filling of the case. Since case drain fluid is typically the hottest fluid in the system, it is advantageous to return this flow through the heat exchanger.

SIZING EQUATIONS

The following equations are helpful when sizing hydraulic pumps. Generally, the sizing process is initiated by an evaluation of the machine system to determine the required motor speed and torque to perform the necessary work function. Refer to *Selection of drive line components, BLN-9885*, for a more complete description of hydrostatic drive line sizing. First, the motor is sized to transmit the maximum required torque. The pump is then selected as a flow source to achieve the maximum motor speed.

<i>SI units</i>	Output flow $Q = \frac{V_g \cdot n \cdot \eta_v}{1000}$ (l/min)	$V_g =$ Displacement per revolution (cm ³ /rev)
	Input torque $M = \frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m}$ (N·m)	$\Delta p =$ $p_o - p_i$ (system pressure) (bar)
	Input power $P = \frac{M \cdot n \cdot \pi}{30\,000} = \frac{Q \cdot \Delta p}{600 \cdot \eta_t}$ (kW)	$n =$ Speed (min ⁻¹ (rpm)) $\eta_v =$ Volumetric efficiency $\eta_m =$ Mechanical efficiency $\eta_t =$ Overall efficiency ($\eta_v \cdot \eta_m$)
<i>US units</i>	Output flow $Q = \frac{V_g \cdot n \cdot \eta_v}{231}$ (US gal/min)	$V_g =$ Displacement per revolution (in ³ /rev)
	Input torque $M = \frac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m}$ (lbf·in)	$\Delta p =$ $p_o - p_i$ (system pressure) (psi)
	Input power $P = \frac{M \cdot n \cdot \pi}{198\,000} = \frac{Q \cdot \Delta p}{1714 \cdot \eta_t}$ (hp)	$n =$ Speed (min ⁻¹ (rpm)) $\eta_v =$ Volumetric efficiency $\eta_m =$ Mechanical efficiency $\eta_t =$ Overall efficiency ($\eta_v \cdot \eta_m$)

SHAFT LOADS

Normal bearing life in B_{10} hours is shown in the table below. The figures reflect a continuous differential pressure of 240 bar [3500 psi], 1800 min^{-1} (rpm) shaft speed, maximum displacement, and no external shaft side load. The data is based on a 50% forward, 50% reverse duty cycle, standard charge pump size, and standard charge pressure.

Series 90 pumps are designed with bearings that can accept external radial and thrust loads. The external radial shaft load limits are a function of the load position and orientation, and the operating conditions of the unit.

The maximum allowable radial load (Re), is based on the maximum external moment (Me), and the distance (L) from the mounting flange to the load. It may be determined using the table and formula below. Thrust (axial) load limits are also shown.

$$Re = Me / L$$

All external shaft loads affect bearing life. In applications with external shaft loads, minimize the impact by positioning the load at 90° or 270° as shown in the figure.

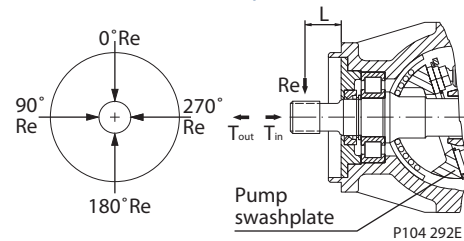
- Contact your Sauer-Danfoss representative for an evaluation of unit bearing life if:
- continuously applied external loads exceed 25 % of the maximum allowable radial load (Re).
 - the pump swashplate is positioned on one side of center all or most of the time.
 - the unit bearing life (B_{10}) is critical.

Sauer-Danfoss recommends tapered input shafts or clamp-type couplings for applications with radial shaft loads.

Bearing life

Frame size	Bearing life – B_{10} hrs
42	18 060
55	22 090
75	22 970
100	22 670
130	17 990
180	16 150
250	12 020

Radial and thrust load position

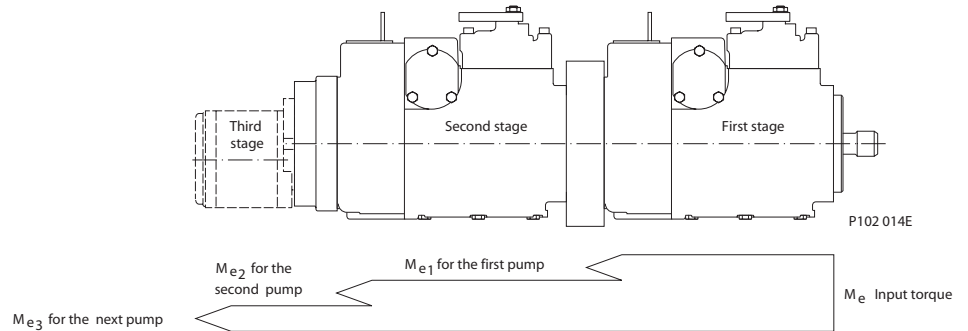


Allowable external shaft load

Parameter	042	055	075	100	130	180	250
External moment (Me)	126	101	118	126	140	161	176
N•m [lbf•in]	[1114]	[893]	[1043]	[1114]	[1238]	[1424]	[1556]
Maximum shaft thrust in (T_{in})	2635	3340	4300	5160	5270	7000	7826
N [lbf]	[592]	[750]	[996]	[1160]	[1184]	[1573]	[1759]
Maximum shaft thrust out (T_{out})	1020	910	930	1000	688	1180	1693
N [lbf]	[229]	[204]	[209]	[224]	[154]	[265]	[380]

**SHAFT AVAILABILITY
 AND TORQUE RATINGS**

Through torque diagram



Torque required by auxiliary pumps is additive. Ensure requirements don't exceed shaft torque ratings.

Shaft availability and torque ratings

Contact your Sauer-Danfoss representative for tapered shaft torque ratings.

- Legend:**
- Not available
 - + Not recommended for front pump in tandem configurations
 - * Based on external moment load on shaft equal to half the maximum torque valve

Shaft description and option code		Shaft availability and torque ratings N•m [lbf•in]						
		042	055	075	100	130	180	250
15 teeth 16/32 pitch spline	C3	530 [4700]	—	—	—	—	—	—
19 teeth 16/32 pitch spline	C5	900 [8000]	—	—	—	—	—	—
21 teeth 16/32 pitch spline	C6	—	1130 [10 000]	—	—	—	—	—
23 teeth 16/32 pitch spline	C7	—	—	1580 [14 000]	1580 [14 000]	—	—	—
27 teeth 16/32 pitch spline	C8	—	—	—	—	2938 [26 000]	2938 [26 000]	2938 [26 000]
13 teeth 8/16 pitch spline	F1	—	—	—	1810 [16 000]	1810 [16 000]	1810 ⁺ [16 000] ⁺	1810 ⁺ [16 000] ⁺
14 teeth 12/24 pitch spline	S1	—	735 [6500]	735 [6500]	735 ⁺ [6500] ⁺	—	—	—
1.375 Str key	K1	—	768* [6800]	—	—	—	—	—
1.5 Str key	K2	—	—	1130* [10 000]	—	—	—	—
1.75 Str key	K3	—	—	—	1582* [14 000]	—	—	—
1.375 tapered	T1	—	768* [6800]	768* [6800]	—	—	—	—
1.5 tapered	T2	—	—	1130* [10 000]	1130* [10 000]	—	—	—
1.75 tapered	T4	—	—	—	—	1582* [14 000]	—	—
1.00 tapered	T3	497* [4400]	—	—	—	—	—	—

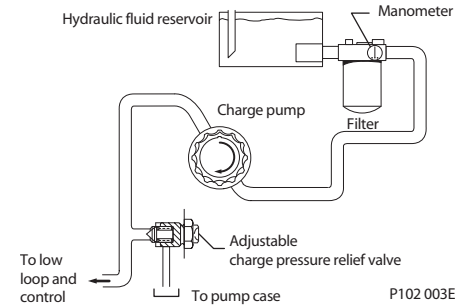
FILTRATION OPTIONS

Suction filtration – option S

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

The use of a filter contamination monitor is recommended.

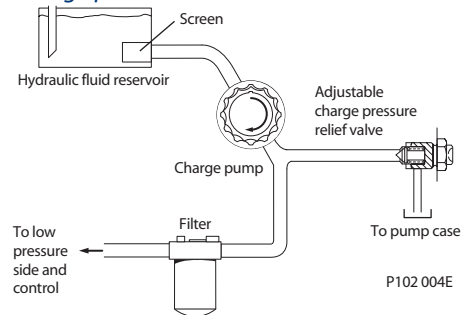
Suction filtration



Charge pressure filtration – option R, T, P, and L

The pressure filter can be mounted directly on the pump or mounted remotely for ease of servicing. A 100-125 µm mesh screen, located in the reservoir or the charge inlet line, is recommended when using charge pressure filtration. This system requires a filter capable of withstanding charge pressure.

Charge pressure filtration

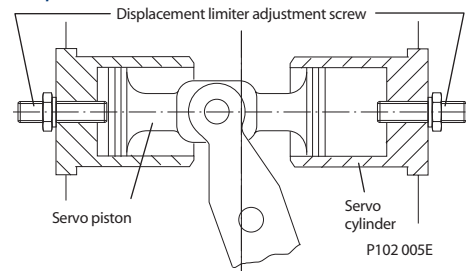


DISPLACEMENT LIMITER

All Series 90 pumps are designed with optional mechanical displacement (stroke) limiters.

The maximum displacement of the pump can be set independently for forward and reverse using the two adjustment screws.

Displacement limiter



Displacement limiter location

Pump rotation	Displacement limiter mounted on servo side	Displacement limitation at high pressure side
Right	1	A
	2	B
Left	1	B
	2	A

MULTI-FUNCTION VALVES **Overpressure protection**

The Series 90 pumps are designed with a sequenced pressure limiting system and high pressure relief valves. When the preset pressure is reached, the pressure limiter system acts to rapidly destroke the pump to limit the system pressure. For unusually rapid load application, the high pressure relief valve is also available to limit the pressure level. The pressure limiter sensing valve acts as the pilot for the relief valve spool, such that the relief valve is sequenced to operate above the pressure limiter level.

Both the pressure limiter sensing valves and relief valves are built into the multi-function valves located in the pump endcap. The sequenced pressure limiter/high pressure relief valve system in the Series 90 provides an advanced design of overpressure protection.

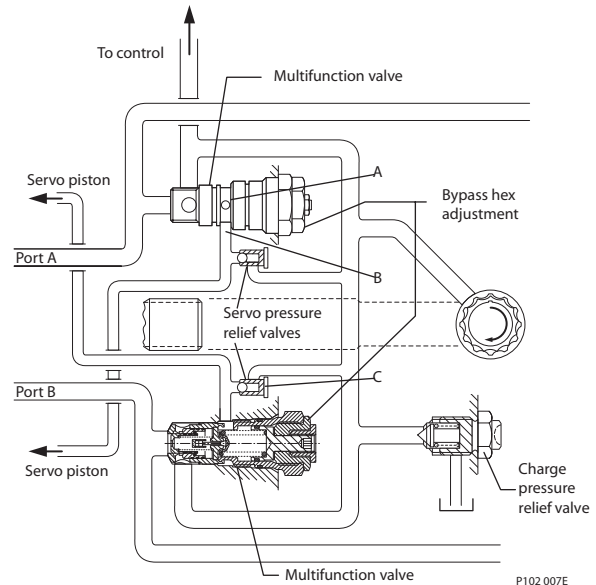
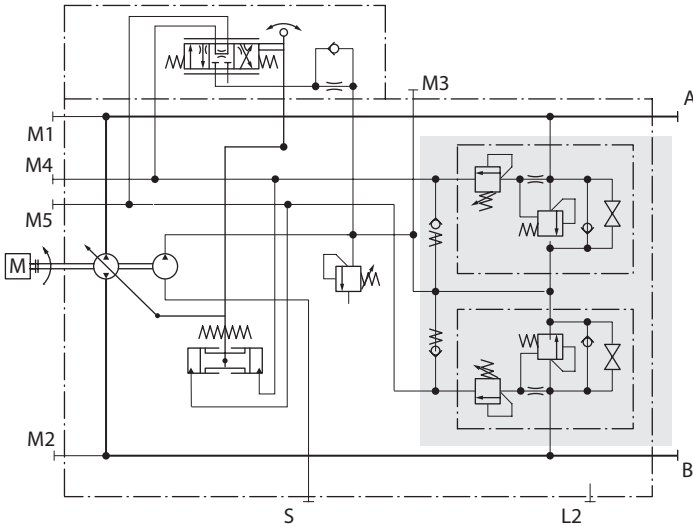
The pressure limiter avoids system overheating associated with relief valves and the sequenced relief valves are available to limit pressure spikes which exist in severe operating conditions.

Because the relief valves open only during extremely fast pressure spike conditions, heat generation is minimized during the short time that they might be open. For some applications, such as dual path vehicles, the pressure limiter function may be defeated such that only the relief valve function remains. The relief response is approximately 20 ms whether used with or without the pressure limiter function.

Pressure limiting function

When set pressure is exceeded, the pressure sensing valve (A) flows oil through passage (B) and across an orifice in the control spool raising pressure on the servo which was at low pressure. Servo pressure relief valves (C) limit servo pressure to appropriate levels. The pressure limiter action cancels the input command of the displacement control and tends to equalize servo pressure. Swashplate moments assist to change the displacement as required to maintain system pressure at the set point.

MULTI-FUNCTION VALVES Multifunction valve, pressure limiter, pressure regulation, option 1
 (continued)



Bypass Function

In some applications it is desirable to bypass fluid around the variable displacement pump when pump shaft rotation is either not possible or not desired. For example, an inoperable vehicle may be moved to a service or repair location or winched onto a trailer without operating the prime mover. To provide for this, Series 90 pumps are designed with a bypass function.

The bypass is operated by mechanically rotating the bypass hex on both multifunction valves three (3) turns counterclockwise (CCW). This connects working loop A and B and allows fluid to circulate without rotating the pump and prime mover.

Caution

Possible pump and/or motor damage

Bypass valves are intended for moving a machine or vehicle for very short distances at very slow speeds. They are NOT intended as tow valves.

SPEED SENSOR

An optional speed sensor for direct measurement of speed is available. This sensor may also be used to sense the direction of rotation.

A special magnetic ring is pressed onto the outside diameter of the cylinder block and a Hall effect sensor is located in the housing. The sensor accepts supply voltage and outputs a digital pulse signal in response to the speed of the ring. The output changes its high/low state as the north and south poles of the permanently magnetized speed ring pass by the face of the sensor. The digital signal is generated at frequencies suitable for microprocessor based controls. The sensor is available with different connectors (see below).



Specifications

Supply voltage*	4.5 to 8.5 VDC
Supply voltage (regulated)	15 VDC max.
Required current	12 mA at 5 VDC, 1 Hz
Max. current	20 mA at 5 VDC, 1 Hz
Max. frequency	15 kHz
Voltage output (high)	Supply -0.5 V min.
Voltage output (low)	0.5 V max.
Temperature range	-40° to 110°C [-40° to 230°F]

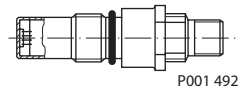
* Do not energize the 4.5 to 8.5 VDC sensor with 12 VDC battery voltage. Use a regulated power supply. If you need to energize the sensor with battery voltage, contact your Sauer-Danfoss representative for a special sensor.

To use the speed sensor in a PLUS+1 Guide application, download HWD file 10106825 from www.sauer-danfoss.com/Plus1.

Pulse frequency

	042	055	075	100	130	180	250
Pulse per revolution	48	52	58	63	69	77	85

Speed sensor with Turck® Eurofast connector

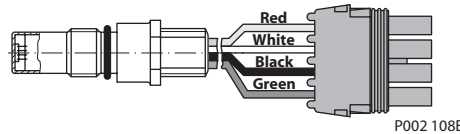


Turck Eurofast Connector
4 pin
(Supplied Connector)

Mating Connector
straight right angle
No.: K14956 No.: K14957
Id.-No.: 500724 Id.-No.: 500725

P001 755E

Speed sensor with Packard® Weather-Pack connector



Packard Weather-Pack
4 pin
(Supplied Connector)

Mating Connector
No.: K03379
Id.-No.: 505341

P001 758E

CHARGE PUMP

Charge flow is required on all Series 90 pumps applied in closed circuit installations. The charge pump provides flow to make up internal leakage, maintain a positive pressure in the main circuit, provide flow for cooling and filtration, replace any leakage losses from external valving or auxiliary systems, and to provide flow and pressure for the control system.

Many factors influence the charge flow requirements. 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, hydrostatic motor type, etc.

**CHARGE PUMP
 (continued)**

Unusual application conditions may require a more detailed review of charge pump sizing. Charge pressure must be maintained at a specified level under all operating conditions to prevent damage to the transmission. Sauer-Danfoss recommends testing under actual operating conditions to verify this.

Charge pump sizing/selection

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

Available charge pump sizes and speed limits

Charge pump size	cm ³ [in ³]	Rated speed
		min ⁻¹ (rpm)
B	11 [0.69]	4200
C	14 [0.86]	4200
D	17 [1.03]	3900
E	20 [1.20]	3600
F	26 [1.60]	3300
G	26 [1.60]	3100 (130 cm ³ pump)
H	34 [2.07]	3100
J	47 [2.82]	2600
K	65 [3.90]	2300

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

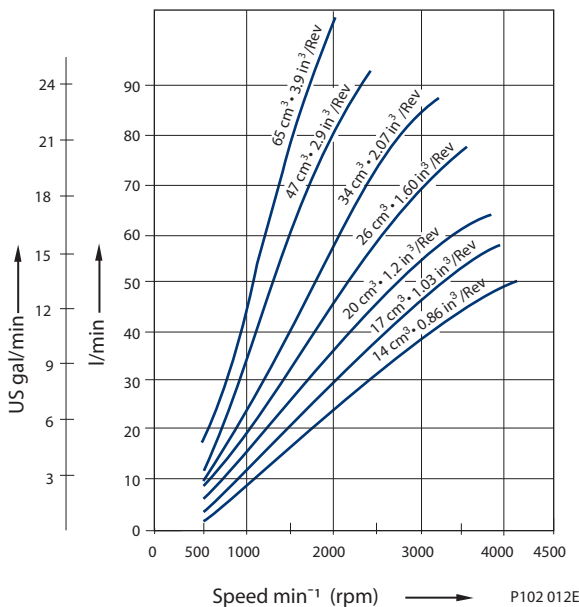
- Continuous operation at low input speeds (< 1500 min⁻¹ (rpm))
- High shock loading
- Excessively long system lines (> 3m [9.8 ft])
- Auxiliary flow requirements
- Use of low speed high torque motors

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

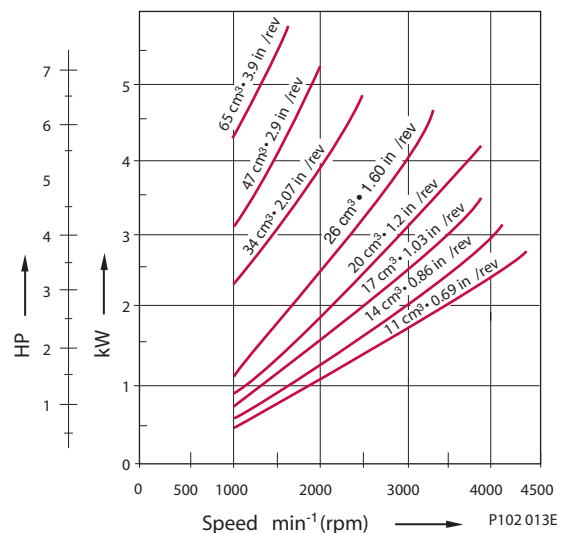
Charge pump flow and power curves

Charge pressure: 20 bar [290 psi]
 Case drain: 80 °C (8.2 cSt) 180 °F (53 SUS)
 Reservoir temperature: 70 °C (11 cSt) 160 °F (63 SUS)

Charge pump output flow



Charge pump power requirements



AUXILIARY MOUNTING PADS

Auxiliary mounting pads specifications

Mounting pad size	Option code	Internal spline size	Minimum spline engagement mm [in]	Rated torque N·m [lbf·in]
SAE A	AB	9 teeth 16/32 pitch	13.5 [0.53]	107 [950]
SAE B	BC	13 teeth 16/32 pitch	14.2 [0.56]	256 [2200]
SAE B-B	BB	15 teeth 16/32 pitch	16.1 [0.63]	347 [2990]
SAE C	CD	14 teeth 12/24 pitch	18.3 [0.72]	663* [5700]*
SAE D	DE	13 teeth 8/16 pitch	20.8 [0.82]	1 186 [10 500]
SAE E	EF	13 teeth 8/16 pitch	20.8 [0.82]	1 637 [14 500]
SAE E	EG	27 teeth 16/32 pitch	27.0 [1.06]	2 362 [20.91]

* For the 055 pump the rated torque is limited to 445 N·m [3830 lbf·in]

Mating pump requirements

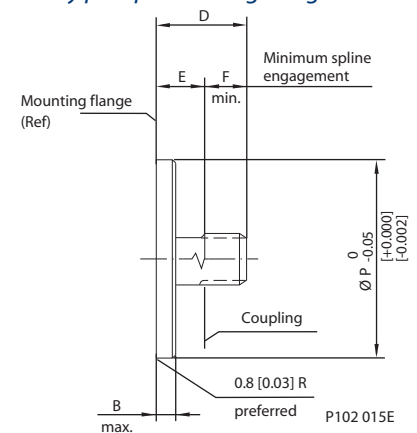
The accompanying drawing provides the dimensions for the auxiliary pump mounting flange and shaft.

Pump mounting flanges and shafts with the dimensions noted below are compatible with the auxiliary mounting pads on the Series 90 pumps.

Auxiliary pump dimensions

Flange size	Units	P diameter	B maximum	D	F minimum
SAE A	mm [in]	82.55 [3.25]	7.4 [0.29]	32 [1.26]	13.5 [0.53]
SAE B		101.6 [4.00]	10.7 [0.42]	41 [1.61]	14.2 [0.56]
SAE B-B		101.6 [4.00]	10.7 [0.42]	46 [1.81]	16.1 [0.63]
SAE C		127.0 [5.00]	14.3 [0.56]	56 [2.20]	18.3 [0.72]
SAE D		152.4 [6.00]	14.3 [0.56]	75 [2.95]	20.8 [0.82]
SAE E 13 teeth		165.1 [6.50]	18.0 [0.71]	75 [2.95]	20.8 [0.82]
SAE E 27 teeth		165.1 [6.50]	18.0 [0.71]	75 [2.95]	27.0 [1.06]

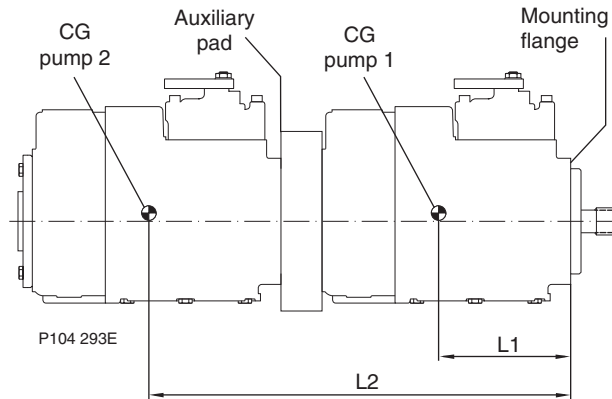
Auxiliary pump mounting flange and shaft



MOUNTING FLANGE LOADS

Adding tandem mounted auxiliary pumps and/or subjecting pumps to high shock loads may result in excessive loading of the mounting flange. The overhung load moment for multiple pump mounting may be estimated as shown in the accompanying figure.

Overhung load example



Estimating overhung load moments

- W = Weight of pump (kg)
- L = Distance from mounting flange to pump center of gravity (m)
(refer to pump installation drawings)

$$M_R = G_R (W_1 L_1 + W_2 L_2 + \dots + W_n L_n)$$

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

Where:

- M_R = Rated load moment (N•m)
- M_S = Shock load moment (N•m)
- G_R = Rated (vibratory) acceleration (G's) * (m/sec²)
- G_S = Maximum shock acceleration (G's) * (m/sec²)

* Calculations will be carried out by multiplying the gravity ($g = 9.81 \text{ m/sec}^2$) with a given factor. This factor depends on the application.

Allowable overhung load moment values are shown in the accompanying table. Exceeding these values requires additional pump support.

Allowable overhung load moments

Frame size	Rated moment (M_R)		Shock load moment (M_S)	
	N•m	lbf•in	N•m	lbf•in
042	860	7600	3020	26 700
055	1580	14 000	5650	50 000
075	1580	14 000	5650	50 000
100	1580	14 000	5650	50 000
130	3160	28 000	10 730	95 000
180	6070	54 000	20 600	182 000
250	6070	54 000	20 600	182 000

**3-POSITION (FNR)
 ELECTRIC CONTROL**

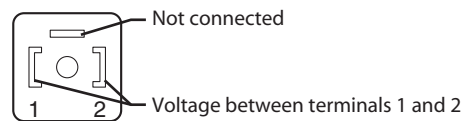


The 3-Position (F-N-R) control uses an electric input signal to switch the pump to a full stroke position. To use the FNR control in a PLUS+1 Guide application, download HWD file 10106826 from www.sauer-danfoss.com/Plus1.

Solenoid connector

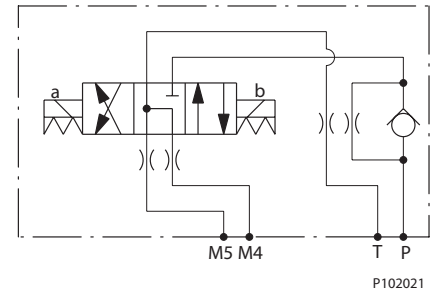
Solenoid plug face for DIN 43650 connector

SAUER-DANFOSS
 mating parts kit
 Part No. K09129



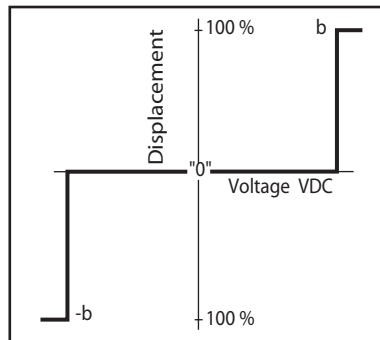
P102 022

3-position electric control hydraulic schematic



P102021

Pump displacement vs. electrical signal



P102 023

Solenoid Data

Voltage	Power	Connector
12 VDC	33 W	Din 46350
24 VDC	33 W	Din 46350

Response time

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a function of the size of the orifice in the control flow passage.

A range of orifice sizes are available for the Series 90 Electric Displacement Control to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. Testing should be carried out to determine the proper orifice selection for the desired response.

Pump output flow direction vs. control signal

Input shaft rotation	CW		CCW	
	a	b	a	b
Signal at solenoid	a	b	a	b
Port A flow	Out	In	In	Out
Port B flow	In	Out	Out	In
Servo cylinder active	M5	M4	M5	M4

ELECTRIC DISPLACEMENT CONTROL (EDC)

Operation

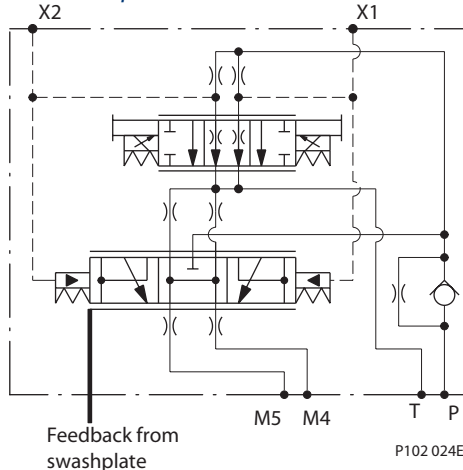
The electric displacement control uses an electrohydraulic Pressure Control Pilot (PCP) valve to control the pilot pressure. The PCP converts an electrical input signal to a hydraulic input signal to operate a 4-way servo valve, which ports hydraulic pressure to either side of a double acting servo piston. 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 control has a mechanical feedback mechanism which moves the servo valve in relation to the input signal and the angular position of the swashplate. The electrical displacement control is designed so the angular rotation of the swashplate (pump displacement) is proportional to the electrical input signal. Due to normal operating force changes, the swashplate tends to drift from the position preset by the machine operator. Drift, sensed by feedback linkage system connecting the swashplate to the control valve, will activate the valve and supply pressure to the servo piston, maintaining the swashplate in its preset position.

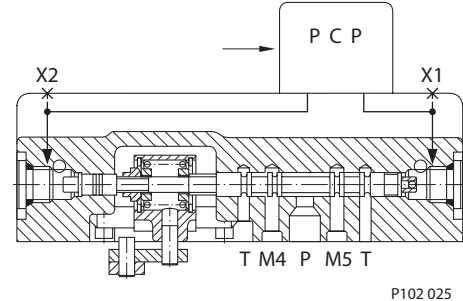
Features and Benefits

- The electric displacement control is a high gain control: With only a small change of the input current, the servo valve moves to a full open position thus porting maximum flow to the servo cylinder.
- Oil filled PCP case lengthens control life by preventing moisture ingression and dampening component vibrations.
- All electrical displacement controls are equipped with dual coil PCPs. The user has the option of using a single coil or both coils (in series or parallel).
- 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.
- The swashplate is coupled to a feedback mechanism. The control valve drains the ends of the servo piston when an electric input signal is not present.
- Benefits:
 - Simple, low cost design
 - Pump returns to neutral after prime mover shuts down
 - Pump returns to neutral if external electrical input signal fails or if there is a loss of charge pressure

Electric displacement control schematic



Cross-section



To use the EDC control in a PLUS+1 Guide application, download HWD file 10106626 from www.sauer-danfoss.com/Plus1.



ELECTRIC DISPLACEMENT CONTROL (EDC) (continued)

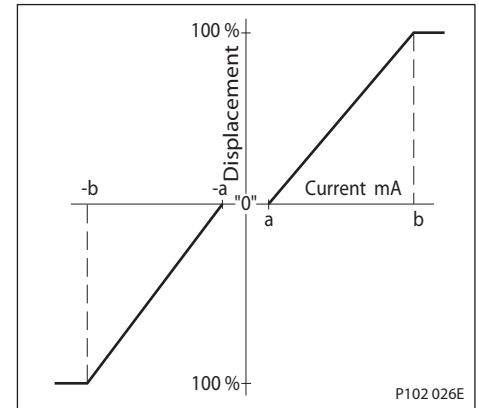
Control signal requirements

Control current

Coil configuration	a mA	b mA	Pin connections
Single coil	14 ± 5	85 ± 18	A&B or C&D
Dual coil in series	7 ± 3	43 ± 9	A&D (C B common)
Dual coil parallel	14 ± 5	85 ± 18	AC & BD

Maximum input current under any condition: 250 mA
 PWM frequency: 200 Hz
 Coil resistance at 24°C [75°F]:
 A-B coil 20 Ω
 C-D coil 16 Ω

Pump displacement vs. control current

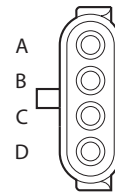


MS connector (option KA) MS 3102C-14S-2P



Sauer-Danfoss mating parts kit
 Part no. K01588
 Ident No. 615062
 P102 027E

Packard® Weather-Pack (option KP) 4-way shroud connector



Sauer-Danfoss mating parts kit
 Part no. K03384
 (female terminals)

P102 028E

Response time

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a function of the size of the orifice in the control flow passage.

A range of orifice sizes is available for the Series 90 Electric Displacement Control to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. Testing should be carried out to determine the proper orifice selection for the desired response.

Pump output flow direction vs. control current

EDC using a single coil or dual coils in parallel (A and C common, B and D common)

Input shaft rotation	CW		CCW	
	Positive current to term	Port A flow	Port B flow	Servo cylinder
Positive current to term	A or C	B or D	A or C	B or D
Port A flow	Out	In	In	Out
Port B flow	In	Out	Out	In
Servo cylinder	M5	M4	M5	M4

EDC using a dual coil or dual coils in series (B and C common)

Input shaft rotation	CW		CCW	
	Positive current to term	Port A flow	Port B flow	Servo cylinder
Positive current to term	A	D	A	D
Port A flow	Out	In	In	Out
Port B flow	In	Out	Out	In
Servo cylinder	M5	M4	M5	M4

Refer to *Installation drawings*, page 60, for port locations.

**HYDRAULIC
 DISPLACEMENT
 CONTROL (HDC)**

Operation

The hydraulic displacement control uses a hydraulic input signal to operate a 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 control has a mechanical feedback mechanism which moves the servo valve in relation to the input signal and the angular rotation of the swashplate. The hydraulic displacement control is designed so the angular position of the swashplate (pump displacement) is proportional to the hydraulic input signal pressure. Due to normal operating force changes, the swashplate tends to drift from the position preset by the machine operator. Drift, sensed by feedback linkage system connecting the swashplate to the control valve, activates the valve to supply pressure to the servo piston, maintaining the swashplate in its preset position.

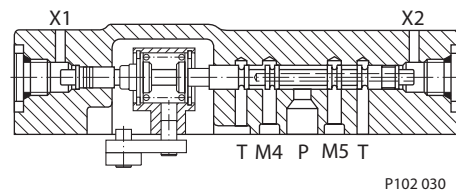
Features and benefits of the hydraulic displacement control:

- The hydraulic displacement control is a high gain control: With only small change of the input signal, 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.
- The swashplate is coupled to a feedback mechanism. The control valve drains the ends of the servo piston when an input signal is not present.
- Benefits:
 - Simple - low cost design.
 - Pump returns to neutral after prime mover shuts down.
 - Pump returns to neutral if there is a loss of input signal pressure or if there is a loss of charge pressure.

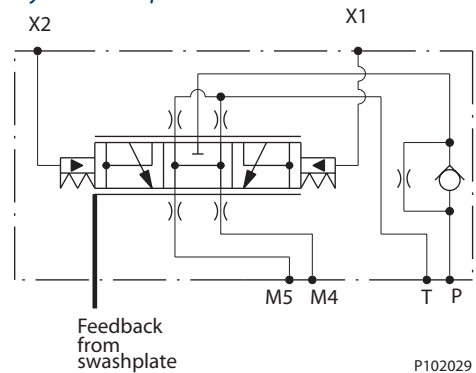
*Hydraulic signal pressure range**

a	3 ± 0.5 bar	[43 ± 6 psi]
b	11 ± 0.5 bar	[160 ± 6 psi]

Cross-section



Hydraulic displacement control schematic



*see diagram page 27

**HYDRAULIC
 DISPLACEMENT
 CONTROL (HDC)
 (continued)**

Control signal requirements

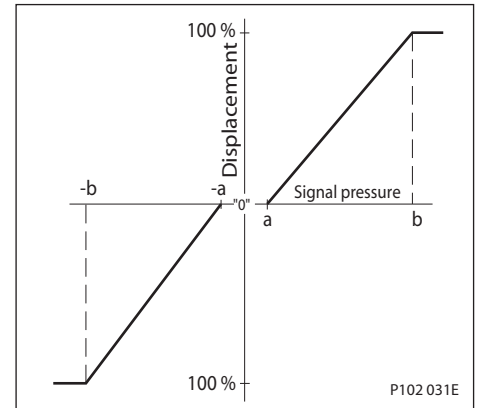
Maximum allowable signal pressure is 60 bar [870 psi].

Response time

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a function of the size of the orifice in the control flow passage.

A range of orifice sizes are available for the Series 90 hydraulic displacement control to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. Testing should be carried out to determine the proper orifice selection for the desired response.

Pump displacement vs. signal pressure



Pump output flow direction vs. control pressure

Input shaft rotation	CW		CCW	
Control pressure to port	X2	X1	X2	X1
Port A flow	In	Out	Out	In
Port B flow	Out	In	In	Out
Servo cylinder	M4	M5	M4	M5

Refer to *Installation drawings*, page 60, for port locations.

MANUAL DISPLACEMENT CONTROL (MDC)

Operation

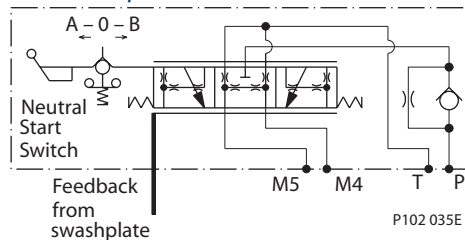
The manual displacement control converts a mechanical input signal to a hydraulic signal that tilts the cradle swashplate through an angular rotation varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The manual displacement control has a mechanical feedback mechanism which moves a servo valve in the proper relationship to the input signal and the angular position of the swashplate. The control is designed so that the angular rotation of the swashplate is proportional to the mechanical input signal. The control is designed with an internal override mechanism which allows the mechanical input to be moved at a faster rate than the movement of the swashplate without damage to the control.

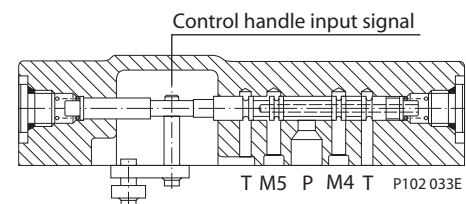
Features and benefits of the manual displacement control:

- Precision parts provide repeatable, accurate displacement settings with a given input signal.
- The manual displacement control is a high gain control: With only small movement of the control handle (input signal), the servo valve moves to full open position porting maximum flow to the servo cylinder. This is a high response system with low input force.
- The integral override mechanism allows rapid changes in input signal without damaging the control mechanism.
- Precision parts provide repeatable, accurate displacement settings with a given input signal.
- The double-acting servo piston is coupled to a spring centering mechanism. The servo control valve is spring centered such that with no input signal the servo valve is open centered and thus no fluid is ported to the servo cylinder.
- Benefits:
 - Pump returns to neutral after prime mover shuts down.
 - Pump returns to neutral if external control linkage fails at the control handle or if there is a loss of charge pressure.

Manual displacement control schematic



Cross-section

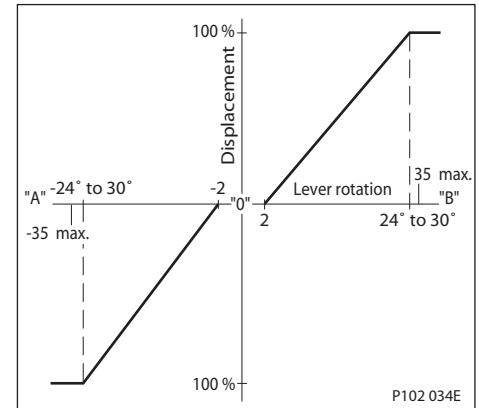


MANUAL DISPLACEMENT CONTROL (MDC) (continued)

External control handle requirements

- Torque required to move handle to maximum displacement is 0.68 to 0.9 N•m [6 to 8 lbf•in].
- Torque required to hold handle at given displacement is 0.34 to 0.57 N•m [3 to 5 lbf•in].
- Torque required to overcome the override mechanism is 1.1 to 2.3 N•m [10 to 20 lbf•in] with the maximum torque required for full forward to full reverse movement.
- Maximum allowable input torque is 17 N•m [150 lbf•in]

Pump displacement vs. control lever rotation



Response time

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a function of the size of the orifice in the control flow passage.

A range of orifice sizes is available for the Series 90 manual displacement control to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. Testing should be carried out to determine the proper orifice selection for the desired response.

Pump output flow direction vs. control handle rotation

Input shaft rotation	CW		CCW	
Handle rotation	A CCW	B CW	A CCW	B CW
Port A flow	Out	In	In	Out
Port B flow	In	Out	Out	In
Servo cylinder	M5	M4	M5	M4

Refer to *Installation drawings*, page 61, for handle connection requirements

**NON-LINEAR MANUAL
 DISPLACEMENT
 CONTROL (MDC)**

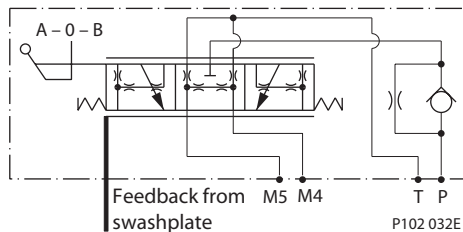
The manual displacement control device a mechanical input signal to a hydraulic signal that tilts the cradle swashplate through an angular rotation varying the pump's displacement from full displacement in one direction to full displacement in the opposite direction.

The manual displacement control has a mechanical feedback mechanism which moves a servo valve in the proper relationship to the input signal and the angular position of the swashplate. The control is designed so that the angular rotation of the swashplate is progressive to the mechanical input signal. The control is designed with an internal override mechanism which allows the mechanical input to be moved at a faster rate than the movement of the swashplate without damage to the control.

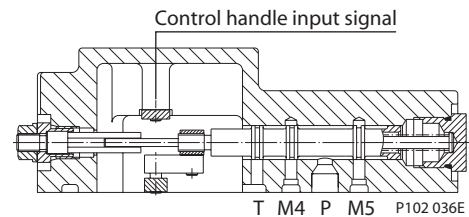
Features and benefits of the non-linear manual displacement control:

- The manual displacement control is a high gain control: With only small movement of the control handle (input signal), the servo valve moves to full open position porting maximum flow to the servo cylinder. This is a high response system with low input force.
- Low spool dead band results in good down hill and braking capability.
- Smooth acceleration is possible.
- The integral override mechanism allows rapid changes in input signal without damaging the control mechanism.
- Precision parts provide repeatable, accurate displacement settings with a given input signal.
- A double-acting servo piston is coupled to a spring centering mechanism. The servo control valve is spring centered such that with "no input signal" the servo valve is open centered and thus no fluid is ported to the servo cylinder.
- Benefits:
 - Pump returns to neutral after prime mover shut down.
 - Pump returns to neutral if external control linkage fails at the control handle, or there is loss of charge pressure.

Non-linear MDC schematic



Cross section



S1 = servo side 1
 S2 = servo side 2

**NON-LINEAR MANUAL
 DISPLACEMENT
 CONTROL (MDC)
 (continued)**

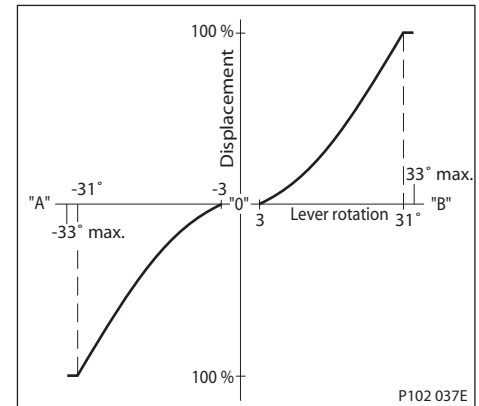
External control handle requirements

- Torque required to move handle to maximum displacement is 0.68 to 0.9 N•m [6 to 8 lbf•in].
- Maximum allowable input torque is 17 N•m [150 lbf•in].

Response time

The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a function of the size of the orifice in the control flow passage.

Pump displacement vs. control lever rotation



A range of orifice sizes is available for the Series 90 Manual Displacement Control to assist in matching the rate of swashplate response to the acceleration and deceleration requirements of the application. Testing should be carried out to determine the proper orifice selection for the desired response.

Pump output flow direction vs. control handle rotation

Input shaft rotation	CW		CCW	
Handle rotation	"A" CCW	"B" CW	"A" CCW	"B" CW
Port A flow	Out	In	In	Out
Port B flow	In	Out	Out	In
Servo cylinder	M5	M4	M5	M4

Refer to *Installation drawings*, page 61, for handle connection requirements.

**NON FEEDBACK
 PROPORTIONAL ELECTRIC
 CONTROL (NFPE)**

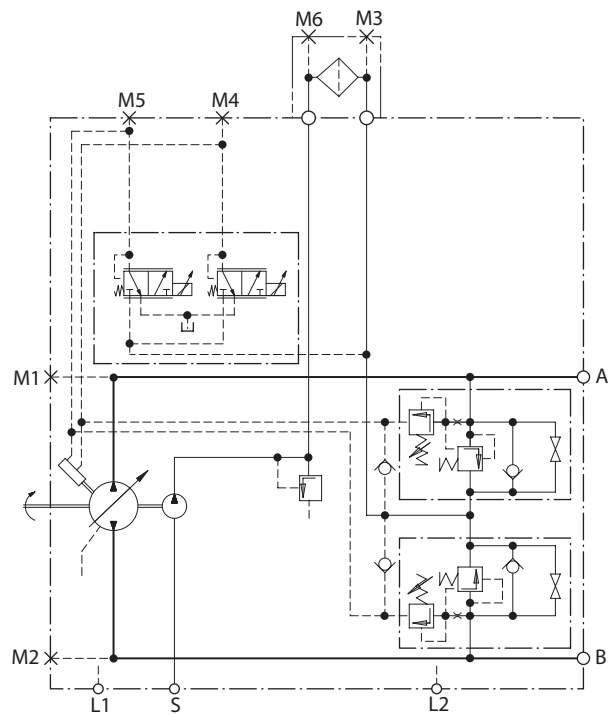
The Non Feedback Proportional Electric (NFPE) control is an electrical automotive control in which an electrical input signal activates one of two proportional solenoids that port charge pressure to either side of the pump servo cylinder. The NFPE control has no mechanical feedback mechanism.

The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swashplate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph.

Resistance Table

Supply Voltage	Coil Resistance
12 V	5.4 Ohms
24 V	21.6 Ohms

NFPE Schematic



P003 174

**NON FEEDBACK
 PROPORTIONAL ELECTRIC
 CONTROL (NFPE)
 (continued)**

Features and benefits of the NFPE control when used with sauer-danfoss microcontroller

- Creep mode
- Two automotive control ramps via mode switch
- Engine overspeed protection
- Electric control
- Anti-stall function
- Smooth operation
- Electronic ramp control is superior to hydraulic control with orifices

Input signal requirements

The NFPE control requires a pulse-width-modulated (PWM) input current to optimize performance. The recommended PWM frequency is 200 Hz. The minimum PWM frequency is 80 Hz.

The NFPE control uses an AMP® Junior Power Timer connector. The solenoids are compatible with Sauer-Danfoss microcontrollers and joysticks.

NFPE pump displacement vs. input signal

Shaft rotation	CW		CCW	
	A	B	A	B
Active solenoid				
Port A flow	Out	In	In	Out
Port B flow	In	Out	Out	In
Servo cylinder	M5	M4	M5	M4

Solenoid data

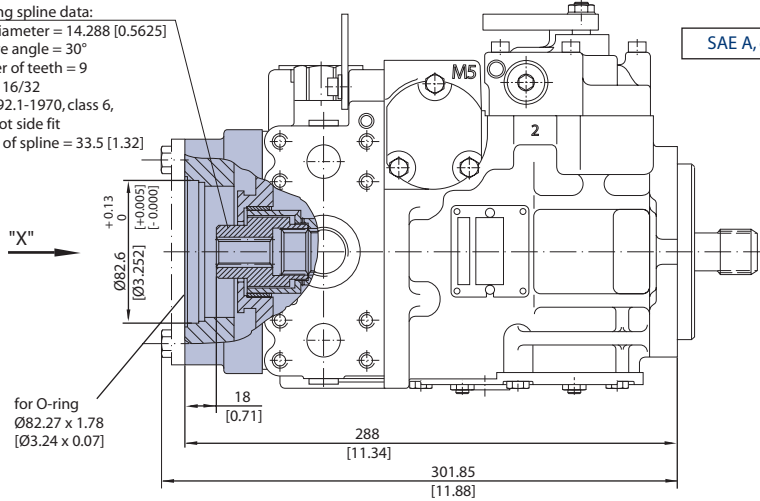
Voltage	Control current		
	Start	End	Max
12 V	~ 440 mA	1290 mA	1500 mA
24 V	~ 220 mA	645 mA	750 mA

FRAME SIZE 042
(continued)

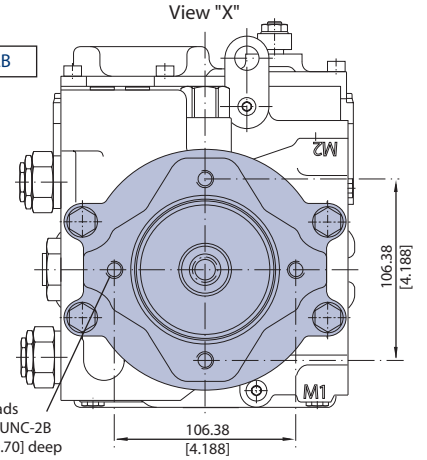
Auxiliary mounting pad – options AB, BC, BB

Coupling spline data:

Pitch diameter = 14.288 [0.5625]
Pressure angle = 30°
Number of teeth = 9
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 33.5 [1.32]

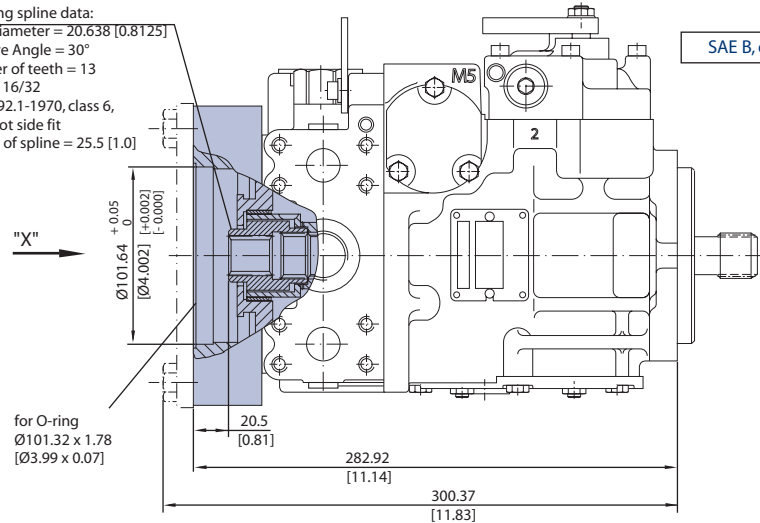


SAE A, option AB

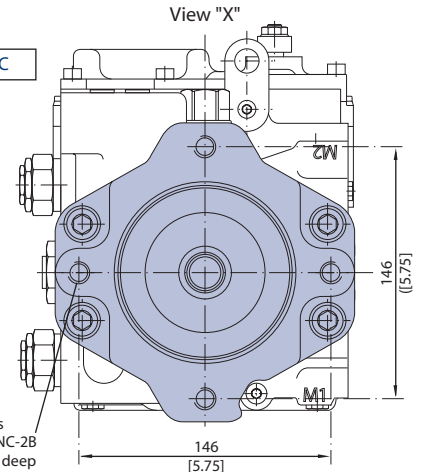


Coupling spline data:

Pitch diameter = 20.638 [0.8125]
Pressure Angle = 30°
Number of teeth = 13
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 25.5 [1.0]

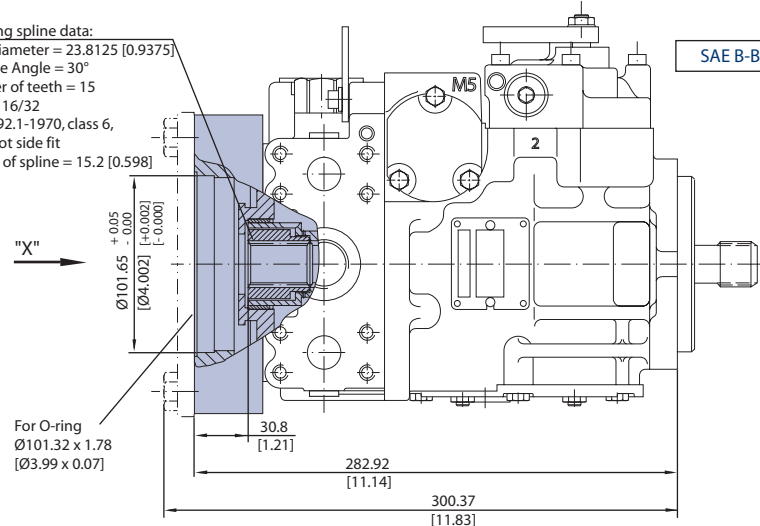


SAE B, option BC

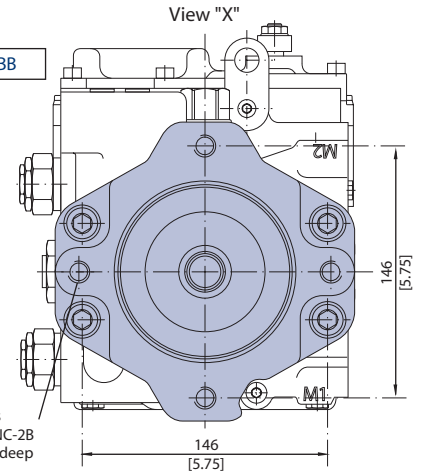


Coupling spline data:

Pitch diameter = 23.8125 [0.9375]
Pressure Angle = 30°
Number of teeth = 15
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 15.2 [0.598]



SAE B-B, option BB

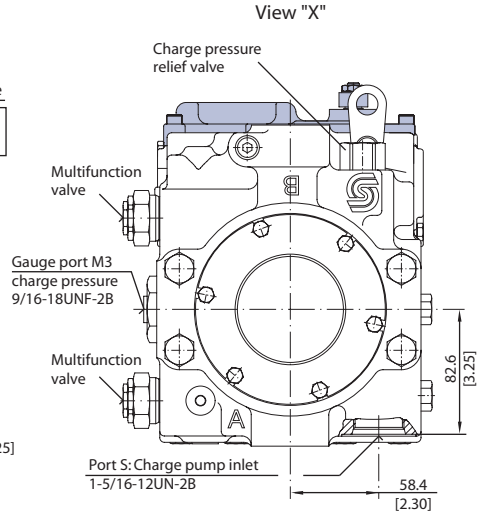
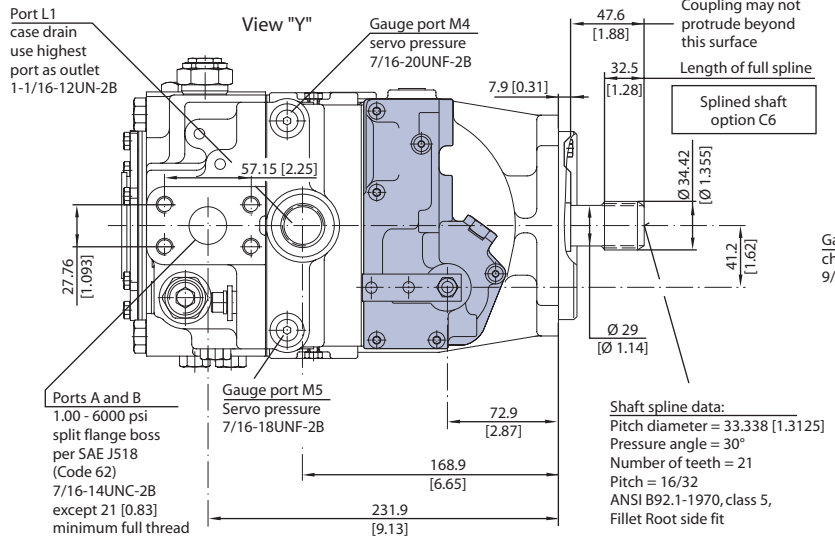
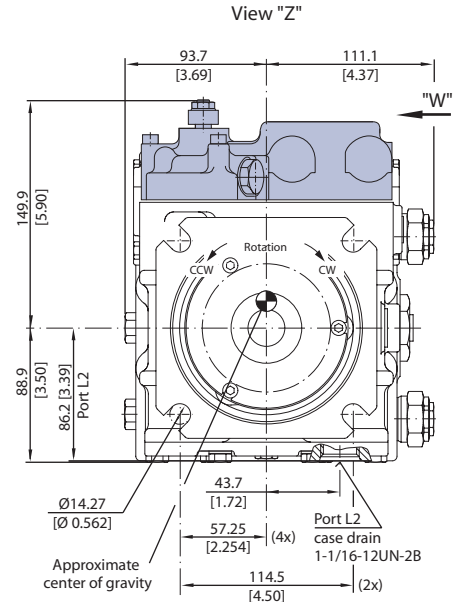
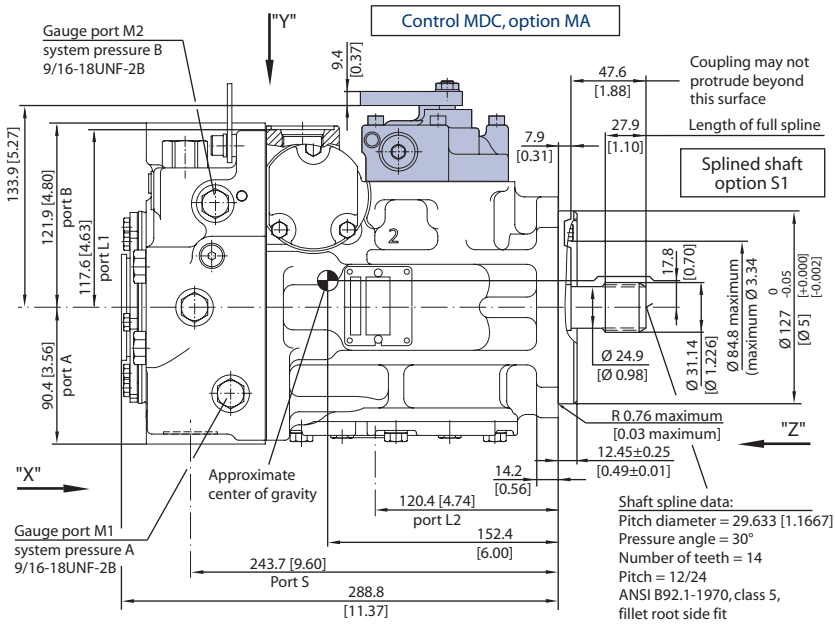


P102 041

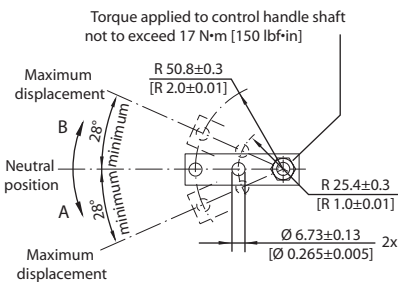
mm [in]

FRAME SIZE 055

Manual displacement control (MDC), endcap side ports, option 60



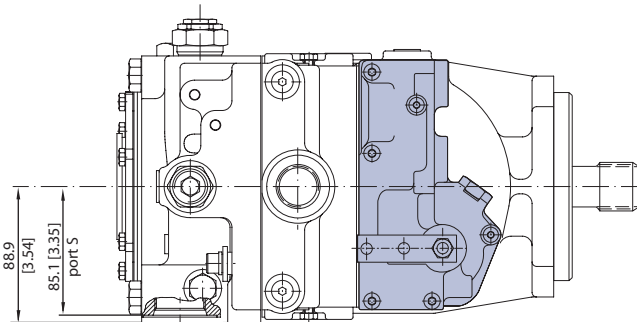
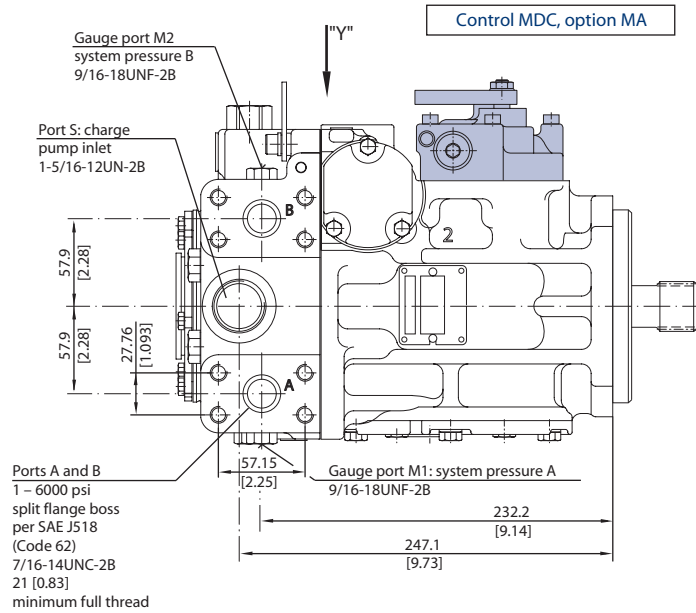
Manual Displacement Control Handle Dimensions



P102 042

**FRAME SIZE 055
(continued)**

Manual displacement control (MDC) endcap twin ports, option 80



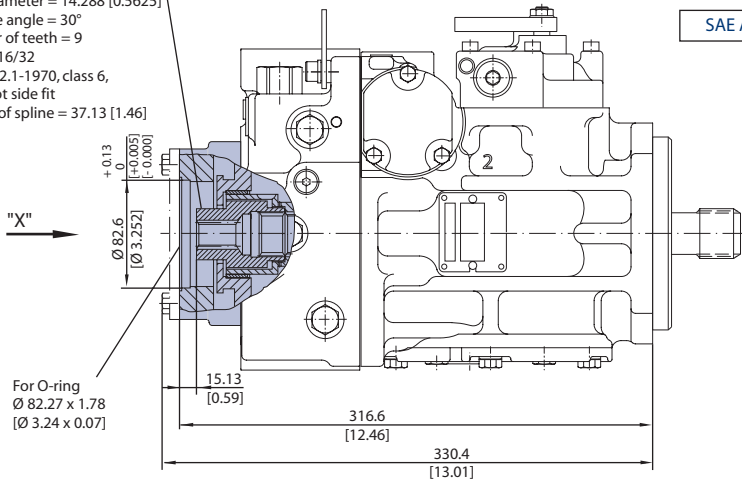
P102 043

mm [in]

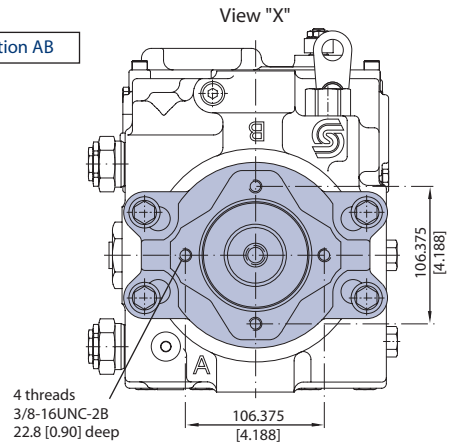
**FRAME SIZE 055
 (continued)**

Auxiliary mounting pad – options AB, BC, CD, BB

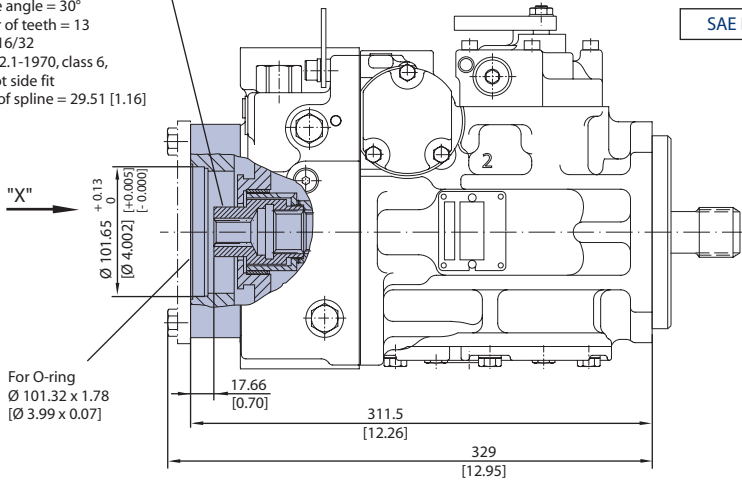
Coupling spline data:
 Pitch diameter = 14.288 [0.5625]
 Pressure angle = 30°
 Number of teeth = 9
 Pitch = 16/32
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 37.13 [1.46]



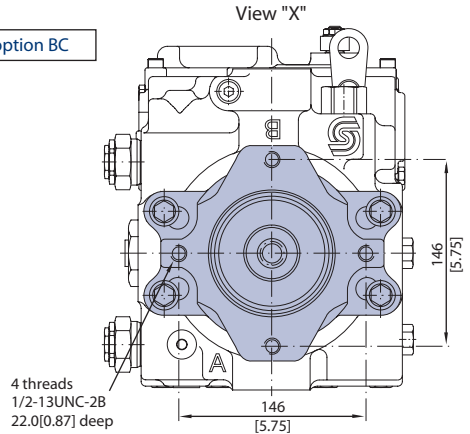
SAE A, option AB



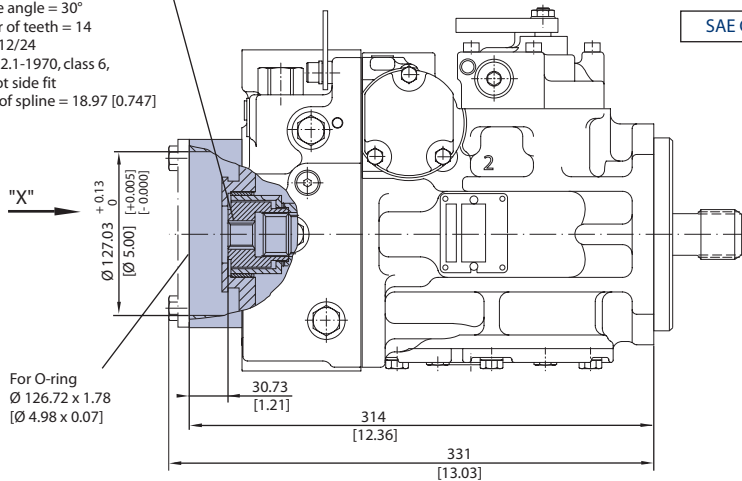
Coupling spline data:
 Pitch diameter = 20.6375 [0.8125]
 Pressure angle = 30°
 Number of teeth = 13
 Pitch = 16/32
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 29.51 [1.16]



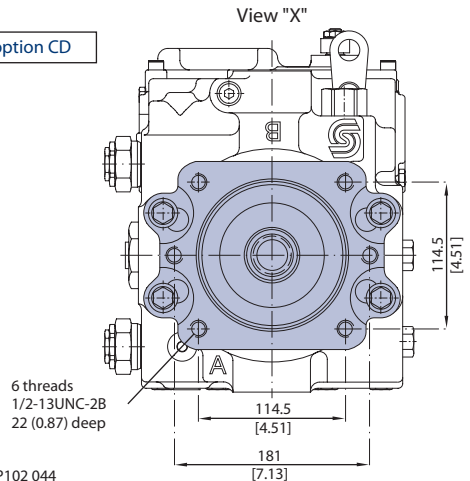
SAE B, option BC



Coupling spline data:
 Pitch diameter = 29.6333 [1.167]
 Pressure angle = 30°
 Number of teeth = 14
 Pitch = 12/24
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 18.97 [0.747]



SAE C, option CD



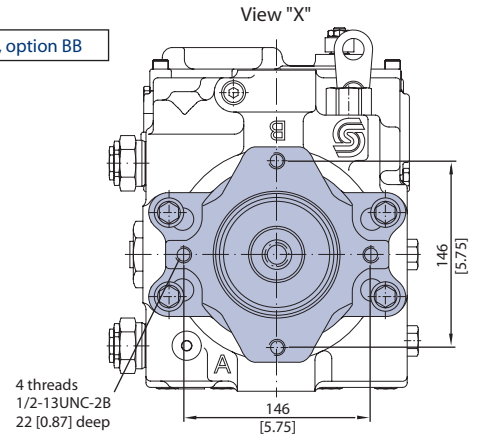
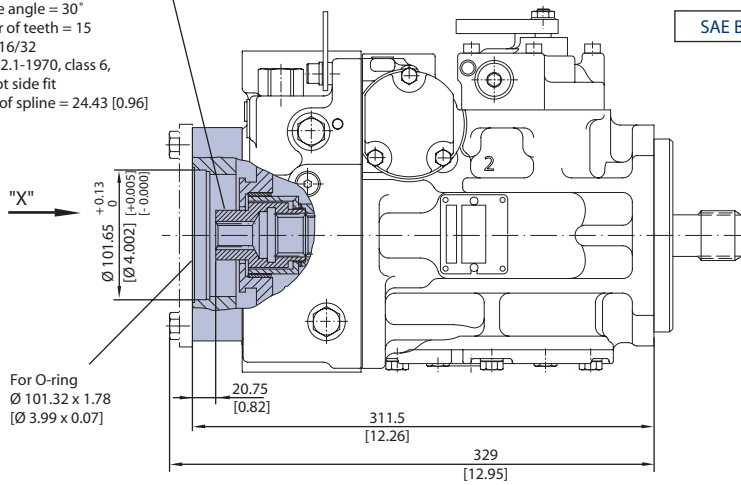
P102 044

FRAME SIZE 055
(continued)

Auxiliary mounting pad – options AB, BC, CD, BB

Coupling spline data:

Pitch diameter = 23.8125 [0.9375]
Pressure angle = 30°
Number of teeth = 15
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 24.43 [0.96]

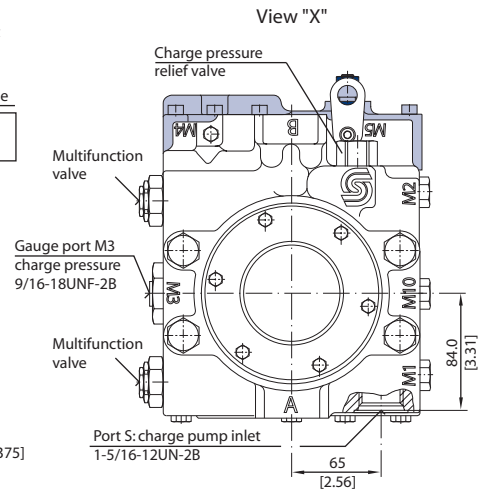
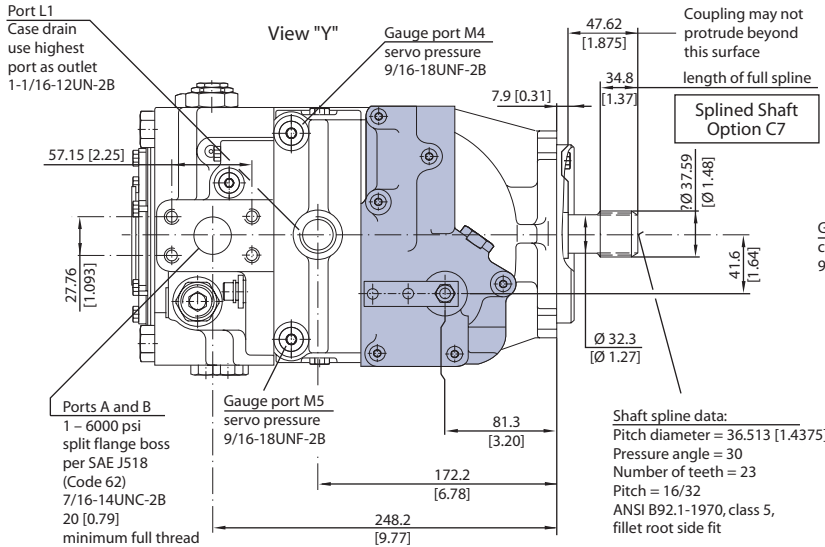
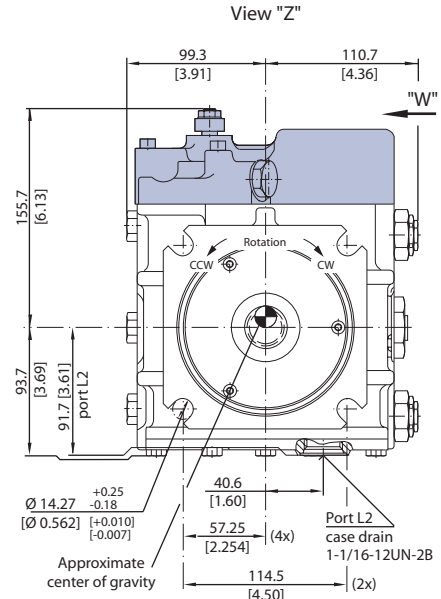
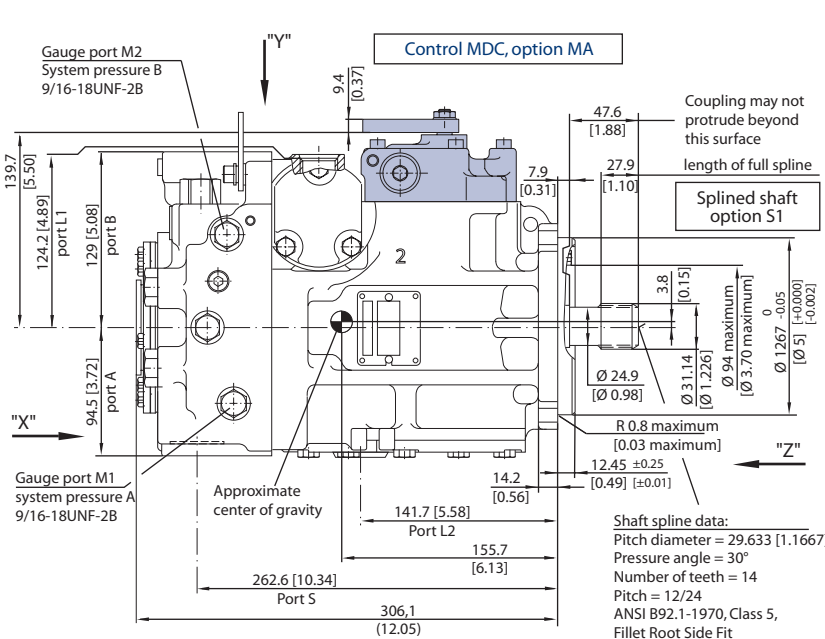


P102 045

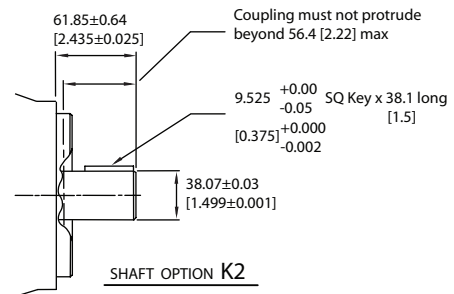
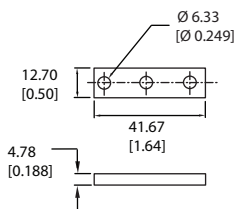
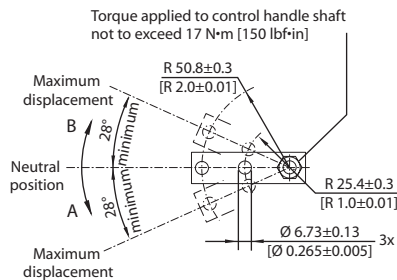
mm [in]

FRAME SIZE 075

Manual Displacement Control (MDC) Endcap Side Ports, Option 60

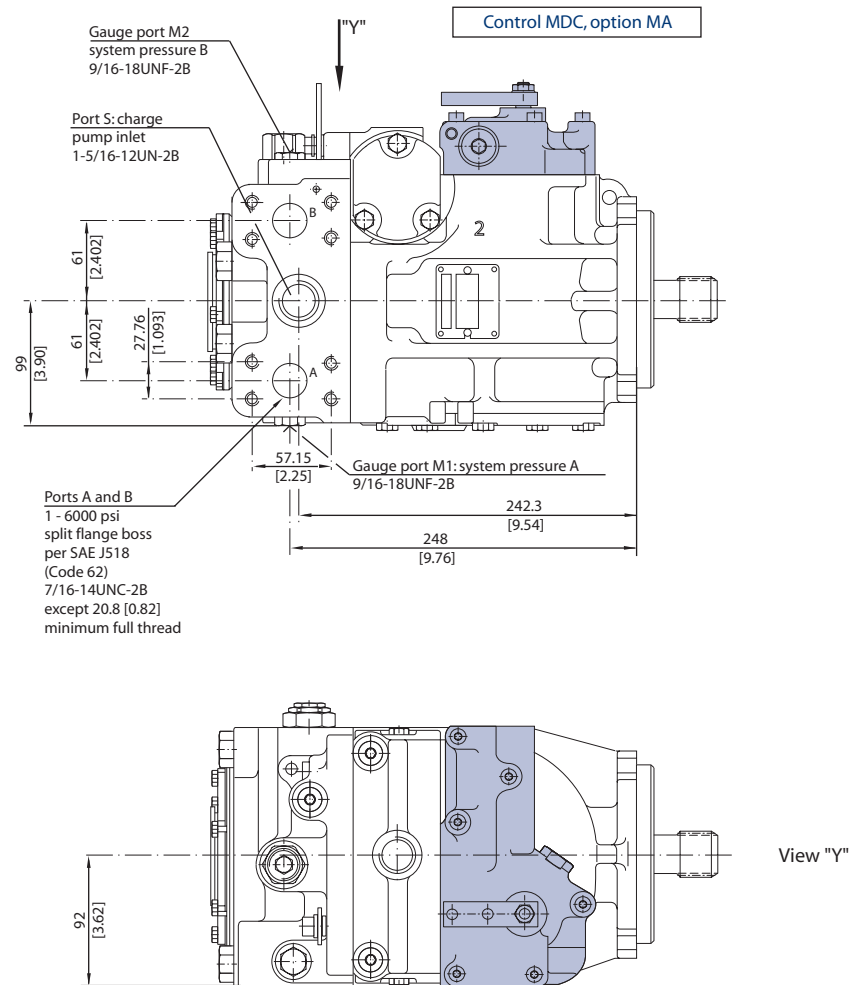


Manual displacement control handle dimensions



FRAME SIZE 075
(continued)

Manual Displacement Control (MDC), endcap twin ports, option 80



P102 047

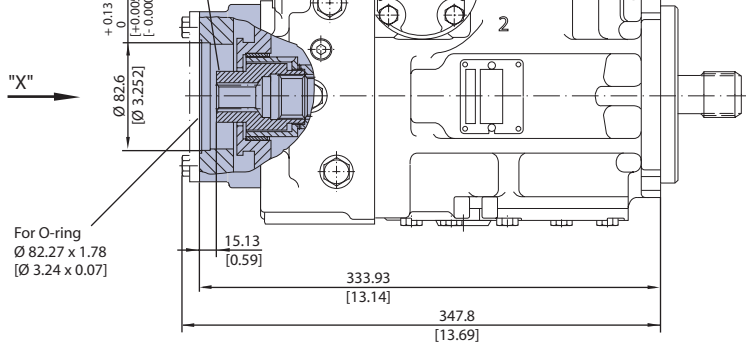
mm [in]

**FRAME SIZE 075
(continued)**

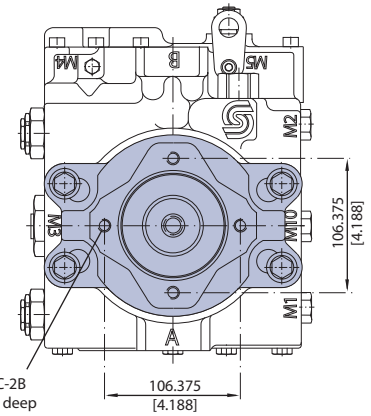
Auxiliary mounting pad – Options AB, BC, CD, BB

Coupling spline data:

Pitch diameter = 14.288 [0.5625]
Pressure angle = 30°
Number of teeth = 9
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 37.13 [1.46]

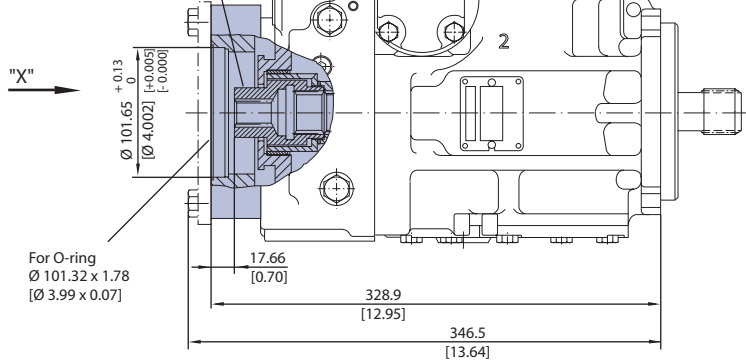


View "X"

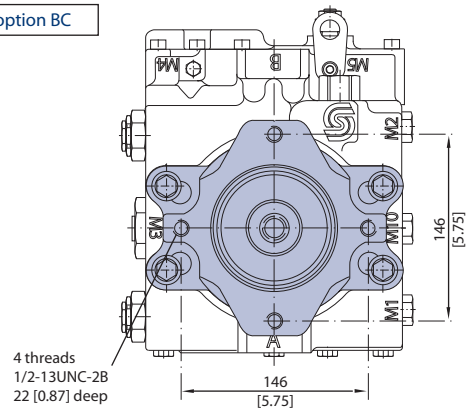


Coupling spline data:

Pitch diameter = 20.6375 [0.8125]
Pressure angle = 30°
Number of teeth = 13
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 29.51 [1.16]

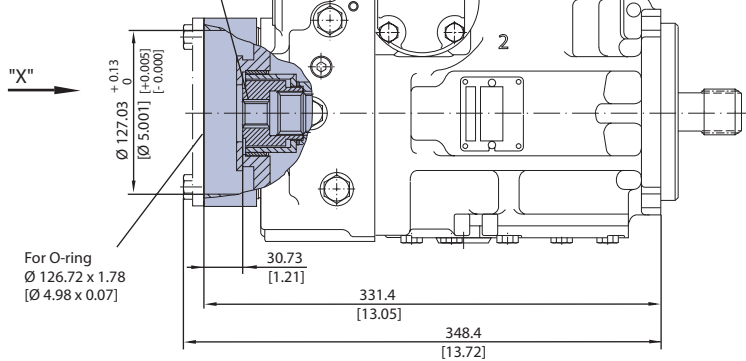


View "X"

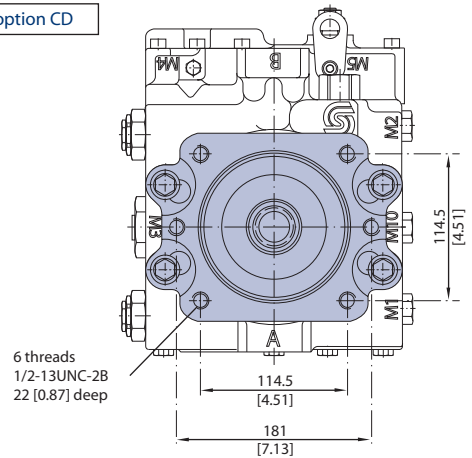


Coupling spline data:

Pitch diameter = 29.6333 [1.167]
Pressure angle = 30°
Number of teeth = 14
Pitch = 12/24
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 18.97 [0.747]



View "X"

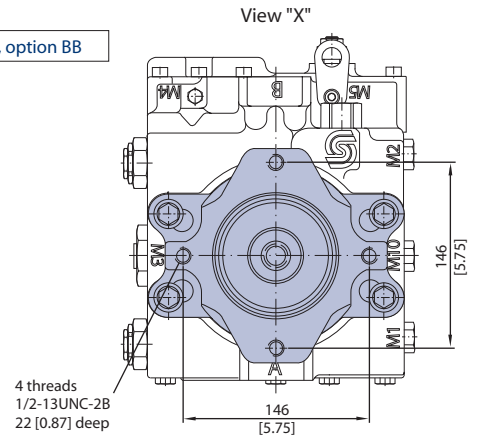
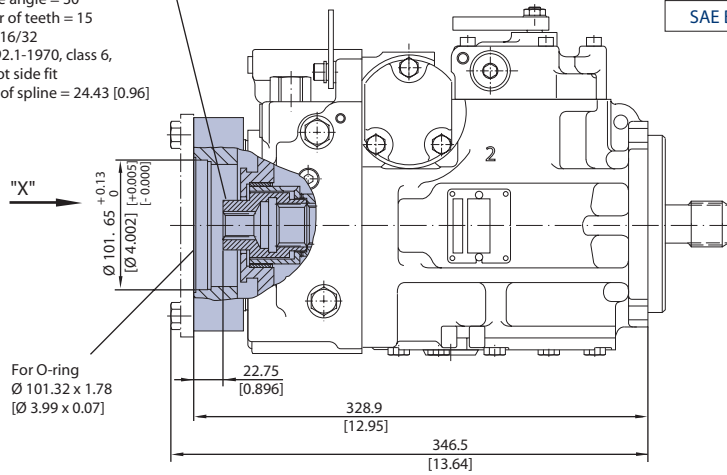


P102 048

FRAME SIZE 075
(continued)

Auxiliary mounting pad – options AB, BC, CD, BB

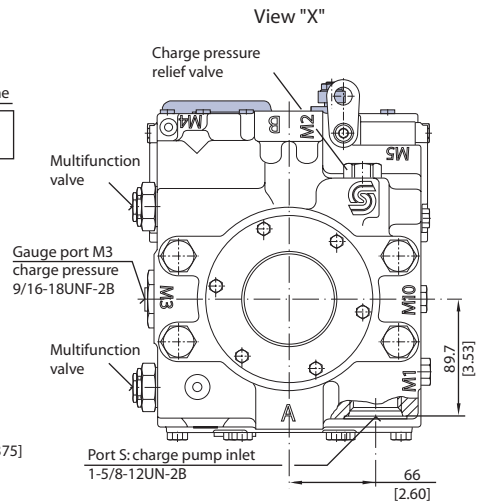
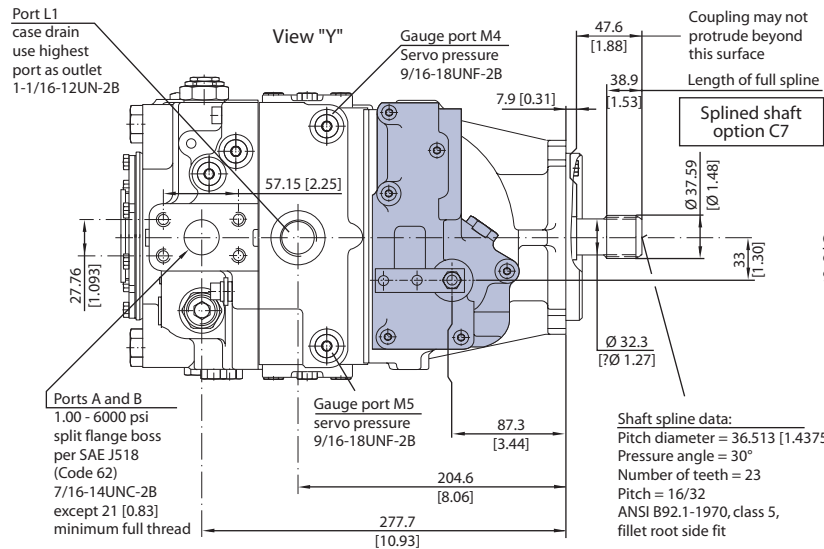
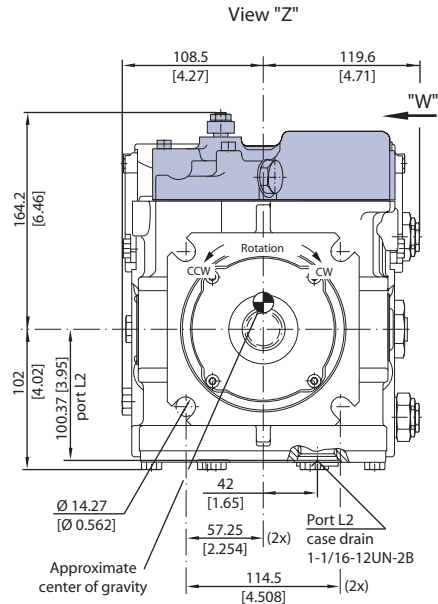
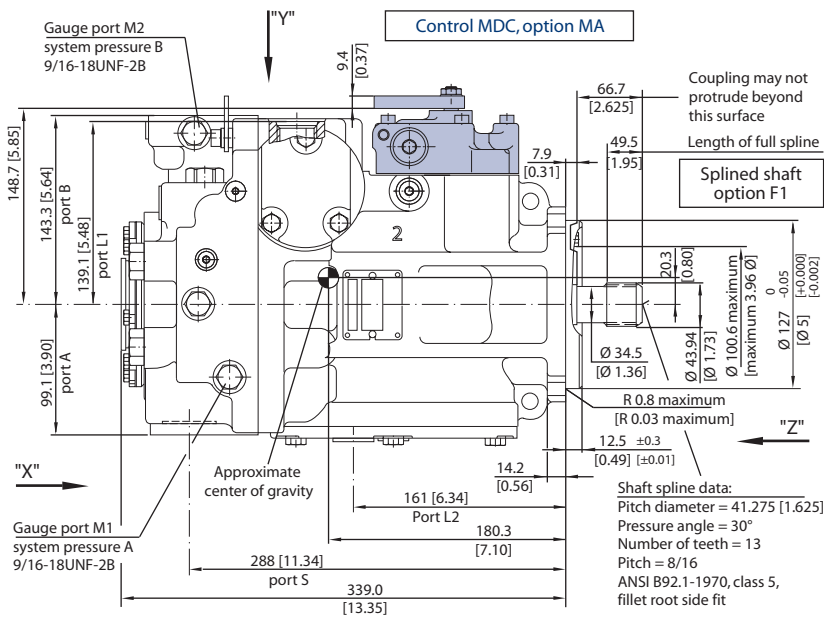
Coupling spline data:
Pitch diameter = 23.8125 [0.9375]
Pressure angle = 30°
Number of teeth = 15
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 24.43 [0.96]



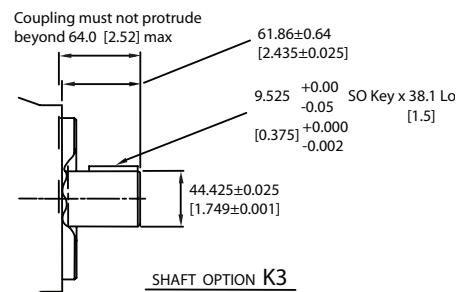
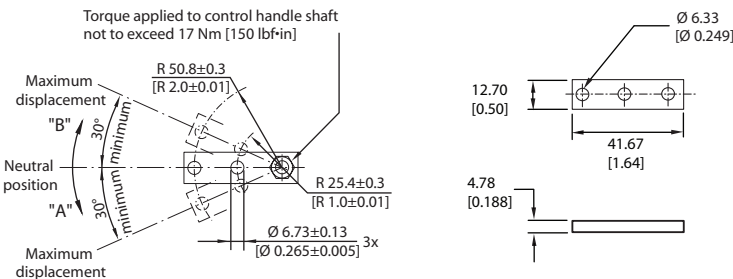
P102 049

FRAME SIZE 100

Manual Displacement Control (MDC), endcap side ports, option 60

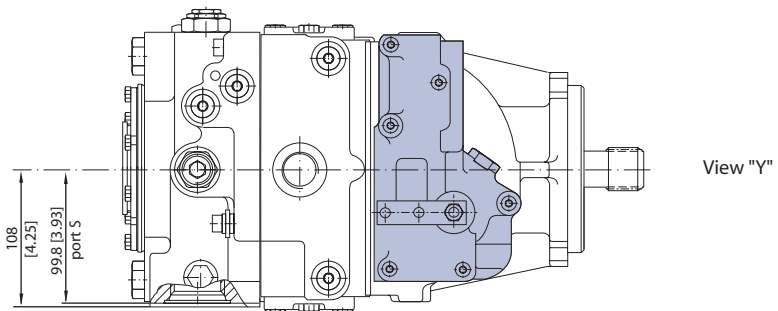
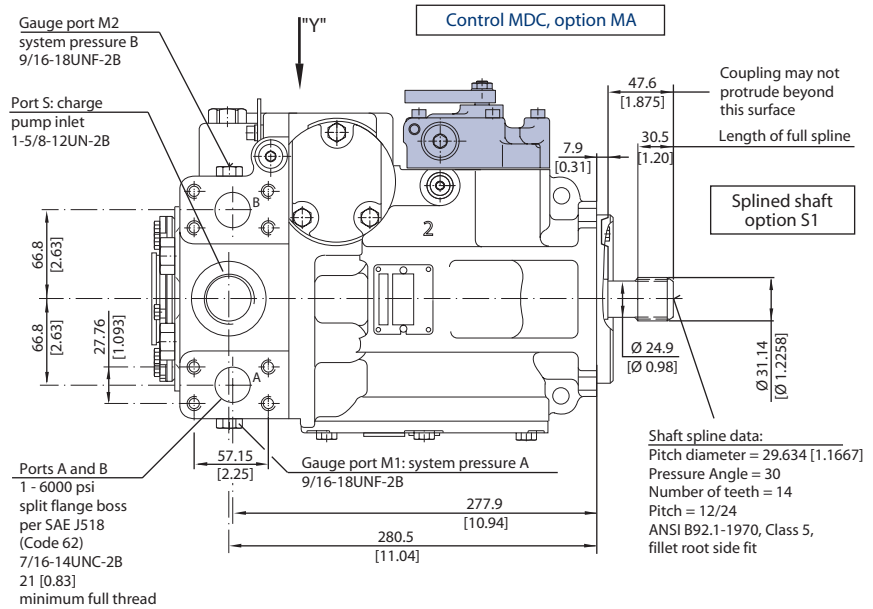


Manual displacement control handle dimensions



FRAME SIZE 100
(continued)

Manual Displacement Control (MDC), endcap twin ports, option 80

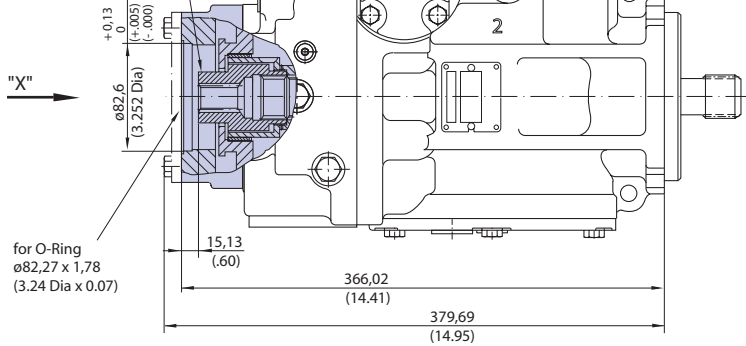


P102 051

**FRAME SIZE 100
(continued)**

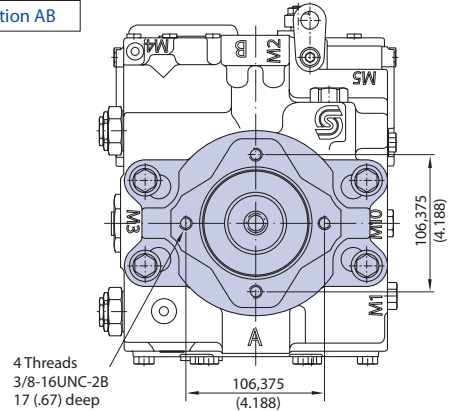
Auxiliary mounting pads, SAE AB, SAE BC, SAE CD

COUPLING SPLINE DATA:
Pitch Dia = 14,288 (.5625)
Pressure Angle = 30
Number of teeth = 9
Pitch = 16/32
ANSI B92.1-1970, Class 6,
Fillet Root Side Fit
Length of spline = 37,13 (1.46)

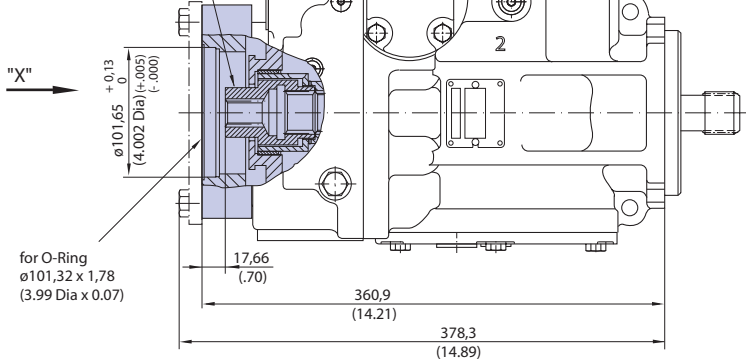


SAE A, Option AB

View "X"

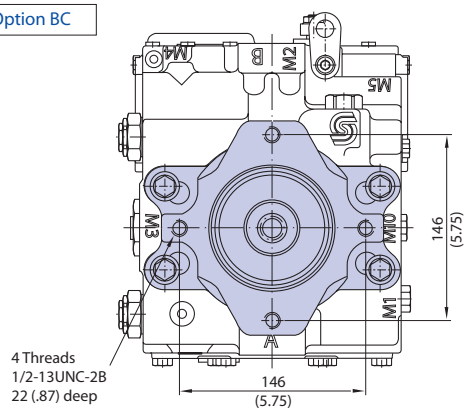


COUPLING SPLINE DATA:
Pitch Dia = 20,6375 (.8125)
Pressure Angle = 30
Number of teeth = 13
Pitch = 16/32
ANSI B92.1-1970, Class 6,
Fillet Root Side Fit
Length of spline = 29,51 (1.16)

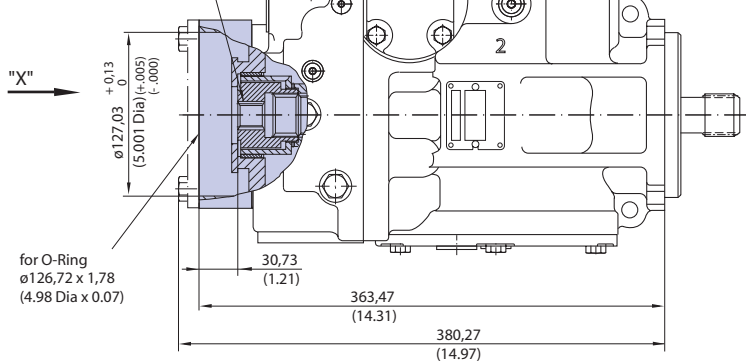


SAE B, Option BC

View "X"

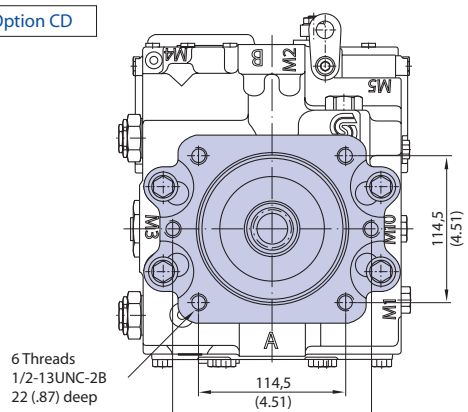


COUPLING SPLINE DATA:
Pitch Dia = 29,6333 (1.167)
Pressure Angle = 30
Number of teeth = 14
Pitch = 12/24
ANSI B92.1-1970, Class 6,
Fillet Root Side Fit
Length of spline = 18,97 (.747)



SAE C, Option CD

View "X"

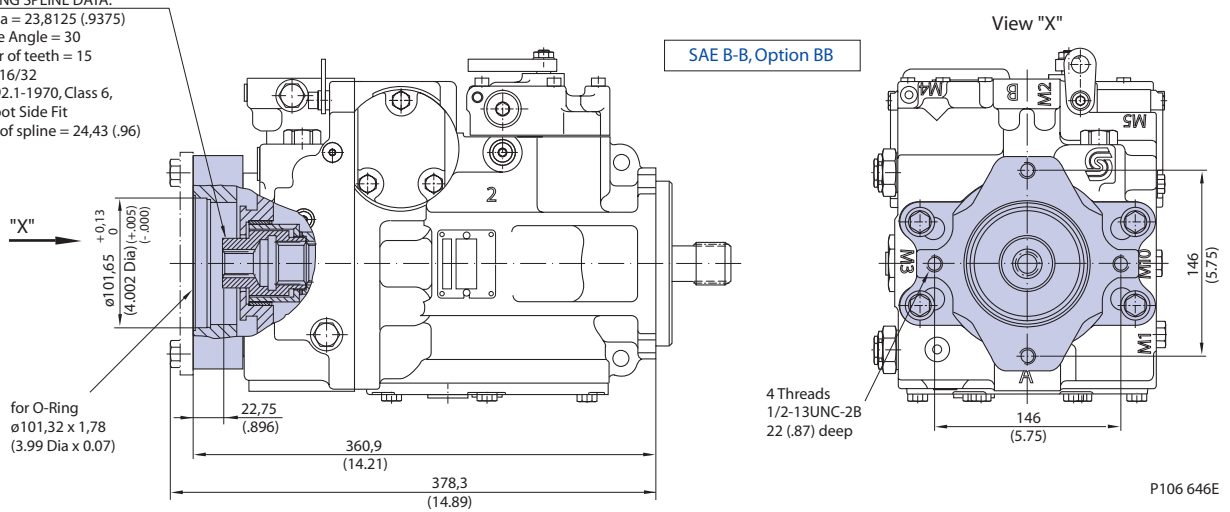


P106 645E

FRAME SIZE 100
(continued)

Auxiliary mounting pad, SAE BB

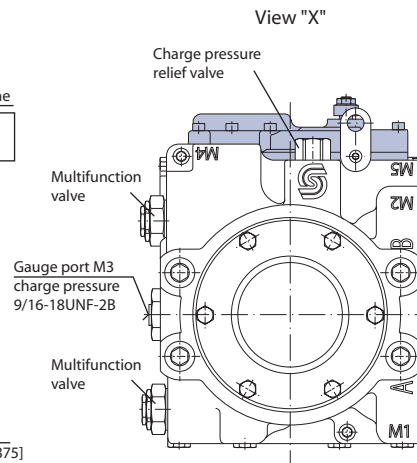
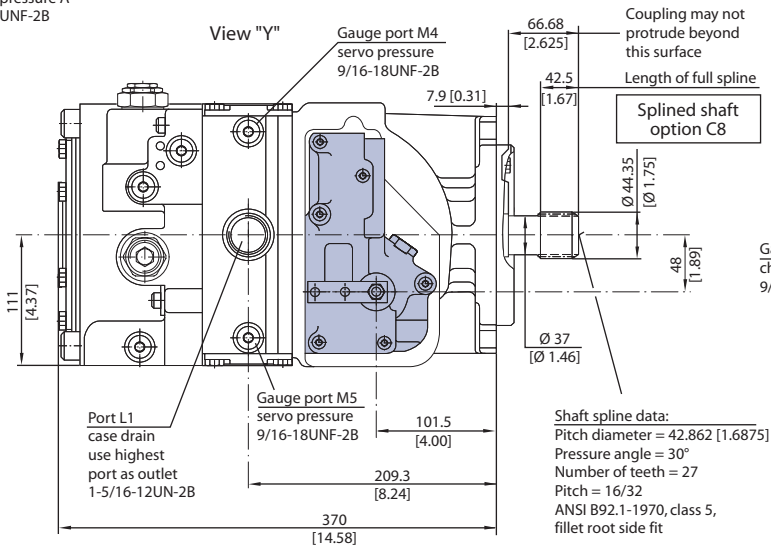
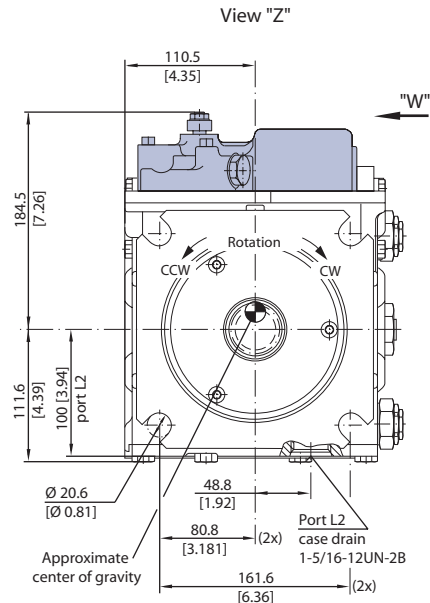
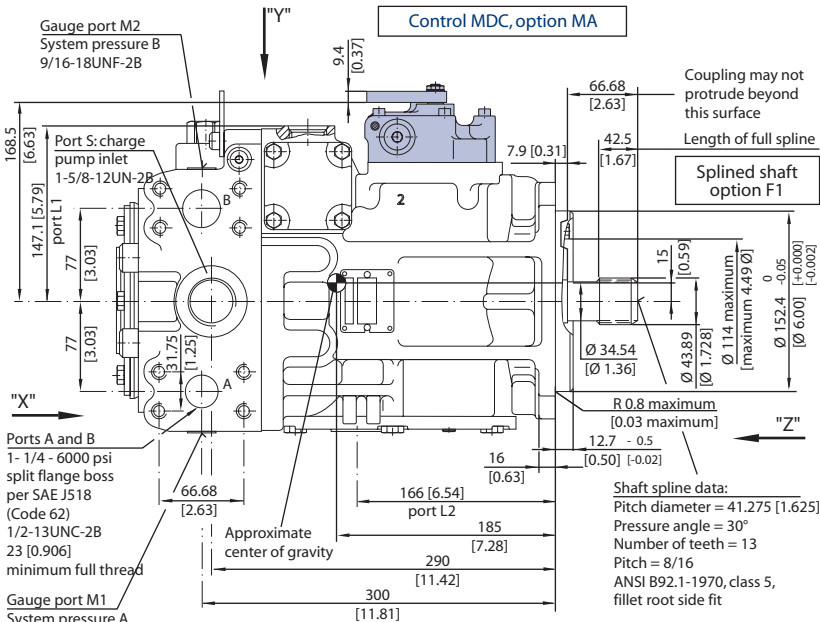
COUPLING SPLINE DATA:
Pitch Dia = 23,8125 (.9375)
Pressure Angle = 30
Number of teeth = 15
Pitch = 16/32
ANSI B92.1-1970, Class 6,
Fillet Root Side Fit
Length of spline = 24,43 (.96)



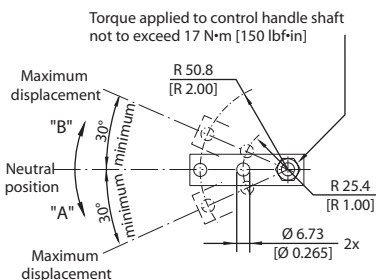
mm [in]

FRAME SIZE 130

Manual Displacement Control (MDC), end cap twin ports, option 80



Manual displacement control handle dimensions



P102 052

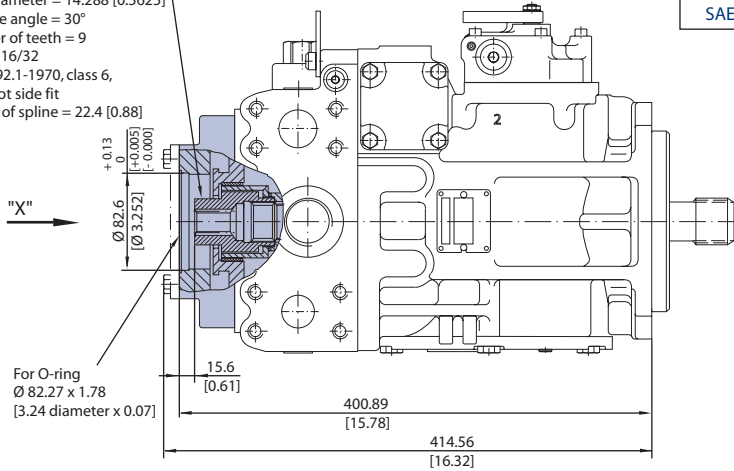
mm [in]

FRAME SIZE 130
(continued)

Auxiliary mounting pad - options AB, BC, CD, DE, BB

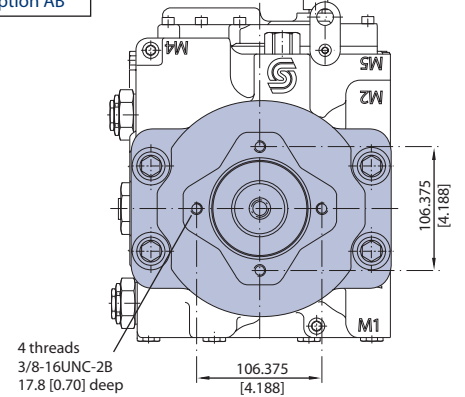
Coupling spline data:

Pitch diameter = 14.288 [0.5625]
Pressure angle = 30°
Number of teeth = 9
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 22.4 [0.88]



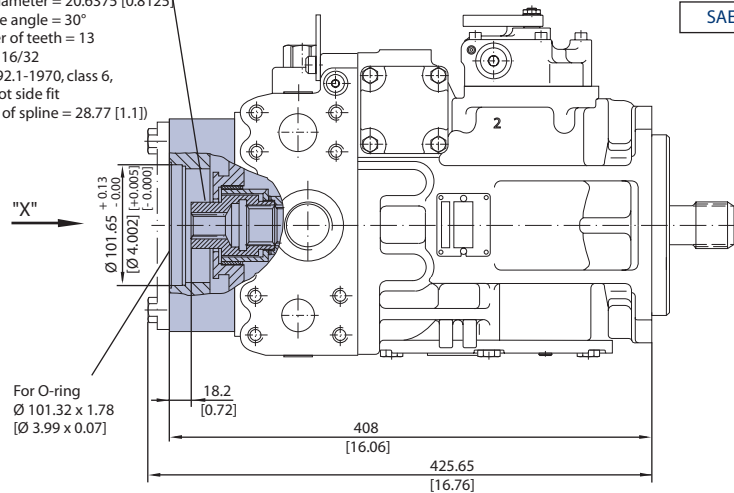
SAE A, option AB

View "X"



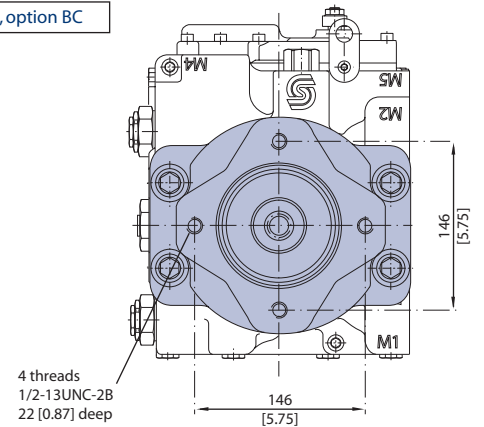
Coupling spline data:

Pitch diameter = 20.6375 [0.8125]
Pressure angle = 30°
Number of teeth = 13
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 28.77 [1.11]



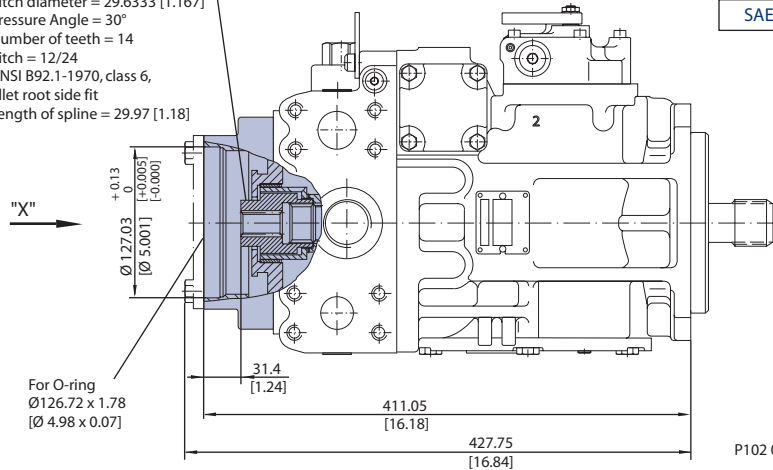
SAE B, option BC

View "X"



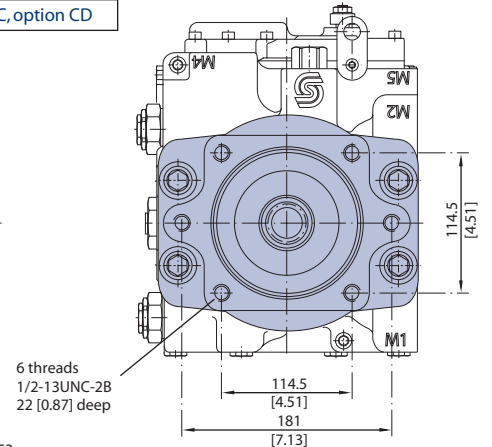
Coupling spline data:

Pitch diameter = 29.6333 [1.167]
Pressure Angle = 30°
Number of teeth = 14
Pitch = 12/24
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 29.97 [1.18]



SAE C, option CD

View "X"



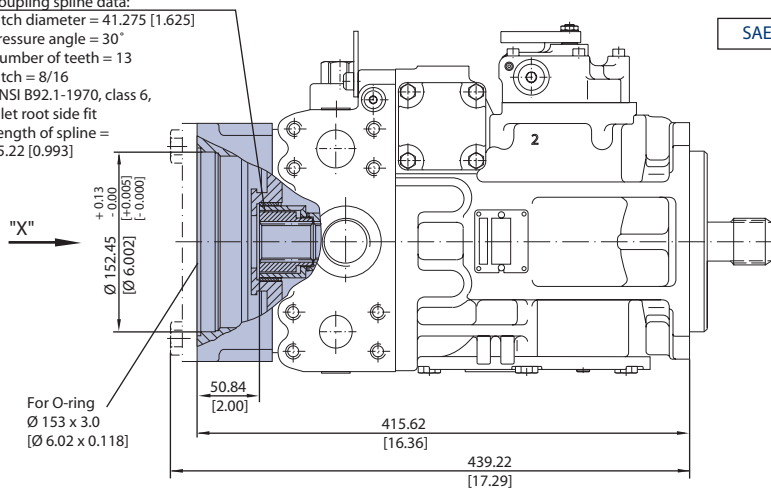
P102 053

mm [in]

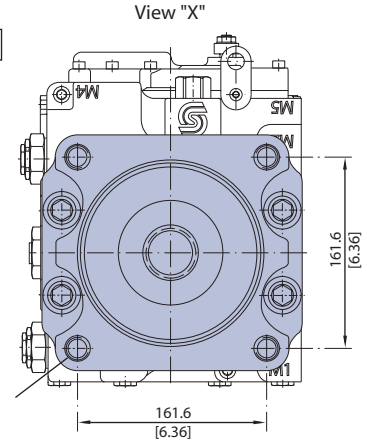
**FRAME SIZE 130
(continued)**

Auxiliary mounting pad - options AB, BC, CD, DE, BB

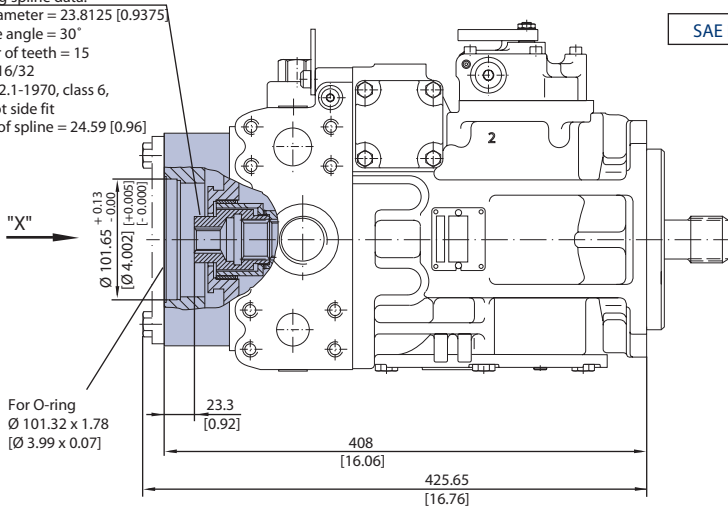
Coupling spline data:
Pitch diameter = 41.275 [1.625]
Pressure angle = 30°
Number of teeth = 13
Pitch = 8/16
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 25.22 [0.993]



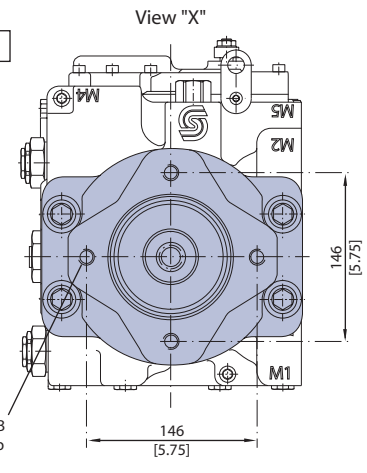
SAE D, option DE



Coupling spline data:
Pitch diameter = 23.8125 [0.9375]
Pressure angle = 30°
Number of teeth = 15
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 24.59 [0.96]



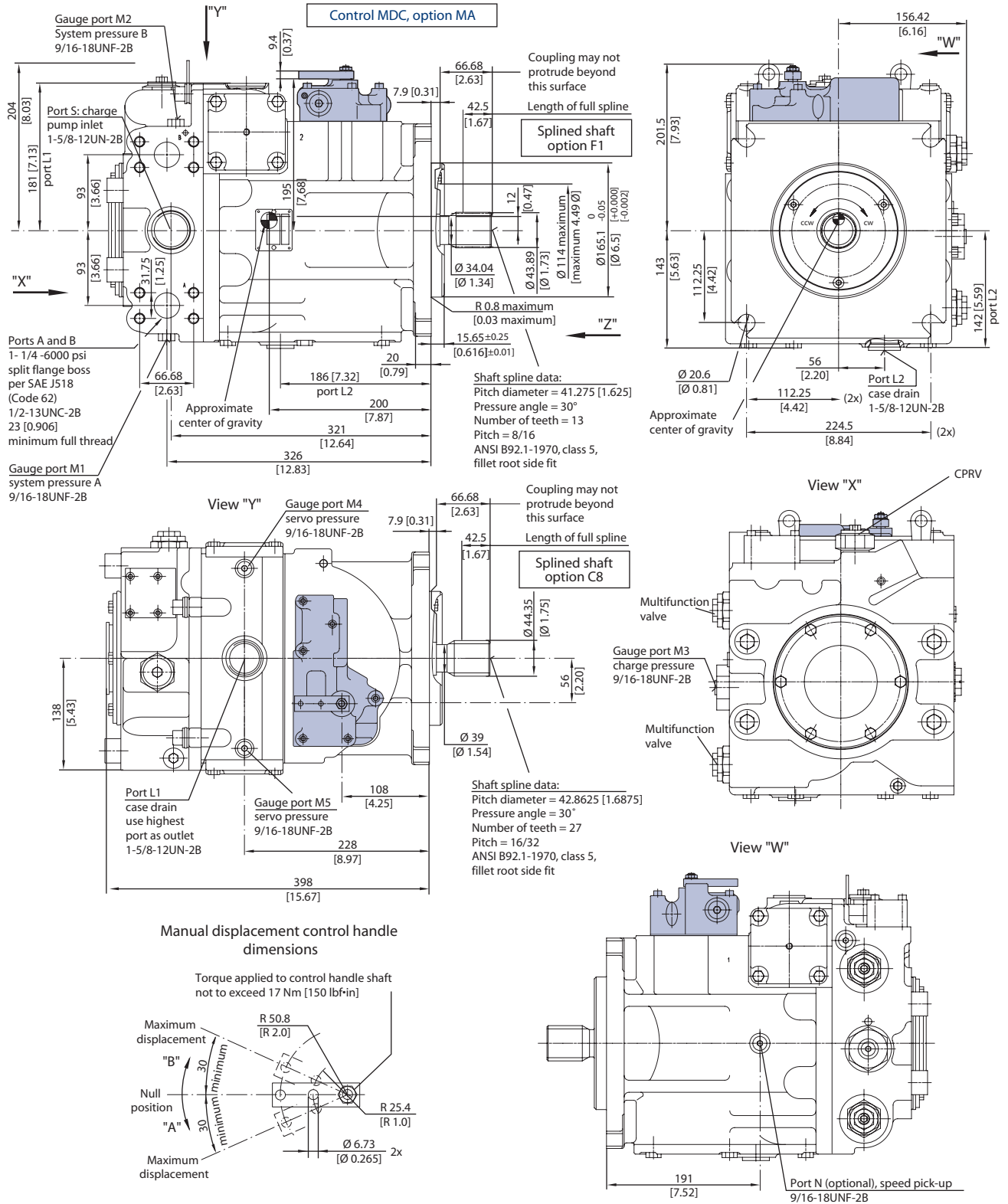
SAE B-B, option BB



P102 054

FRAME SIZE 180

Manual Displacement Control (MDC), end cap twin ports, option 80

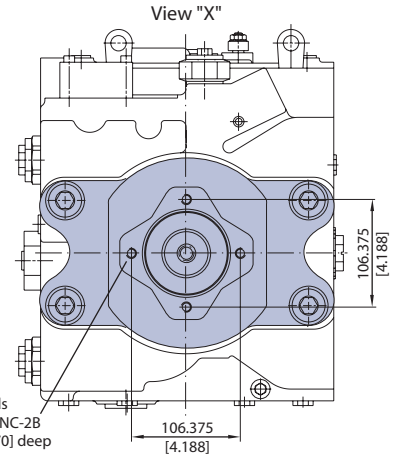
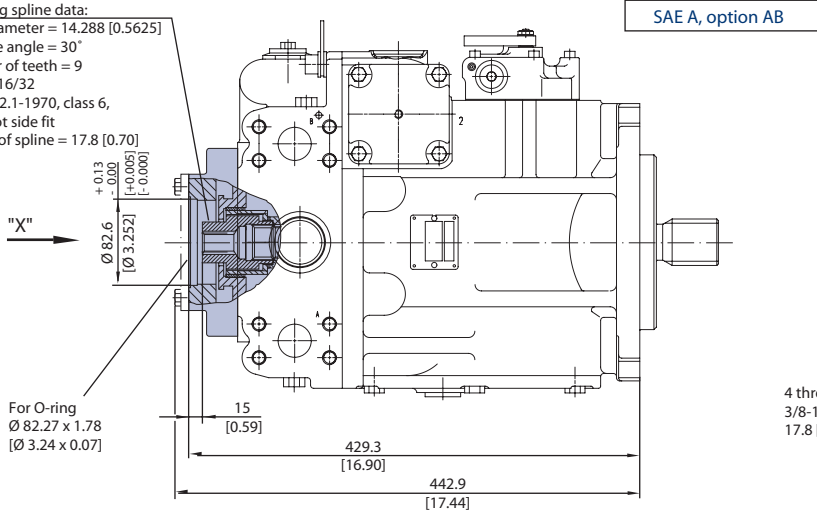


mm [in]

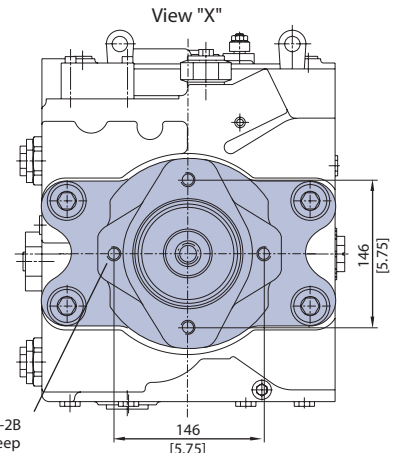
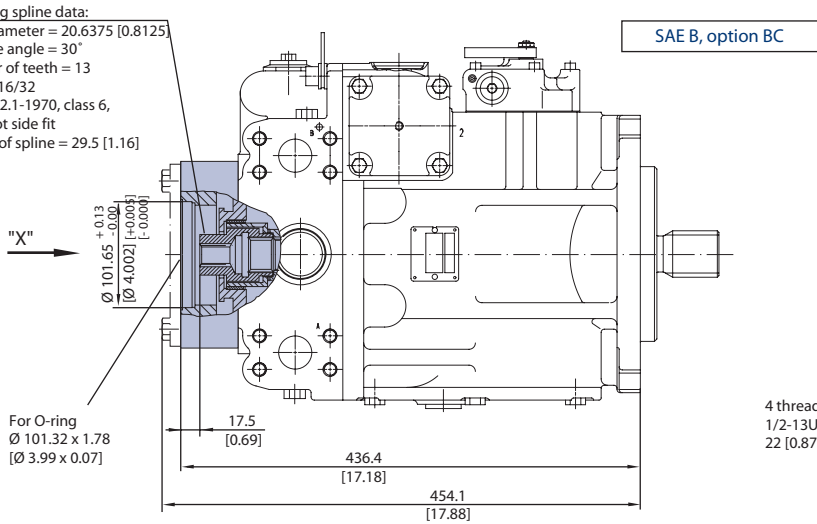
**FRAME SIZE 180
(continued)**

Auxiliary mounting pad - options AB, BC, CD, DE, EF, EG, BB

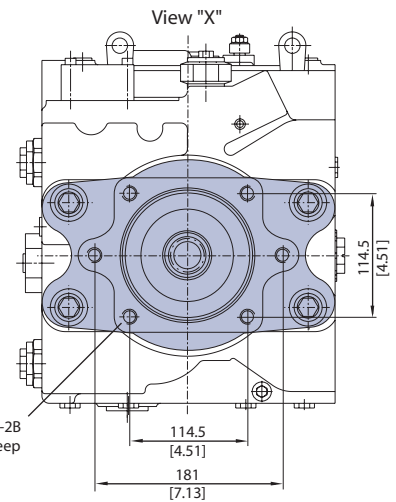
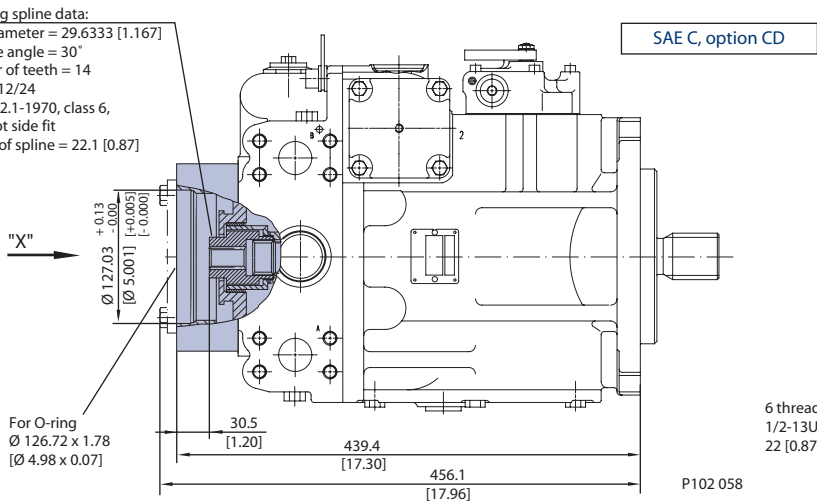
Coupling spline data:
Pitch diameter = 14.288 [0.5625]
Pressure angle = 30°
Number of teeth = 9
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 17.8 [0.70]



Coupling spline data:
Pitch diameter = 20.6375 [0.8125]
Pressure angle = 30°
Number of teeth = 13
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 29.5 [1.16]



Coupling spline data:
Pitch diameter = 29.6333 [1.167]
Pressure angle = 30°
Number of teeth = 14
Pitch = 12/24
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 22.1 [0.87]



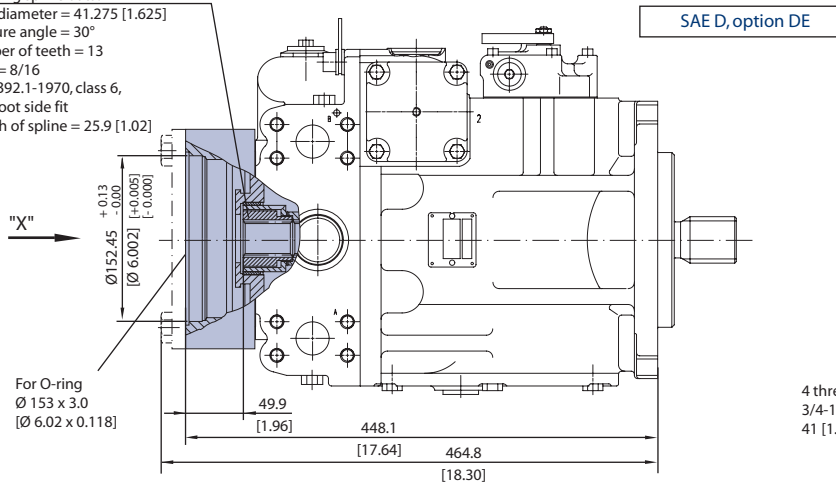
P102 058

**FRAME SIZE 180
 (continued)**

Auxiliary mounting pad - options AB, BC, CD, DE, EF, EG, BB

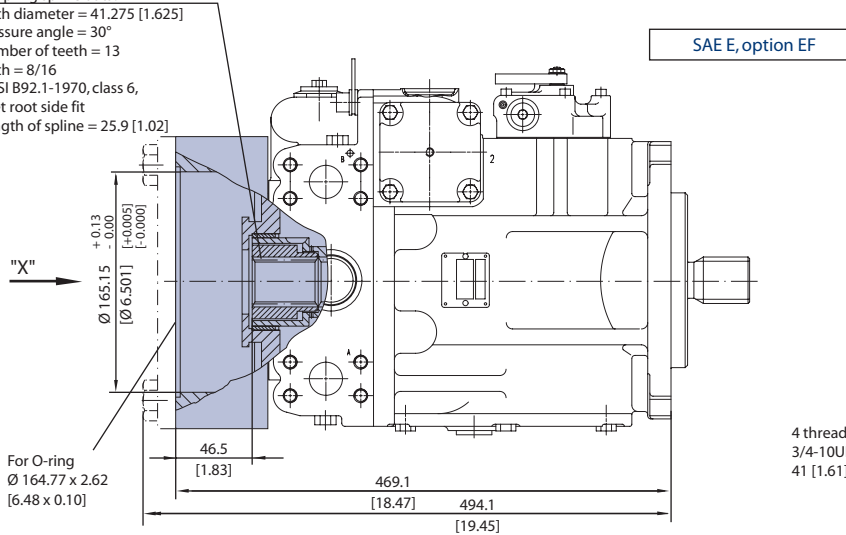
Coupling spline data:

Pitch diameter = 41.275 [1.625]
 Pressure angle = 30°
 Number of teeth = 13
 Pitch = 8/16
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 25.9 [1.02]



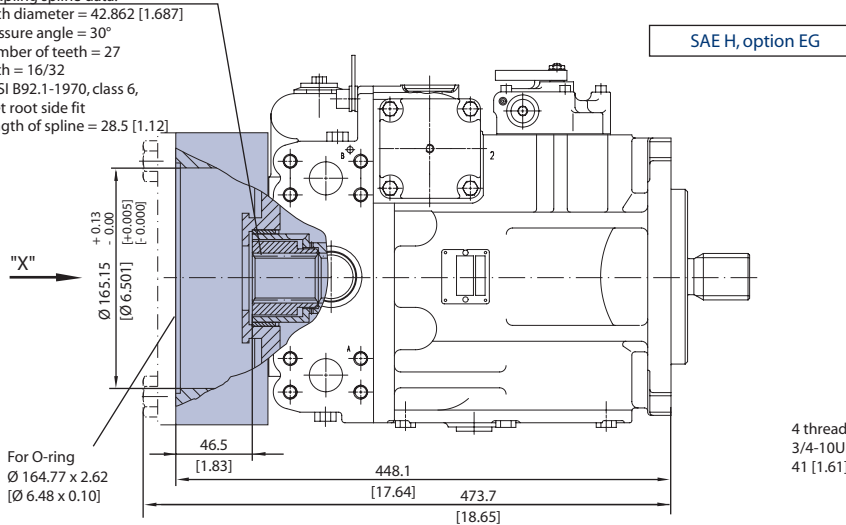
Coupling spline data:

Pitch diameter = 41.275 [1.625]
 Pressure angle = 30°
 Number of teeth = 13
 Pitch = 8/16
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 25.9 [1.02]



Coupling spline data:

Pitch diameter = 42.862 [1.687]
 Pressure angle = 30°
 Number of teeth = 27
 Pitch = 16/32
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 28.5 [1.12]

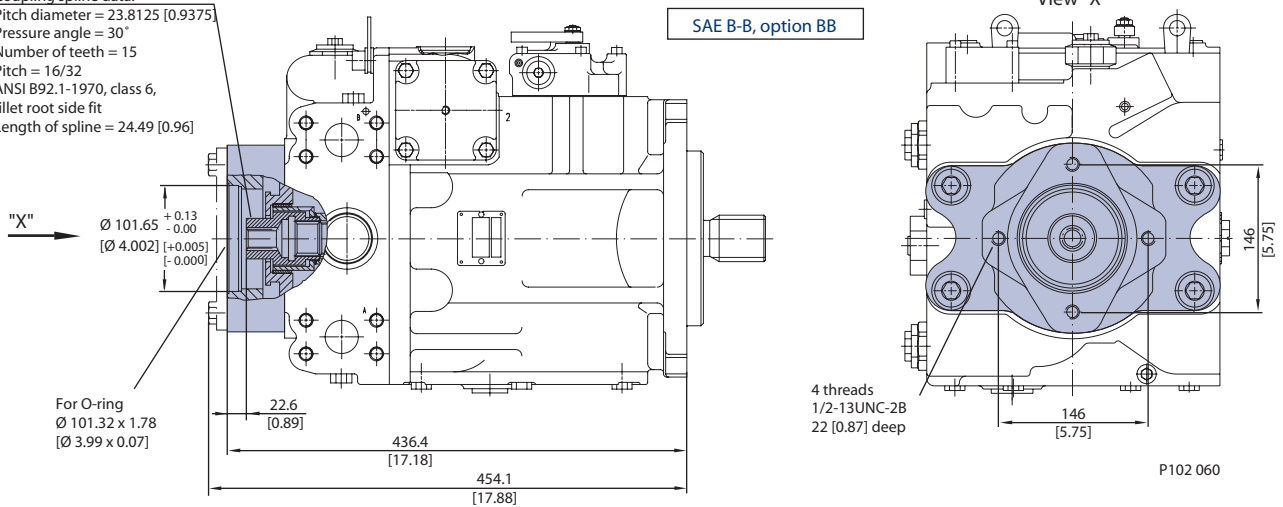


**FRAME SIZE 180
(continued)**

Auxiliary mounting pad - options AB, BC, CD, DE, EF, EG, BB

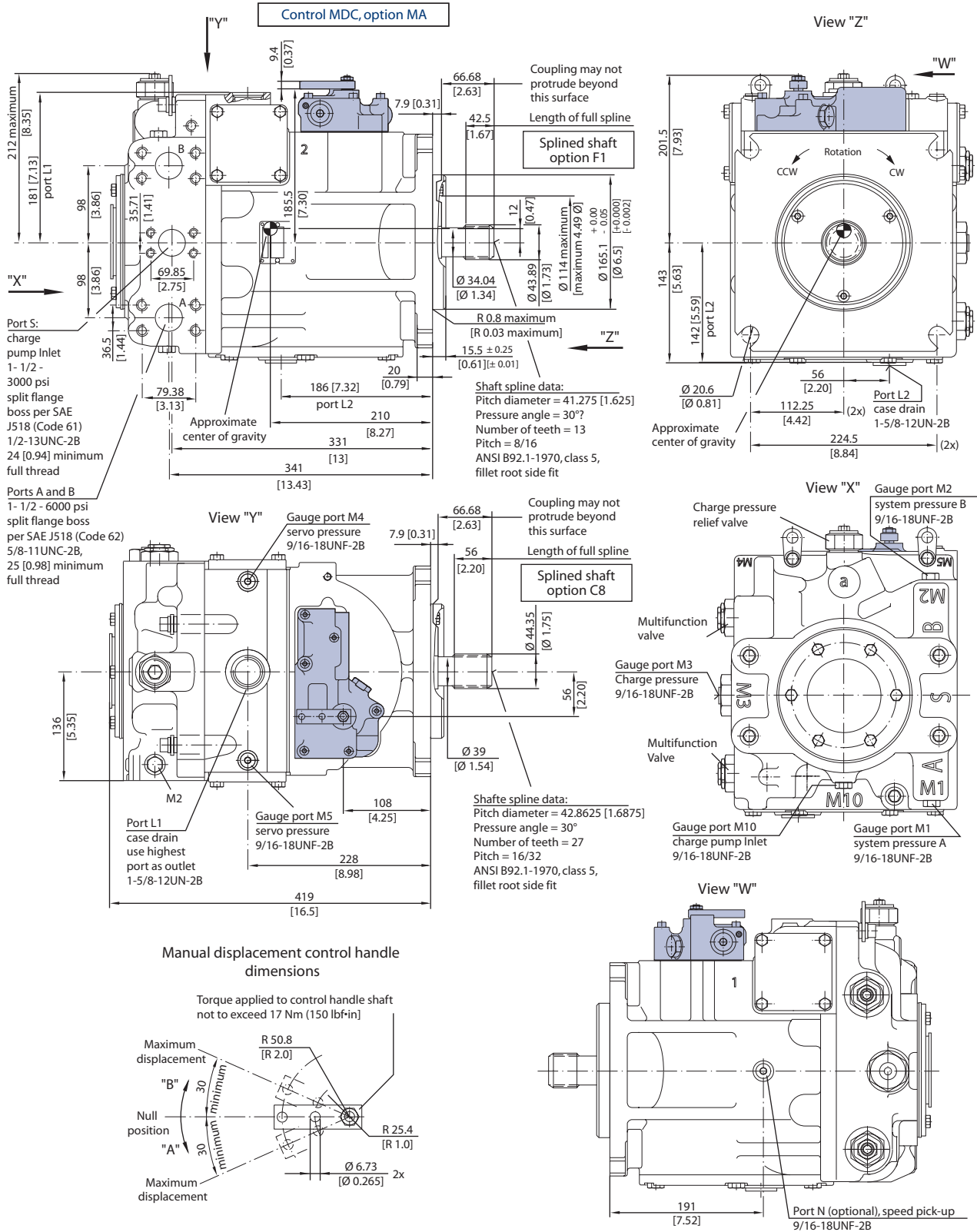
Coupling spline data:

Pitch diameter = 23.8125 [0.9375]
Pressure angle = 30°
Number of teeth = 15
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 24.49 [0.96]



FRAME SIZE 250

Manual Displacement Control (MDC), end cap twin ports, option 80

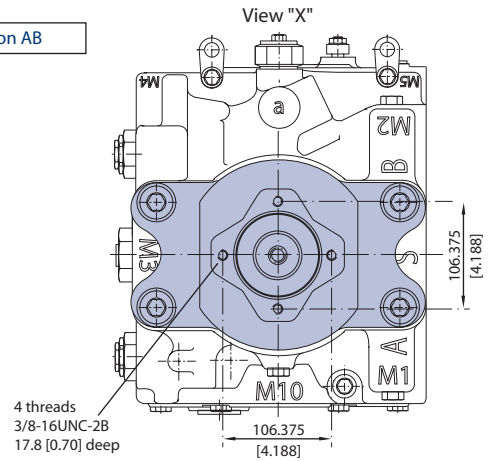
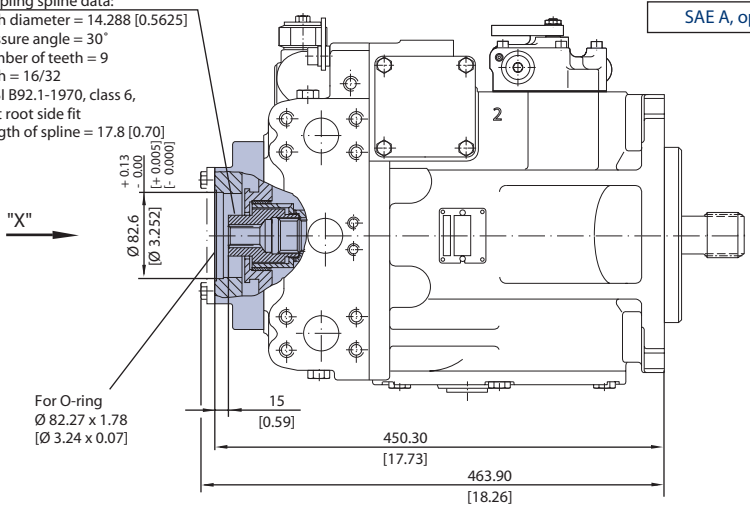


mm [in]

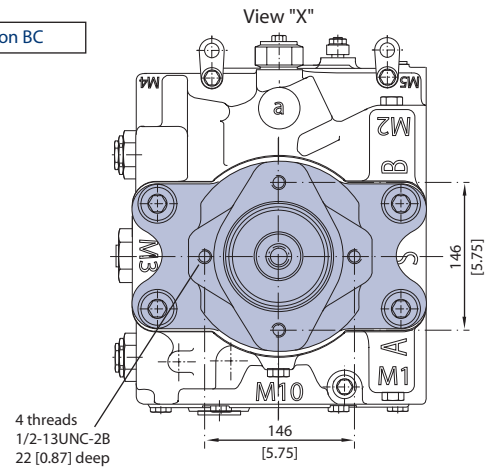
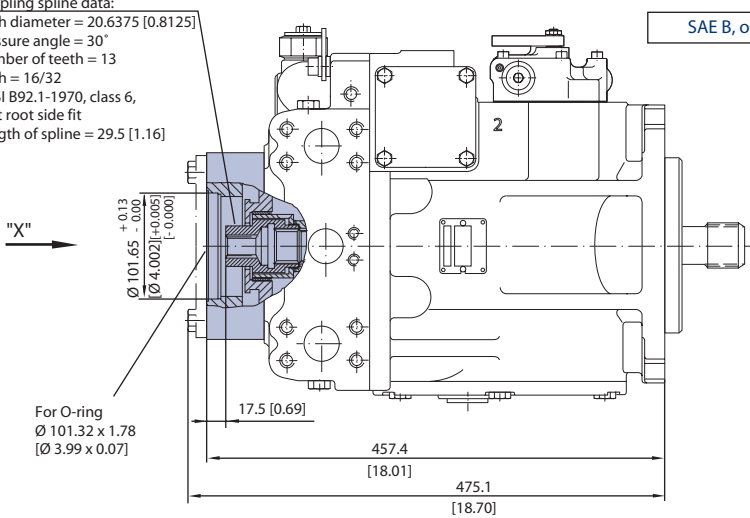
**FRAME SIZE 250
(continued)**

Auxiliary mounting pad - options AB, BC, CD, DE, EF, EG, BB

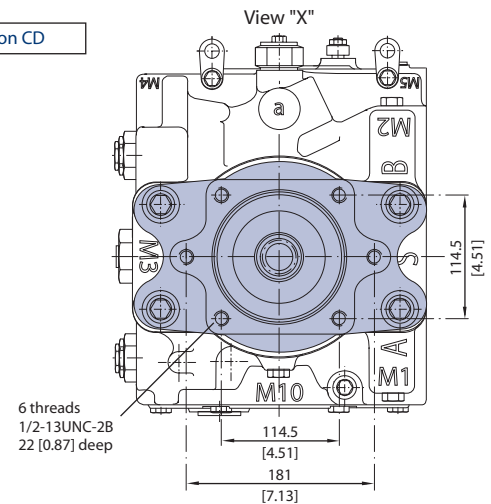
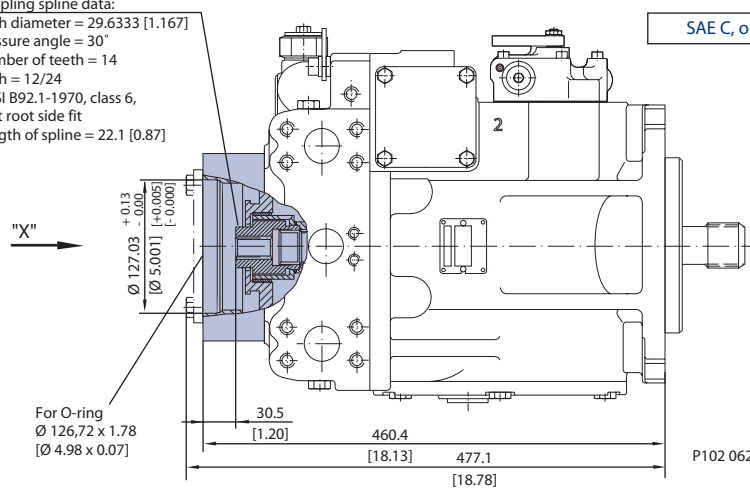
Coupling spline data:
Pitch diameter = 14.288 [0.5625]
Pressure angle = 30°
Number of teeth = 9
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 17.8 [0.70]



Coupling spline data:
Pitch diameter = 20.6375 [0.8125]
Pressure angle = 30°
Number of teeth = 13
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 29.5 [1.16]



Coupling spline data:
Pitch diameter = 29.6333 [1.167]
Pressure angle = 30°
Number of teeth = 14
Pitch = 12/24
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 22.1 [0.87]

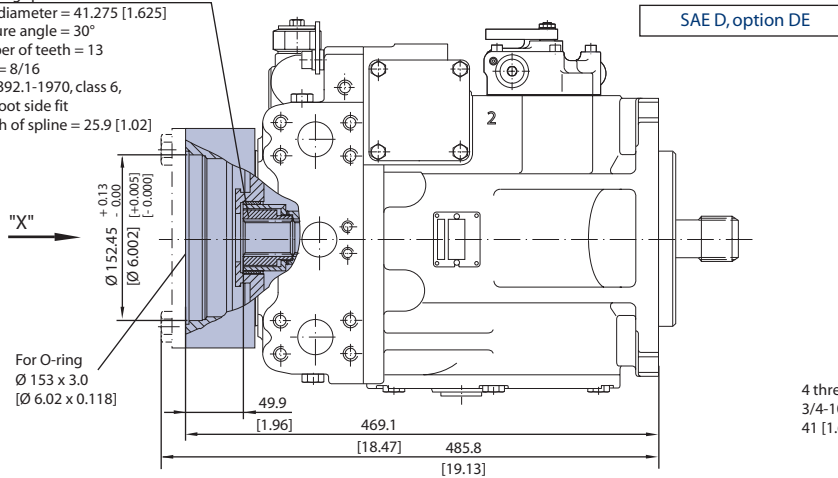


**FRAME SIZE 250
 (continued)**

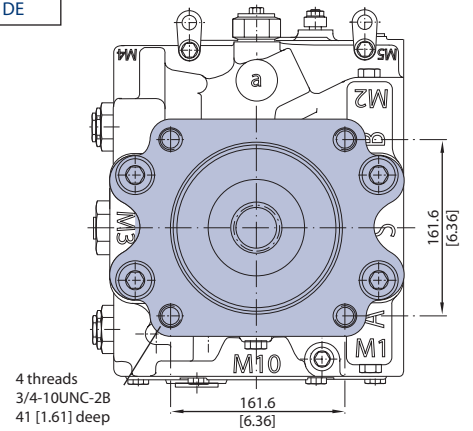
Auxiliary mounting pad – options AB, BC, CD, DE EF, EG, BB

Coupling spline data:

Pitch diameter = 41.275 [1.625]
 Pressure angle = 30°
 Number of teeth = 13
 Pitch = 8/16
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 25.9 [1.02]

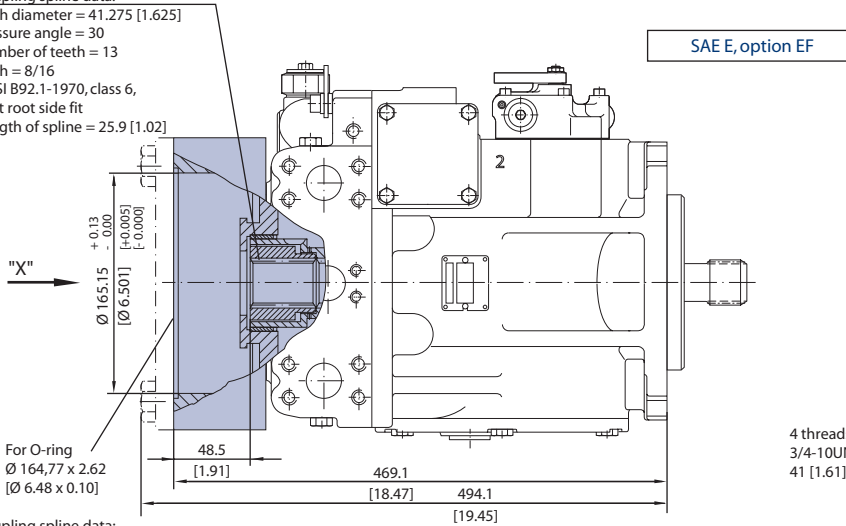


View "X"

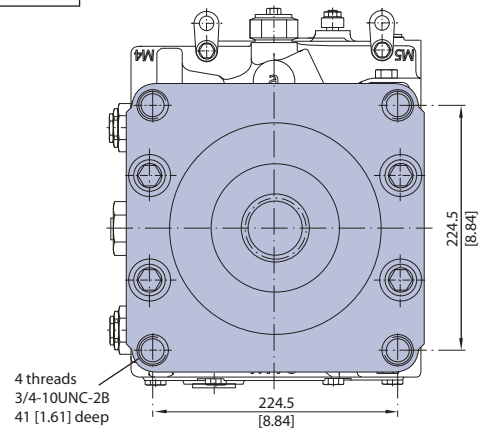


Coupling spline data:

Pitch diameter = 41.275 [1.625]
 Pressure angle = 30°
 Number of teeth = 13
 Pitch = 8/16
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 25.9 [1.02]

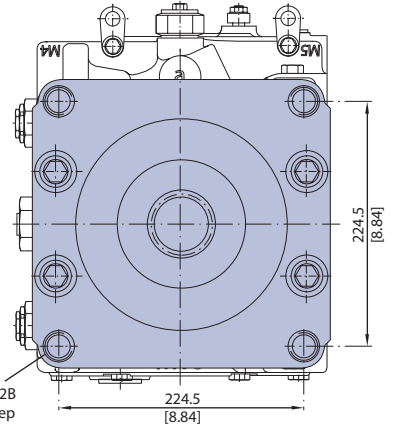
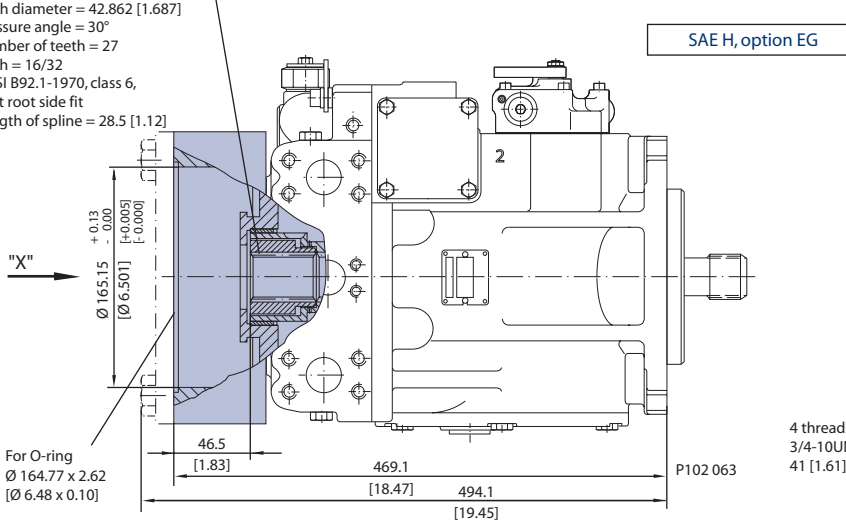


View "X"



Coupling spline data:

Pitch diameter = 42.862 [1.687]
 Pressure angle = 30°
 Number of teeth = 27
 Pitch = 16/32
 ANSI B92.1-1970, class 6,
 fillet root side fit
 Length of spline = 28.5 [1.12]



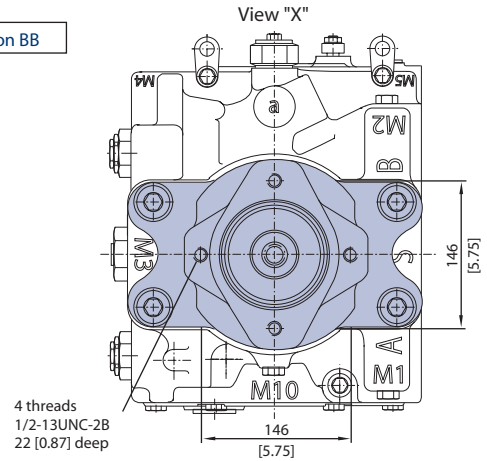
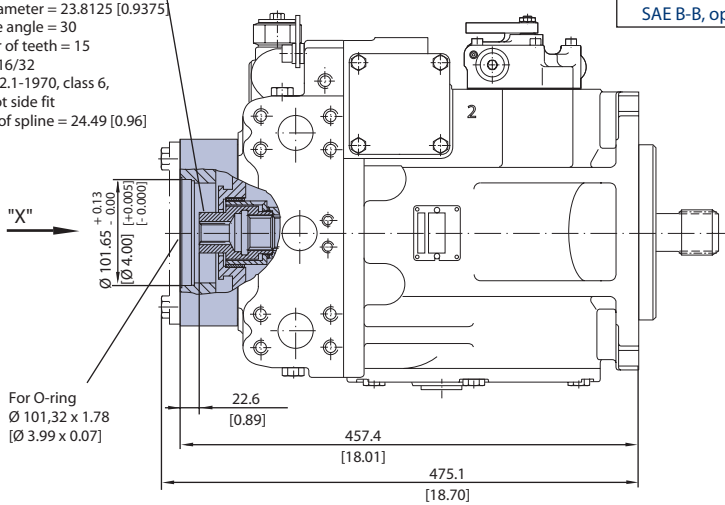
mm [in]

FRAME SIZE 250
(continued)

Auxiliary mounting pad – options AB, BC, CD, DE, EF, EG, BB

Coupling spline data:
Pitch diameter = 23.8125 [0.9375]
Pressure angle = 30
Number of teeth = 15
Pitch = 16/32
ANSI B92.1-1970, class 6,
fillet root side fit
Length of spline = 24.49 [0.96]

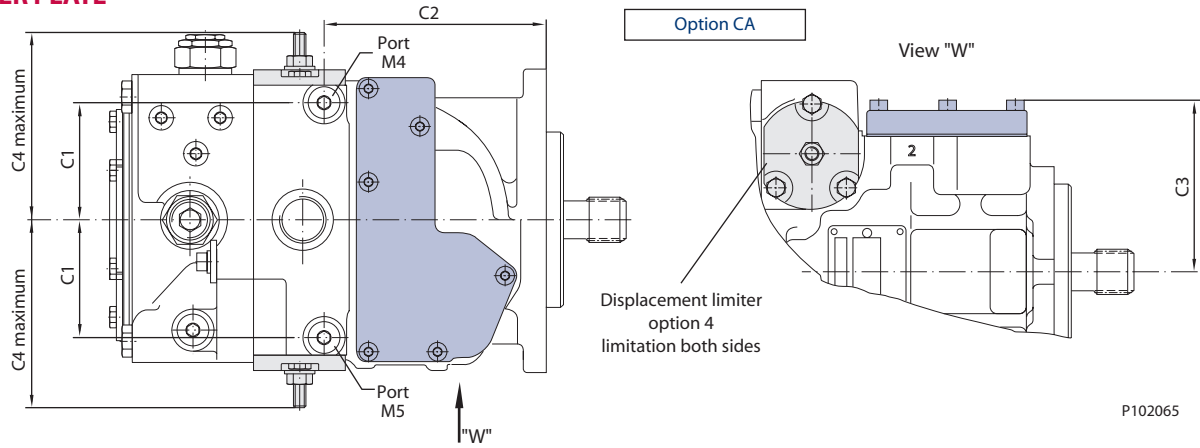
SAE B-B, option BB



P102 064

mm [in]

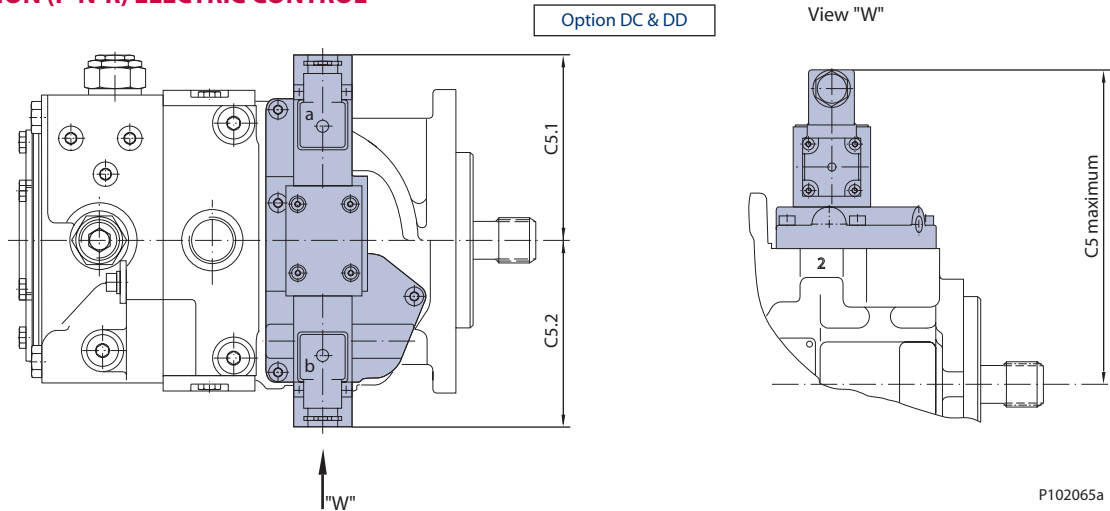
COVER PLATE



Dimensions

Frame size	C1	C2	C3	C4 maximum (option 4)
042	67.9 [2.67]	129.5 [5.10]	99.5 [3.92]	108 [4.25]
055	69.2 [2.72]	179.4 [7.06]	103.6 [4.08]	114 [4.48]
075	74.2 [2.92]	185.7 [7.31]	109.4 [4.31]	118 [4.65]
100	83.3 [3.28]	183.3 [7.22]	118.3 [4.66]	136 [5.35]
130	86.6 [3.41]	209.3 [8.24]	137.2 [5.40]	141 [5.55]
180	-	-	-	184 [7.24]
250	-	-	-	184 [7.24]

3-POSITION (F-N-R) ELECTRIC CONTROL

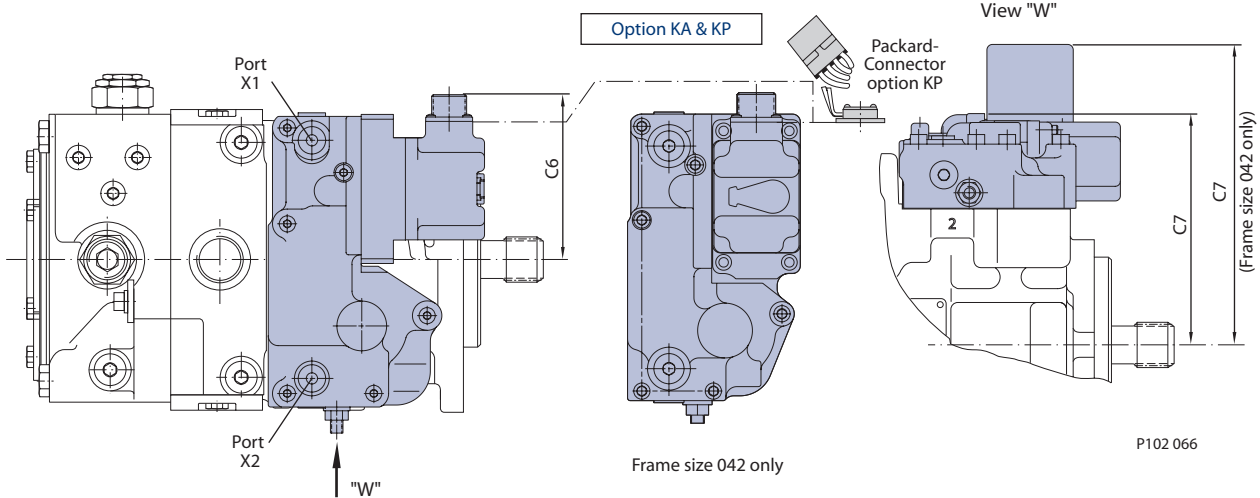


Dimensions

Frame size	C5 maximum	C5.1	C5.2
042	196.5 [7.74]	108.8 [4.28]	106.2 [4.18]
055	200.6 [7.90]	108.8 [4.28]	106.2 [4.18]
075	207.9 [8.19]	108.8 [4.28]	106.2 [4.18]
100	216.8 [8.54]	117.4 [4.62]	97.6 [3.84]
130	235.7 [9.28]	102.4 [4.03]	112.6 [4.43]
180	252.4 [9.94]	94.6 [7.32]	120.4 [4.74]
250 [option DD only]	210.4 [8.28]	94.6 [7.32]	120.4 [4.74]

mm [in]

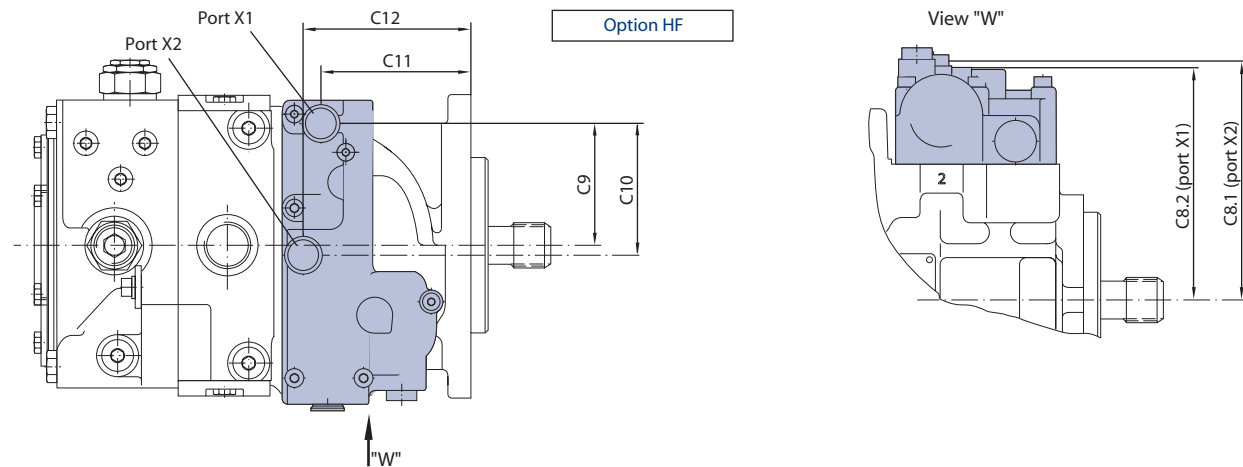
ELECTRIC DISPLACEMENT CONTROL (EDC) WITH MS-CONNECTOR OR PACKARD® CONNECTOR



Dimensions

Frame size	C6	C7
042	95.3 [3.75]	168.6 [6.64]
055	95.3 [3.75]	141.2 [5.56]
075	105.2 [4.14]	144.8 [5.70]
100	114.0 [4.49]	153.7 [6.05]
130	99.1 [3.90]	172.7 [6.80]
180	93.4 [3.68]	190.0 [7.48]
250	93.4 [3.68]	226.2 [8.91]

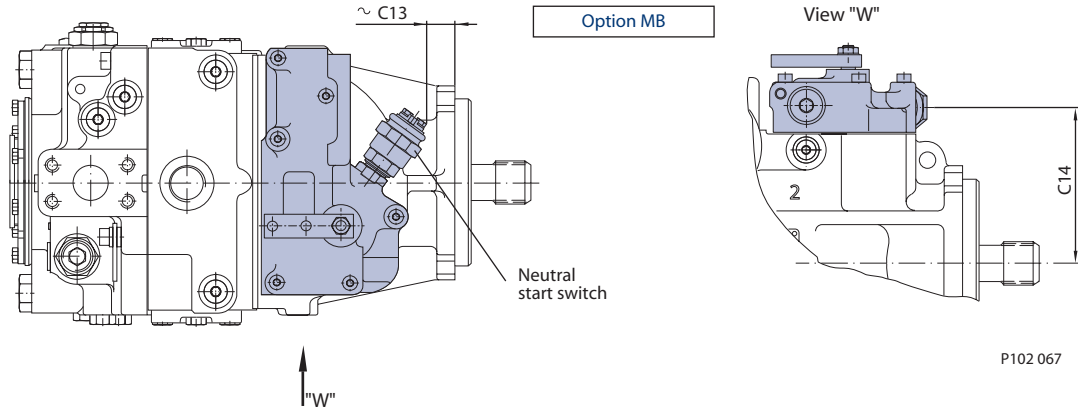
HYDRAULIC DISPLACEMENT CONTROL (HDC)



Dimensions

Frame size	C8.1	C8.2	C9	C10	C11	C12
042	143.5 [5.65]	135.0 [5.31]	71.0 [2.79]	75.7 [2.98]	89.6 [3.52]	99.2 [3.90]
055	150.8 [5.94]	139.0 [5.47]	71.0 [2.79]	75.7 [2.98]	105.6 [4.15]	115.2 [4.53]
075	148.9 [5.86]	139.0 [5.47]	68.2 [2.68]	67.0 [2.63]	121.8 [4.79]	125.3 [4.93]
100	158.0 [6.22]	149.0 [5.86]	76.8 [3.02]	67.0 [2.63]	127.9 [5.03]	131.4 [5.17]
130	176.7 [6.95]	167.7 [6.60]	61.8 [2.43]	67.0 [2.63]	142.1 [5.59]	145.6 [5.73]
180/250	194.0 [7.63]	185.0 [7.28]	54.0 [2.12]	67.0 [2.63]	148.6 [5.85]	152.1 [5.99]

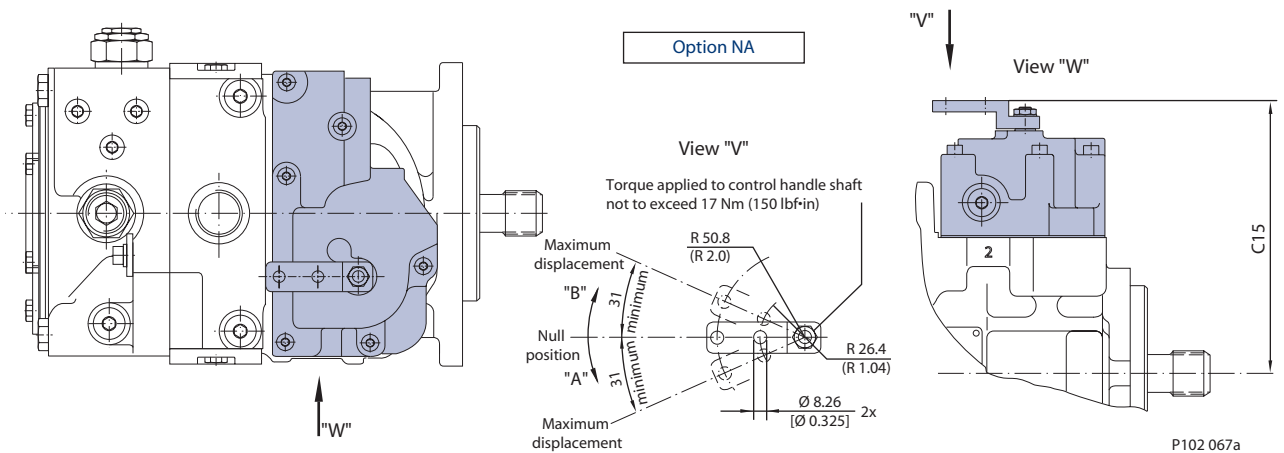
MANUAL DISPLACEMENT CONTROL (MDC) WITH NEUTRAL START SWITCH



Dimensions

Frame size	C13	C14
042	0.35 [0.014]	96.0 [3.78]
055	18.0 [071]	100.0 [3.94]
075	25.0 [0.98]	106.9 [4.21]
100	31.3 [1.23]	115.8 [4.56]
130	46.0 [1.81]	134.5 [5.29]
180	52.0 [2.04]	151.8 [5.97]
250	52.0 [2.04]	151.8 [5.97]

NON-LINEAR MANUAL DISPLACEMENT CONTROL (MDC)

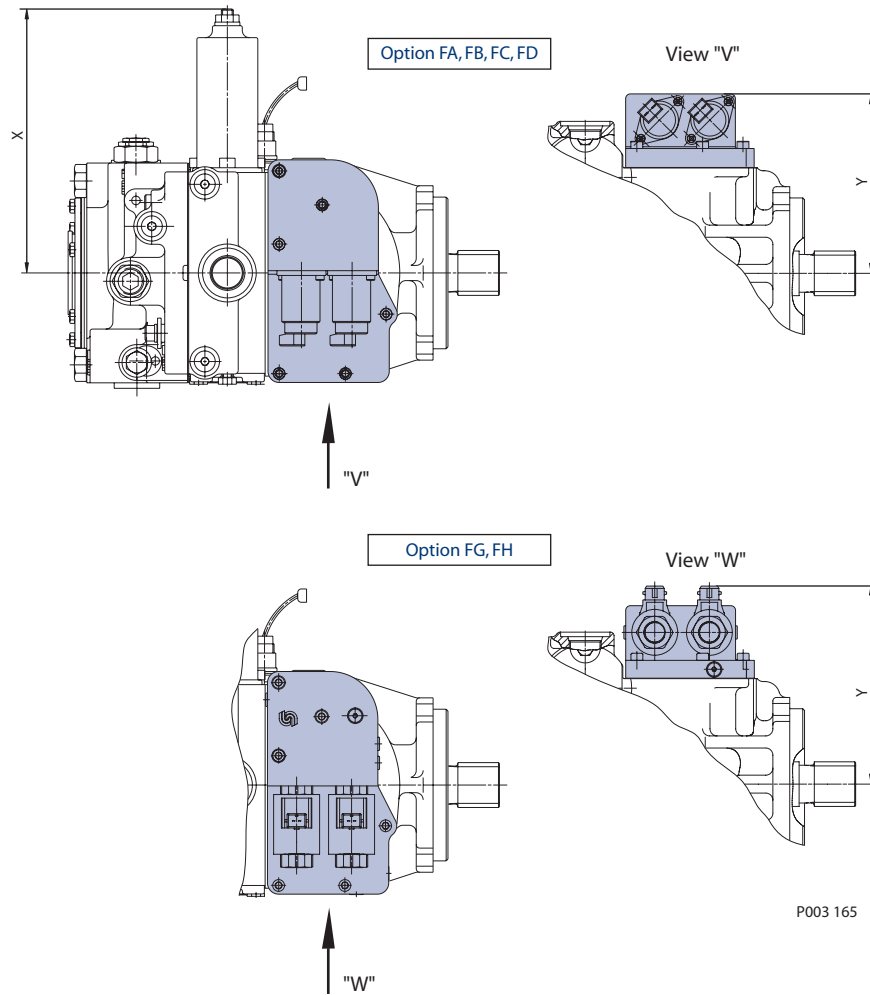


Dimensions

Frame size	C15
075	178.9 [7.04]
100	187.8 [7.39]
130	209.4 [8.24]

**ELECTROHYDRAULIC
 DISPLACEMENT
 CONTROL (NFPE)
 (EXCEPT 075 NFPE)**

mm [in]



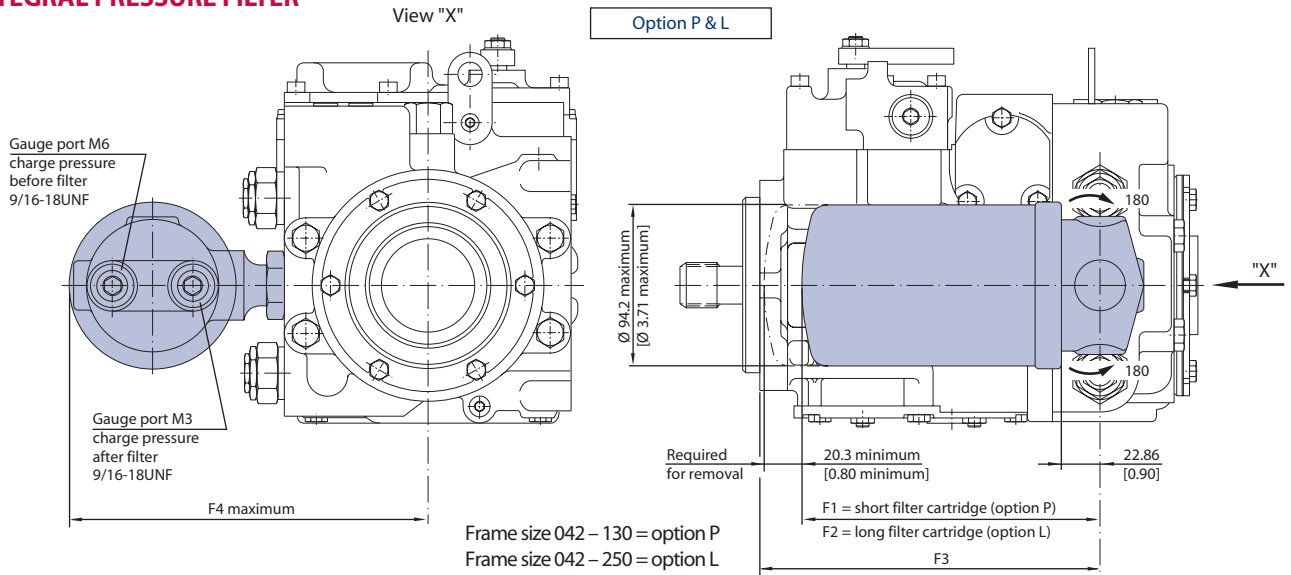
P003 165

Dimensions

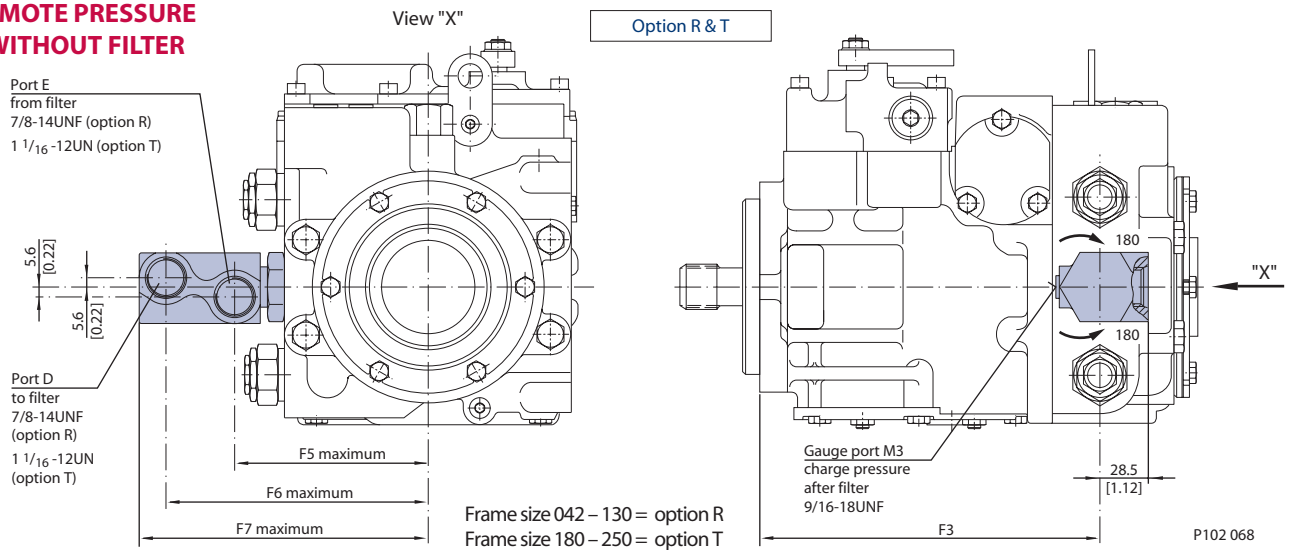
Frame Size	Option	"X"	"Y"
042	FA, FB, FC, FD	169.30 [6.67]	140.00 [5.51]
055	FA, FB, FC, FD	207.00 [8.15]	145.00 [5.71]
075	Special version see page 63		
100	FA, FB, FC, FD	235.00 [9.25]	161.10 [6.34]
100	FG, FH		176.60 [6.95]
130	FG, FH	244.10 [9.61]	195.50 [7.70]
180	FG, FH	290.00 [11.42]	213.00 [8.39]
250	—	—	—

mm [in]

INTEGRAL PRESSURE FILTER



**REMOTE PRESSURE
 – WITHOUT FILTER**



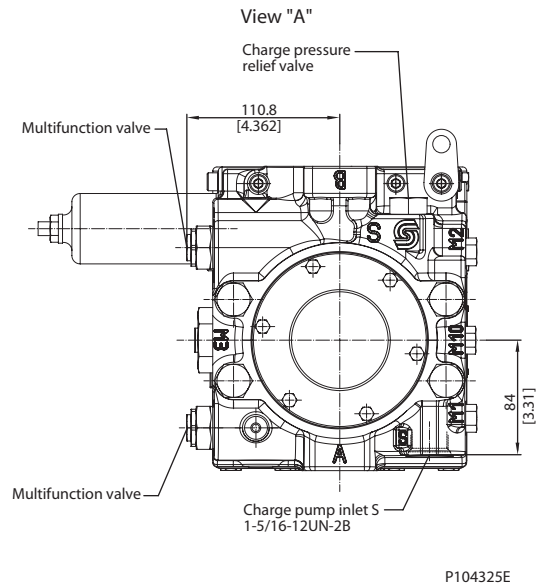
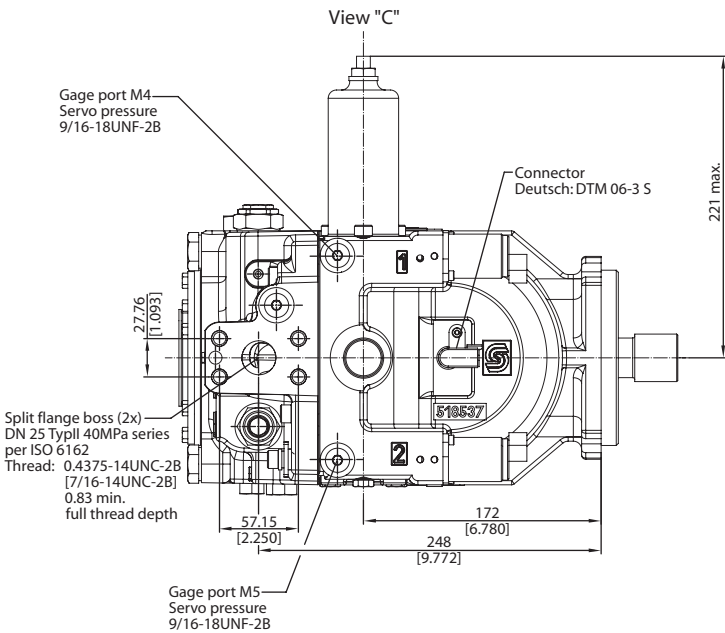
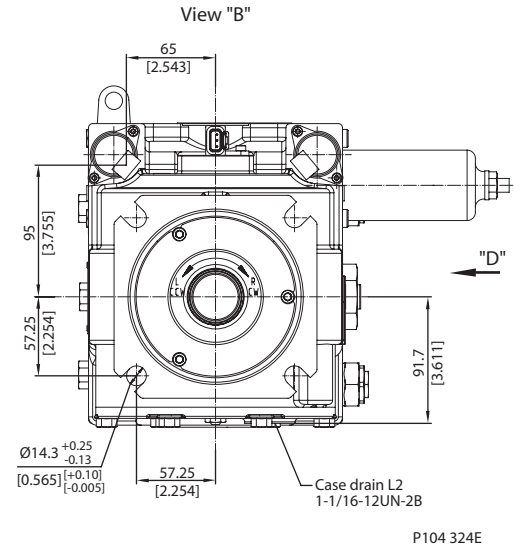
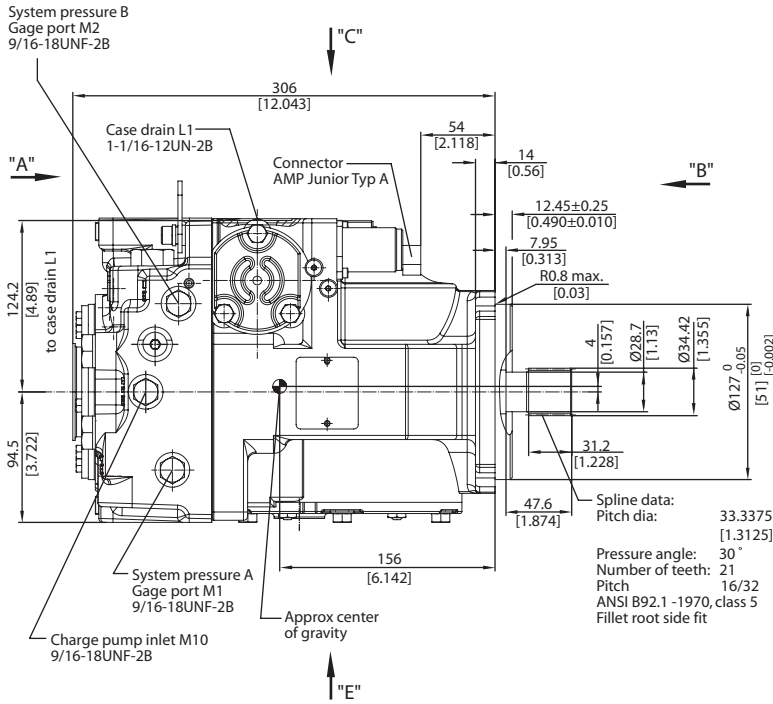
Dimensions

Frame size	F1	F2	F3	F4 maximum	F5 maximum	F6 maximum	F7 maximum
042	174.5 [6.87]	262.6 [10.34]	201.4 [7.93]	207.7 [8.12]	112.7 [4.44]	152.7 [6.01]	168.0 [6.61]
055	174.5 [6.87]	262.6 [10.34]	240.9 [8.19]	209.6 [8.25]	114.3 [4.50]	154.3 [6.07]	169.6 [6.68]
075	174.5 [6.87]	262.6 [10.34]	253.2 [9.67]	214.4 [8.44]	119.1 [4.69]	159.1 [6.26]	174.4 [6.86]
075 NFPE	174.5 [6.87]	262.4 [10.34]	253.7 [9.99]	214 [8.441]	119 [4.691]	159 [6.264]	174 [6.866]
100	174.5 [6.87]	262.6 [10.34]	280.7 [11.05]	223.0 [8.78]	127.7 [5.03]	167.7 [6.60]	183.0 [7.20]
130	174.5 [6.87]	262.6 [10.34]	299.9 [11.81]	223.0 [9.17]	137.7 [5.03]	177.7 [6.99]	193.0 [7.60]
180	-	-	327.8 [12.90]	-	182.0 [7.16]	236.8 [9.32]	259.2 [10.2]
250	-	-	342.8 [13.49]	-	182.0 [7.16]	236.8 [9.32]	259.2 [10.2]

mm [in]

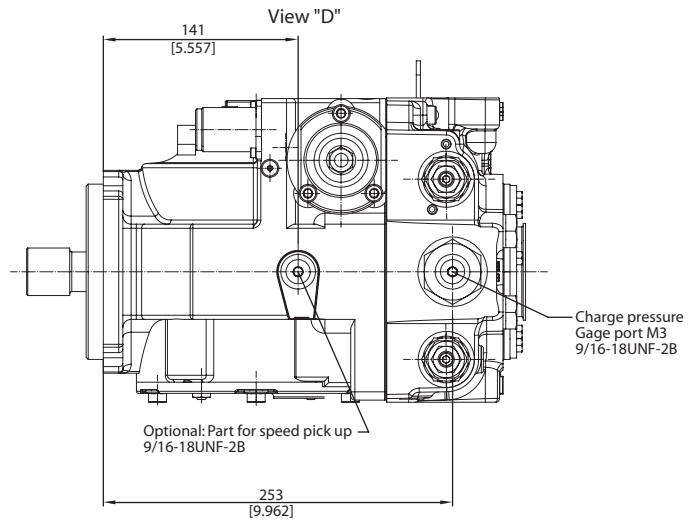
FRAME SIZE 075 NFPE

Integrated NFPE control, endcap side ports

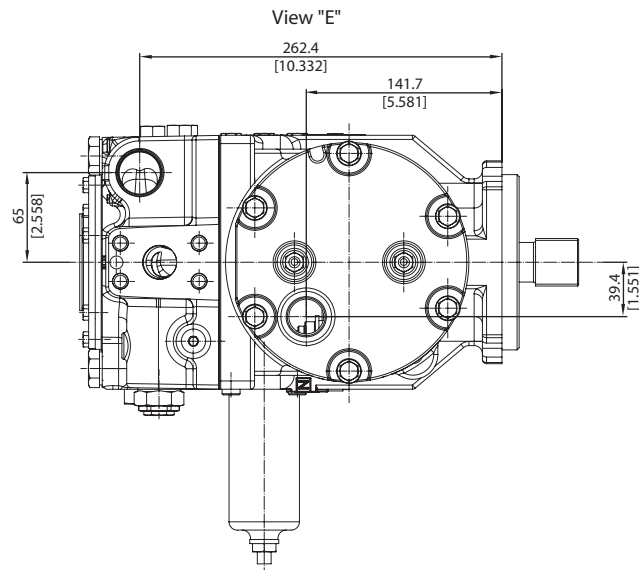


**FRAME SIZE 075 NFPE
(continued)**

Integrated NFPE control, endcap side ports (continued)



P104 326E

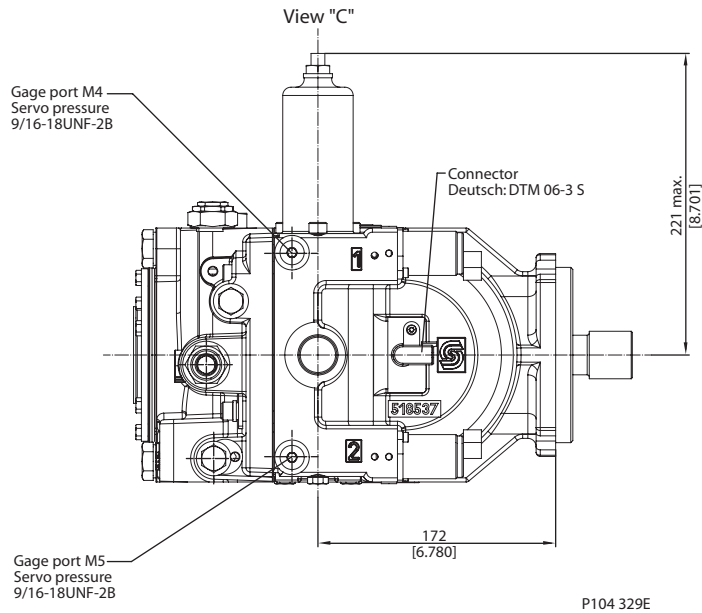
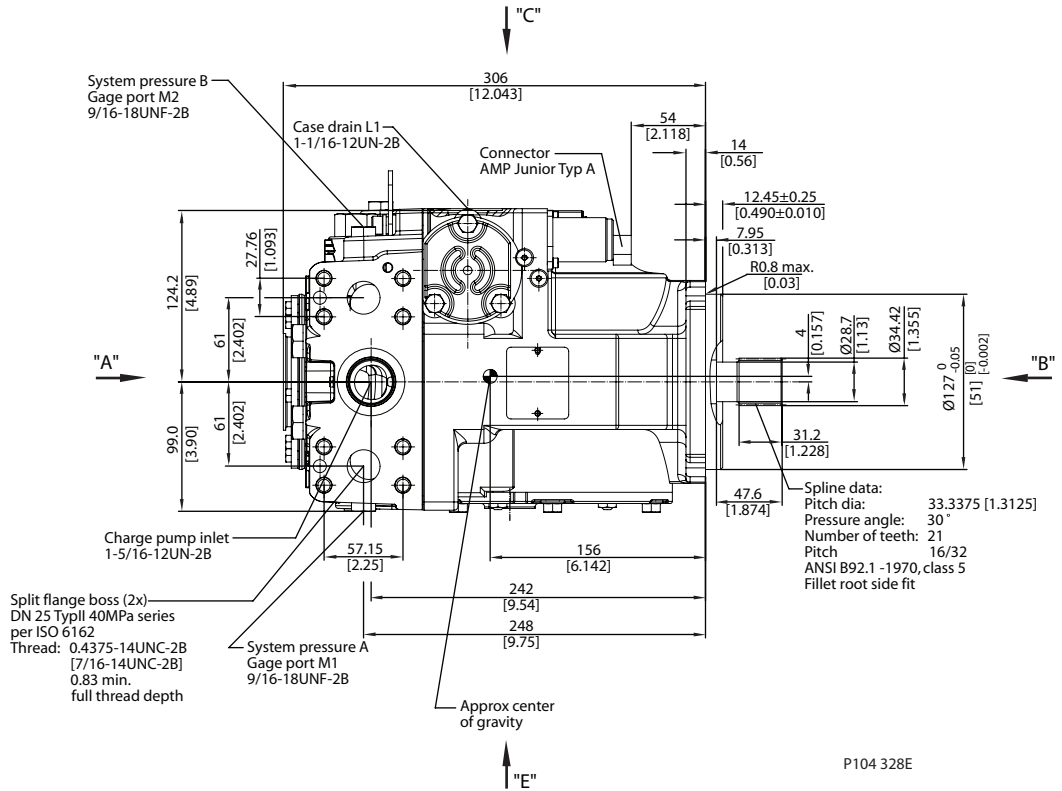


P104 327E

mm [in]

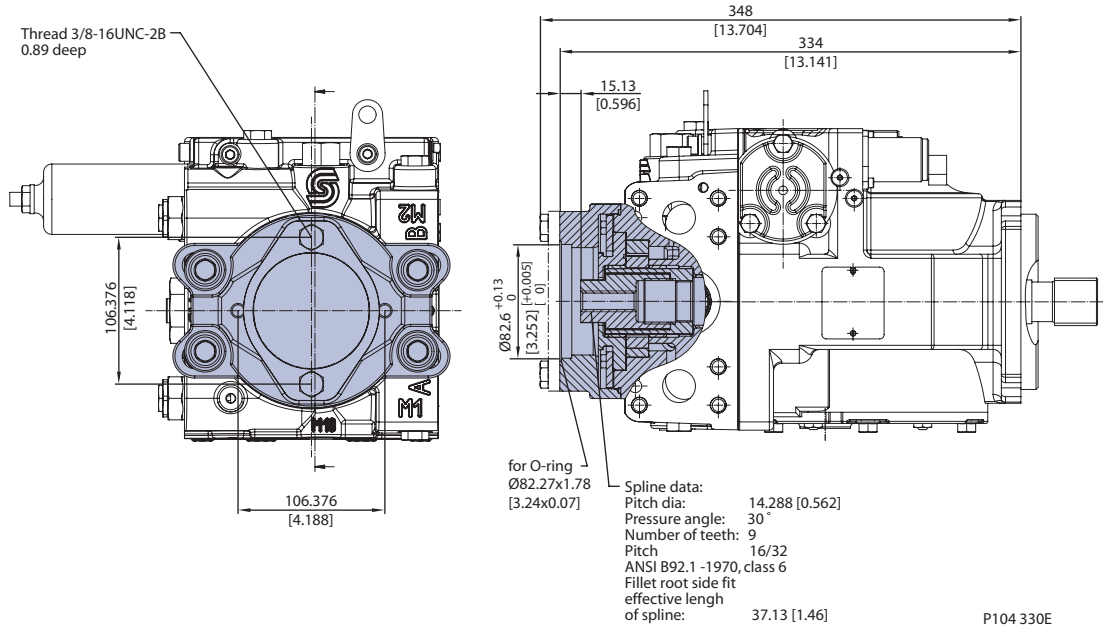
**FRAME SIZE 075 NFPE
(continued)**

Integrated NFPE control, endcap twin ports



**FRAME SIZE 075 NFPE
 (continued)**

Auxiliary mounting pad SAE-A





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Cartridge valves
Hydraulic integrated circuits
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