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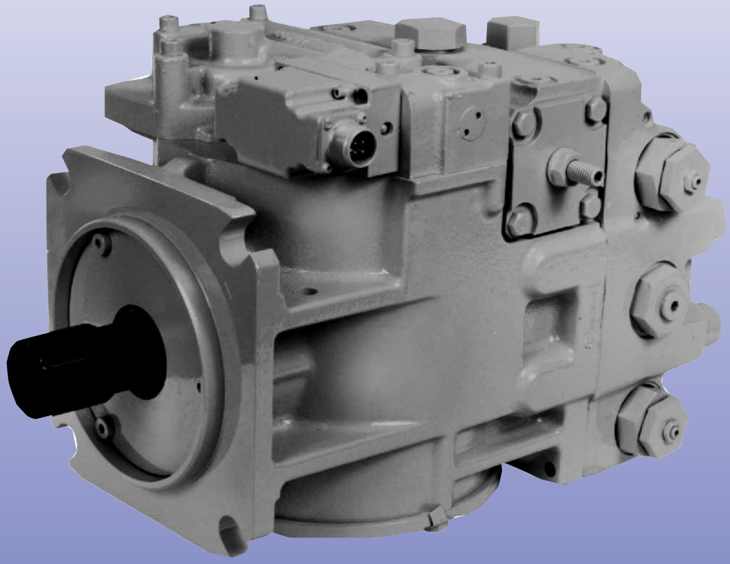
SAUER SUNDSTRAND

Series 90



Axial Piston

Pumps

Technical Information

General Description

Series 90 axial piston variable displacement pumps are of cradle swashplate design with variable displacement, and are intended for closed circuit applications.

The flow rate is proportional to the pump input speed and displacement.

The latter is infinitely adjustable between zero and maximum displacement.

Flow direction is reversed by tilting the swash-plate to the opposite side of the neutral (zero displacement) position.

- **The Series 90 - Advanced Technology Today**
- **8 Sizes of Variable Displacement Pumps**
- **Complete Family of Control Systems**
- **Proven Reliability and Performance**
- **Optimum Product Configurations**
- **Compact and Lightweight**

Front page: Option - electric displacement control (EDC)

F000 539

Technical Features

A Complete Family to Meet Market Needs

- Eight (8) Different Sizes - 30 cm^3 (1.83 in^3) to 250 cm^3 (15.25 in^3)
- Wide Range of Installation Options
- Control System Flexibility - Manual, Hydraulic, and Electrical Controls
- High Power Auxiliary Pads for Multiple Pump Configurations
- Closed Circuit Installations

The Latest Technology

- Unique Product Features
- High Power Density
- Designed to Lower Installation Costs
- Design Provides for Reduced Operating Costs

High Performance

- Speeds to 5 000 min^{-1} (rpm)
- Pressure to 480 bar (6 960 psi)
- High Overall Efficiency
- Low Noise Levels

Reliability

- Designed to Rigorous Standards, and Proven in Laboratory and Field
- Manufactured to Rigid Quality Standards
- Long Service Life
- Input Shaft Bearings provide for Large External Shaft Loads

World Product

- Designed for Worldwide Markets
- Identical Product Manufactured Worldwide
- Mobile, Industrial, and Stationary Markets

Worldwide Support

- Sales and Technical Support in All Industrialized Countries of the World
- Serviced by a Worldwide Network of Authorized Service Centers

Contents

Description

General Technical Specifications

Options

External Load Limits

Efficiency Graphs

Contents

Description

Controls - Circuit Diagram, Nomenclature and Description

Dimensions

System Circuit Description

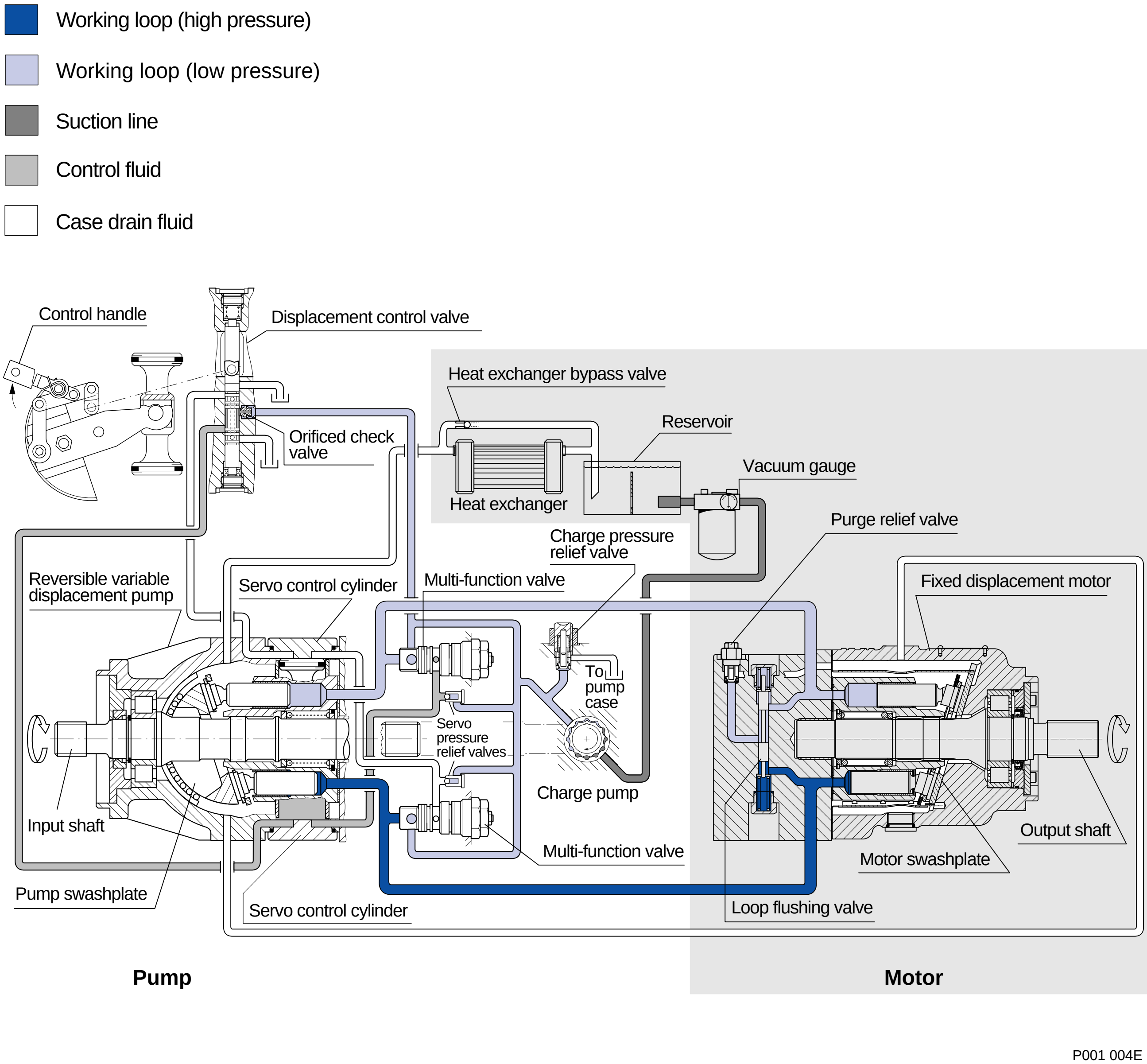
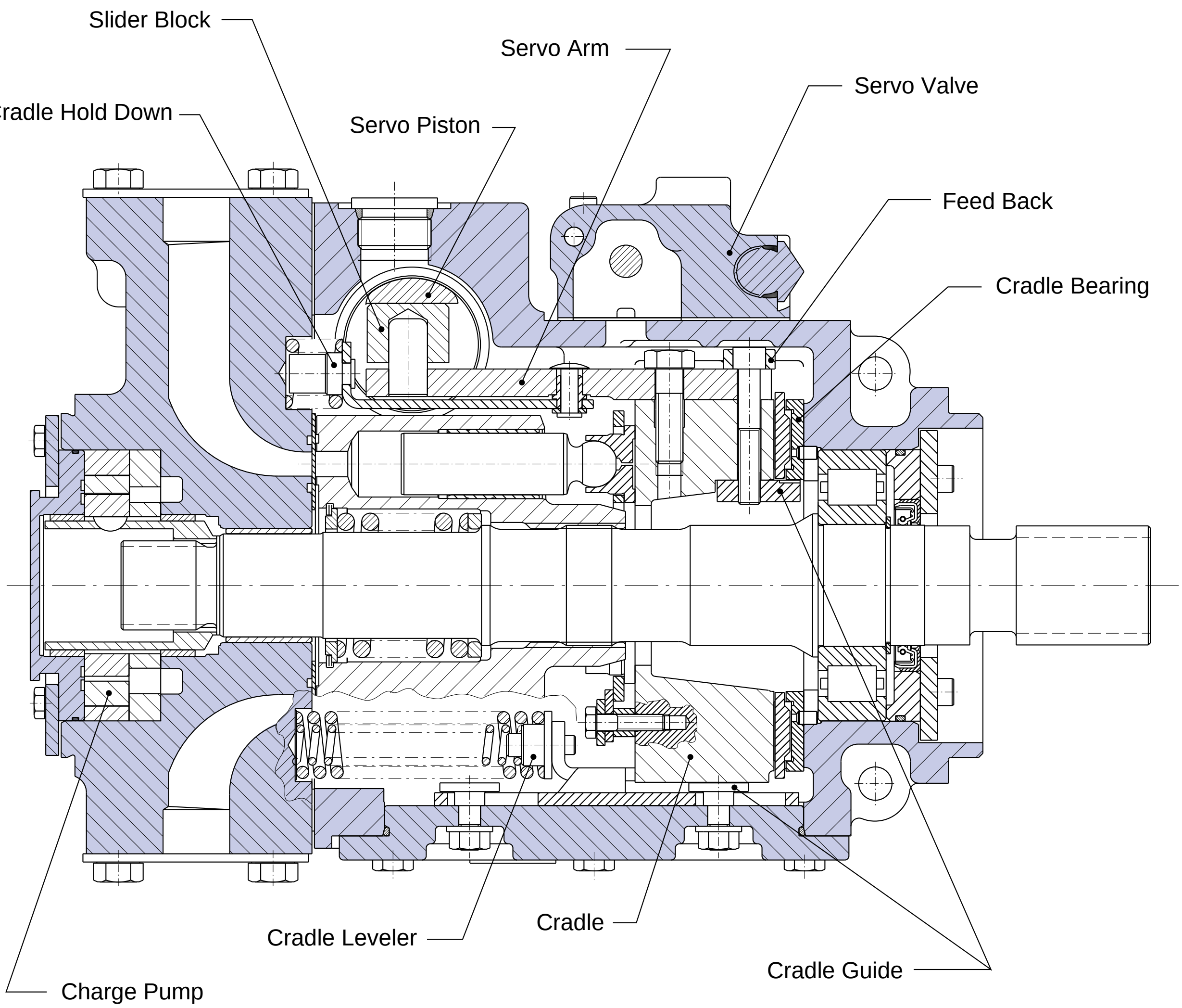


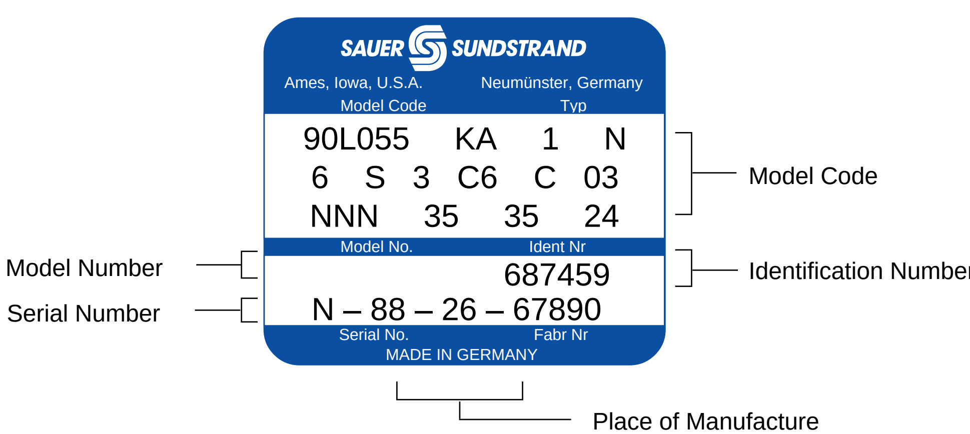
Figure 1 shows a hydrostatic transmission using a series 90 axial piston variable displacement pump and a series 90 fixed displacement motor.

Sectional View

Figure 2: Variable displacement pump



Name Plate



Type Designation and Order Code

	R		M	P	J	G	N
9 0							

Series or Product

90 = Series 90, Closed Circuit

R — Design and Rotation

L	= Pump, Left Hand (CCW)
R	= Pump, Right Hand (CW)

Frame Size

Displacement per revolution cm^3 (in^3)

030	= 30	(1.83)	**100**	= 100	(6.10)
042	= 42	(2.56)	**130**	= 130	(7.93)
055	= 55	(3.35)	**180**	= 180	(10.99)
075	= 75	(4.57)	**250**	= 250	(15.25)

M — Controls

Controls	Frame Size	030	042	055	075	100	130	180	250
CA	= Cover plate (without feedback link)	●	●	●	●	●	●	-	-
DC	= Electric 3-Position (FNR) Solenoid (12 VDC)	❍	❍	❍	❍	❍	❍	-	-
DD	= Electric 3-Position (FNR) Solenoid (24 VDC)	❍	❍	❍	❍	❍	-	-	-
KA	= Electric Displacement (EDC) MS-Connector	❍	❍	❍	❍	❍	❍	❍	❍
KP	= Electric Displacement (EDC) Packard-Connector	❍	❍	❍	❍	❍	❍	❍	❍
HF	= Hydraulic Displacement (HDC) 3—11 bar (44—160 psi)	❍	❍	❍	❍	❍	❍	❍	❍
MA	= Manual Displacement (MDC)	●	●	●	●	●	●	●	●
MB	= Manual Displacement with Neutral Start Switch (NSS)	-	❍	❍	❍	❍	❍	❍	❍
NA	= Non-Linear Manual Displacement	❍	❍	❍	❍	❍	❍	❍	❍

P — Pressure Regulation

Pressure Regulation	Frame Size	030	042	055	075	100	130	180	250
1	= Pressure limiter (PL) in Port " A " and " B "	●	●	●	●	●	●	●	●

J — Auxiliary Mounting Pad

Auxiliary Mounting Pad		Frame Size	030	042	055	075	100	130	180	250
A	= SAE A with sealed cover	(9 teeth, 16/32 pitch)	❍	❍	❍	❍	❍	❍	❍	❍
B	= SAE B with sealed cover	(13 teeth,16/32 pitch)	❍	❍	❍	❍	❍	❍	❍	❍
C	= SAE C with sealed cover	(14 teeth,12/24 pitch)	-	-	❍	❍	❍	❍	❍	❍
D	= SAE D with sealed cover	(13 teeth, 8/16 pitch)	-	-	-	-	-	❍	❍	❍
E	= SAE E with sealed cover	(13 teeth, 8/16 pitch)	-	-	-	-	-	-	❍	❍
H	= SAE H with sealed cover	(27 teeth,16/32 pitch)	-	-	-	-	-	-	❍	❍
V	= SAE B-B with sealed cover	(15 teeth,16/32 pitch)	❍	❍	❍	❍	❍	❍	❍	❍
N	= No Auxiliary Mounting Pad		●	●	●	●	●	●	●	●

G — Endcap Ports (SAE J518c Code 62)

Endcap Ports (SAE J518c Code 62)	Frame Size	030	042	055	075	100	130	180	250
3	= Twin ports with shuttle valve in high press. circuit for pressure override valve	-	-	-	-	-	-	●	-
6	= Side ports	-	-	●	●	●	-	-	-
8	= Twin ports, radial	●	●	●	●	●	●	❍	●

N — Filtration

Filtration	Frame Size	030	042	055	075	100	130	180	250
S	= Suction filtration	●	●	●	●	●	●	●	●
R	= Remote pressure - without filter	❍	❍	❍	❍	❍	❍	-	-
T	= Remote pressure - without filter	-	-	-	-	-	-	❍	❍
P	= Integral pressure filter - with spin-on filter (short)	❍	❍	❍	❍	❍	❍	-	-
L	= Integral pressure filter - with spin-on filter (long)	-	❍	❍	❍	❍	❍	❍	❍

Type Designation and Order Code (Continued)

F L H T W Y Z K X

X — Data Sheet Code

On Request

K — Charge Pressure Setting

18 = 18 bar (260 psi) ❍	**24** = 24 bar (350 psi) ●	**30** = 30 bar (435 psi) ❍
20 = 20 bar (290 psi) ❍	**28** = 28 bar (410 psi) ❍	

Z — High Pressure Setting, Port "B"

00 = no pressure regulating valves ❍	**20** = 200 bar (2 900 psi) ❍	**32** = 320 bar (4 640 psi) ❍
	23 = 230 bar (3 330 psi) ❍	**35** = 350 bar (5 070 psi) ❍
14 = 140 bar (2 030 psi) ❍	**26** = 260 bar (3 770 psi) ❍	**38** = 380 bar (5 510 psi) ❍
17 = 170 bar (2 460 psi) ❍	**29** = 290 bar (4 200 psi) ❍	**42** = 420 bar (6 090 psi) ●

Y — High Pressure Setting, Port "A" = See **Port "B"**

W — Special Hardware Features

Frame Size	030	042	055	075	100	130	180	250
GBA	●	●	●	●	●	●	-	-
NNN	-	-	-	-	-	-	●	●

T — Control Feed Orifice in Control Inlet

00 = no orifice ❍	**04** = ø 1.02 mm (.040 in.Dia) ❍
01 = ø 0.46 mm (.018 in.Dia) ❍	**05** = ø 1.37 mm (.054 in.Dia) ❍
02 = ø 0.66 mm (.026 in.Dia) ❍	**06** = ø 1.57 mm (.062 in.Dia) ❍
03 = ø 0.81 mm (.032 in.Dia) ●	**09** = ø 2.34 mm (.092 in.Dia) ❍

H — Charge Pump Displacement

Frame Size	030	042	055	075	100	130	180	250
A = 8 cm³ (0.50 cu.in./Rev.)	❍	-	-	-	-	-	-	-
B = 11 cm³ (0.69 cu.in./Rev.)	●	❍	❍	-	-	-	-	-
C = 14 cm³ (0.86 cu.in./Rev.)	-	●	●	❍	-	-	-	-
D = 17 cm³ (1.03 cu.in./Rev.)	-	-	❍	●	❍	-	-	-
E = 20 cm³ (1.20 cu.in./Rev.)	-	-	-	❍	●	❍	-	-
F = 26 cm³ (1.60 cu.in./Rev.)	-	-	-	-	❍	❍	-	-
H = 34 cm³ (2.07 cu.in./Rev.)	-	-	-	-	-	●	❍	-
J = 47 cm³ (2.82 cu.in./Rev.)	-	-	-	-	-	-	●	❍
K = 65 cm³ (3.90 cu.in./Rev.)	-	-	-	-	-	-	-	●
L = external charge pump with internal relief valve	❍	❍	❍	❍	❍	❍	❍	❍

L — Shaft Configuration

Frame Size	030	042	055	075	100	130	180	250
C2 = 13 Teeth 16/32 pitch	❍	-	-	-	-	-	-	-
C3 = 15 Teeth 16/32 pitch	●	●	-	-	-	-	-	-
C5 = 19 Teeth 16/32 pitch	-	❍	-	-	-	-	-	-
C6 = 21 Teeth 16/32 pitch	-	-	●	-	-	-	-	-
C7 = 23 Teeth 16/32 pitch	-	-	-	●	●	-	-	-
C8 = 27 Teeth 16/32 pitch	-	-	-	-	-	●	●	●
F1 = 13 Teeth 8/16 pitch	-	-	-	-	❍	❍	+❍	+❍
S1 = 14 Teeth 12/24 pitch	-	-	●	●	+●	-	-	-
T1 = 1.375 in. tapered	-	-	❍	-	-	-	-	-
T2 = 1.500 in. tapered	-	-	-	❍	❍	-	-	-
T3 = 1.000 in. tapered	❍	❍	-	-	-	-	-	-
T4 = 1.750 in. tapered	-	-	-	-	-	❍	-	-

F — Displacement Limitation

3 = no limiters	●
4 = variable, limitation both sides (factory set at max. displ.)	❍

● = Standard
❍ = Option
- = not available

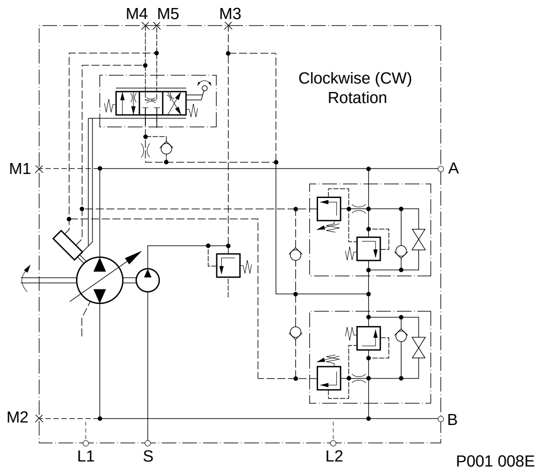
\+ = not recommended for front pump in tandem configurations

Technical Specifications - Variable Displacement Pump

Circuit Diagram and Nomenclature

Variable displacement pump

Figure 3: Variable displacement pump with charge pump and manual displacement control MA, clockwise rotation



Ports:

A, B	=	Main pressure lines
S	=	Suction line - charge pump
L1, L2	=	Case drain lines
M1, M2	=	Gauge port for port "A" and "B"
M3	=	Gauge port - charge pressure
M4, M5	=	Gauge port - servo pressure

Design

Axial piston pump of cradle swashplate design with variable displacement.

Type of Mounting

SAE flange, Size B, C, D, E (SAE J 744) mounting pad

Pipe Connections

Main pressure ports:	SAE-Flange Twin ports, radial (all Frame Sizes)
	SAE-Flange Side ports, radial (055 / 075 / 100)
Remaining ports:	SAE straight thread O-ring boss

Direction of Rotation

Clockwise or counterclockwise (unidirectional).

Installation Position

Installation position discretionary.
The housing must always be filled with hydraulic fluid.

Flow Direction

See tables 12, 15, 17, 19, 20 on pages 25, 27, 28, 30, and 31.

Hydraulic Parameters

System Pressure Range, Input p_1 (see page 12)

Variable displacement pump:
Charge pressure = see order code on page 9
Charge pump input pressure:

Min. rated pressure	=	0.7 bar (20.6 in Hg) absolute
Min. allowable pressure, intermittent	=	0.2 bar (5.9 in Hg) absolute

System Pressure Range, Output p_2 (see page 12)

Rated pressure :	420 bar	(6 000 psi)
Max. Pressure :	480 bar	(7 000 psi)

Case Pressure (see page 12)

Max. Rated:	3 bar	(40 psi)	
Intermittent pressure:	5 bar	(75 psi)	Cold start

Hydraulic Fluid (see page 12)

Refer to SAUER-SUNDSTRAND publication, BLN-9887 or 697581. Refer to ATI-9101E for information relating to biodegradable fluids.

Temperature Range[1)] (see page 12)

ϑ min	=	- 40 °C	(- 40 °F)	intermittent, cold start
ϑ nenn	=	104 °C	(220 °F)	
ϑ max	=	115 °C	(240 °F)	intermittent

at the hottest point, e.g. drain line
[1)] Hydraulic fluid viscosity has to be considered

Fluid Viscosity Limits

mm²/s (1 mm²/s = 1 cSt)			SUS (Saybolt Universal Second)	
ν min	=	7	47	intermittent
ν nenn	=	12 - 60	66 - 278	rated viscosity
ν max	=	1 600	7 500	intermittent, cold start

Filtration

Required cleanliness level: ISO 4406 Code 18/13 or better.
Refer to SAUER-SUNDSTRAND publication
BLN-9887 or 697581 and ATI-9201E.

Technical Data

Table 1

			Frame Size							
		Dimension	**030**	**042**	**055**	**075**	**100**	**130**	**180**	**250**
Displacement		**cm^3**	**30**	**42**	**55**	**75**	**100**	**130**	**180**	**250**
		in^3	1.83	2.56	3.35	4.57	6.10	7.93	10.98	15.25
Input speed	Minimum	min^{-1} (rpm)	500	500	500	500	500	500	500	500
	Rated *	min^{-1} (rpm)	4 200	4 200	3 900	3 600	3 300	3 100	2 600	2 300
	Maximum *	min^{-1} (rpm)	4 600	4 600	4 250	3 950	3 650	3 400	2 850	2 500
	Max. Attainable *	min^{-1} (rpm)	5 000	5 000	4 700	4 300	4 000	3 700	3 150	2 750
Theoretical Torque		**Nm/bar**	**0.48**	**0.67**	**0.88**	**1.19**	**1.59**	**2.07**	**2.87**	**3.97**
		in lb/1000 psi	290	410	530	730	970	1 260	1 750	2 433
Mass moment of inertia of the int. rotating parts		**kg m²**	**0.0023**	**0.0039**	**0.0060**	**0.0096**	**0.0150**	**0.023**	**0.0380**	**0.0650**
		lb • ft²	0.0546	0.0926	0.1424	0.2280	0.3560	0.5460	0.9020	1.5430
Weight (with MA Control)		**kg**	**28**	**34**	**40**	**49**	**68**	**88**	**136**	**154**
		lb	62	75	88	108	150	195	300	340

* General Technical Specifications, see page 12

Determination of Nominal Pump Size

Inch-System:

Pump output flow $Q = \dfrac{PD \cdot PS \cdot EV}{231}$ gpm

Input torque $PT = \dfrac{PD \cdot p}{2 \cdot \pi \cdot ET}$ lbf•in

Input power $p = \dfrac{PD \cdot PS \cdot p}{396\,000 \cdot ET}$ hp

Metric-System:

Pump output flow $Qe = \dfrac{Vg \cdot n \cdot hv}{1\,000}$ l/min

Input torque $Me = \dfrac{Vg \cdot \Delta p}{20 \cdot \pi \cdot hmh}$ Nm

Input power $Pe = \dfrac{Me \cdot n}{9\,550} = \dfrac{Qe \cdot \Delta p}{600 \cdot ht}$ kW

Description:

Inch-System:

- PD = Pump displacement per rev. in^3
- PS = Hydrostatic pump speed rpm
- p = Differential hydraulic pressure psi
- EV = Pump volumetric efficiency
- ET = Pump mechanical - hydraulic (Torque) efficiency

Metric-System:

- Vg = Pump displacement per rev. cm^3
- Δp = pHD - pND bar
- hv = Pump volumetric efficiency
- hmh = Pump mechanical -

General Technical Specifications

Speed Range

The **Rated Speed** is the highest speed recommended at full power condition at which normal life can be expected.

All other operating conditions (e.g. fluid viscosity and temperature, charge pressure) must be within recommended ranges.

Maximum Speed is the highest operating speed permitted and cannot be exceeded without reduction in the life of the product or risking immediate failure and loss of driveline power (which may create a safety hazard).

Braking Warning !

The loss of hydrostatic driveline power in any mode (e.g. acceleration, deceleration, or neutral mode of operation) may cause a loss of braking capacity. A braking system which is independent of the hydrostatic transmission must, therefore, be provided which is adequate to stop and hold the system should the condition develop.

Maximum Attainable Speed requires approval from SAUER-SUNDSTRAND Application Engineering. Special unit hardware and/or special operating conditions may be required.

System Pressure Range

System pressure is a dominant operating variable affecting hydraulic unit life. High pressure, which results from high load, reduces expected life in a manner similar to many mechanical assemblies such as engines and gearboxes.

The **maximum pressure** is the highest intermittent pressure allowed. It is determined by the max. machine load demand.

Maximum pressure is assumed to occur a small percentage of operating time, usually less than 2 % of the total.

Maximum pressure is normally the pressure relief valve setting. It is desirable to have a machine duty cycle with the percentage of time at various loads and speeds. An appropriate design pressure can be calculated by our application department from this information. This method of selecting operating pressure is recommended whenever duty cycle information is available.

Case Pressure

Under normal operating conditions, the maximum continuous case pressure must not exceed 3 bar (40 psi).

Maximum allowable intermittent case pressure during cold start must no exceed 5 bar (75 psi).

Hydraulic Fluids

Ratings and data for Series 90 products are based on operating with premium hydraulic fluids containing oxidation, rust and foam inhibitors.

The following are suitable:
- Premium turbine oils
- API CD engine oils per SAE J183
- M2C33F or G automatic transmission fluids (ATF)
- Dexron II (ATF) meeting Allison C3 or Caterpillar TO-2
- Certain agricultural tractor fluids (STOU)
- Hydraulic fluids per DIN 51524, part 2 (HLP)
- Hydraulic fluids per DIN 51524, part 3 (HVLP)

Fire resistant fluids are also suitable at modified operating conditions. For more information see Sauer-Sundstrand publication BLN-9887 or 697581.
Refer to publication ATI-9101E for information relating to biodegradable fluids.
While fluids containing anti-wear additives are not necessary for the satisfactory performance of the Series 90 units, they are often required for associated equipment. These fluids must possess good thermal and hydrolytic stability to prevent wear, erosion and corrosion of the internal components.
It is not permissible to mix hydraulic fluids. Contact Sauer-Sundstrand Application Engineering for more information.

Temperature Limits

For petroleum based fluids, see page 10 for maximum allowable temperatures.

These temperature limits apply at the hottest point of the transmission, which is normally the case drain.

Heat exchangers should be sized to keep the fluid within the limits.

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). The motor charge relief valve pressure setting is the pressure generated at a charge flow of 15 l/min (4 gpm).

Options

Reservoir

The function of the reservoir is to remove air and to provide make up fluid for volume changes associated with fluid expansion or contraction, possible cylinder flow, and minor leakage.

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

A suggested minimum reservoir volume equal to 1/2 charge pump flow/min. 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. The reservoir outlet to the charge pump inlet should be above the bottom of the reservoir to take advantage of the gravity separation and prevent large foreign particles from entering the charge inlet line.

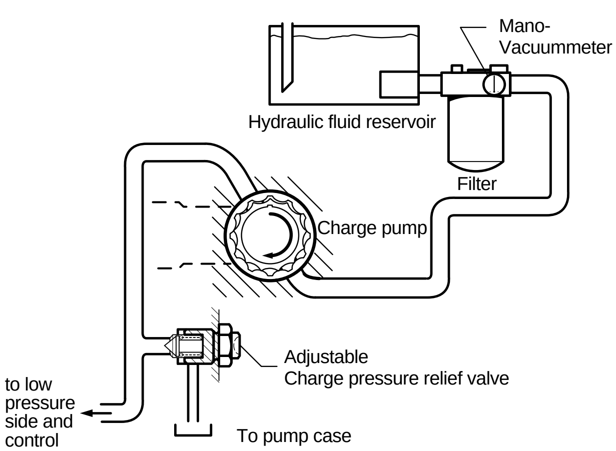
The reservoir inlet (fluid return) should be positioned so that the flow to the reservoir is discharged below the normal fluid level, and also directed into the interior of the reservoir for maximum dwell and efficient deaeration.

Suction Filtration - Option S

The suction filter is placed in the circuit between the reservoir and the inlet to the charge pump, as shown in Figure 4. For closed loop transmissions with controlled reservoir ingression a filter having a Beta 10 ratio of 1.5 to 2 has been shown to provide acceptable performance.

The use of a filter contamination monitor is recommended.

Figure 4: Suction filtration



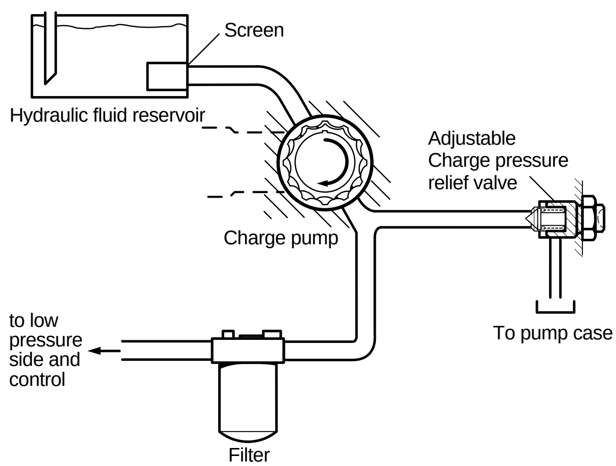
P000 797E

Charge Pressure Filtration - Option R, T, P, L

The pressure filter can be integrally mounted directly on the pump or mounted remotely, Figure 5, for ease of servicing. A 200 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.

Pressure filters with Beta 10 ratio of 10-20 have been shown to provide acceptable performance.

Figure 5: Charge pressure filtration



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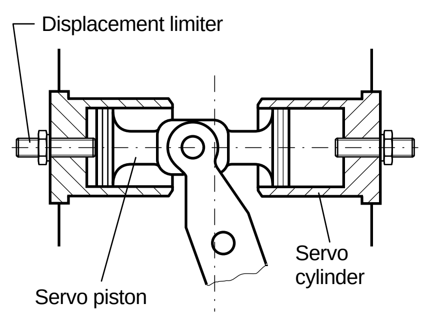
Displacement Limiter - Option 4

All Series 90 pumps are designed with optional mechanical displacement (stroke) limiters (Figure 6).

The maximum displacement of the pump can be set using the hexagon adjustment screw.

Figure 6: Displacement limiter



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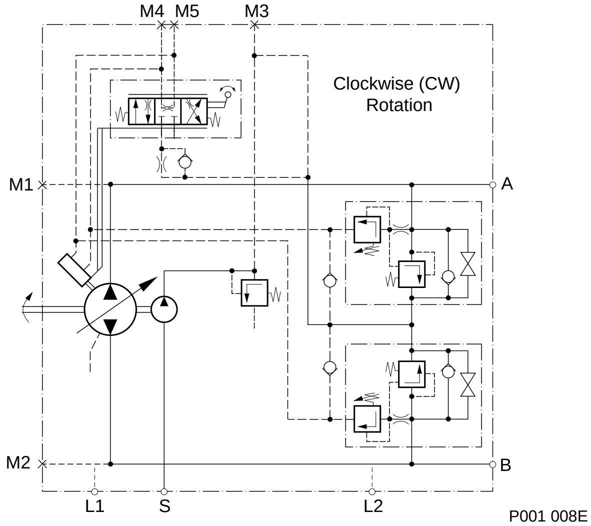
Options (Continued)

Multi-function Valve

Figure 7: Circuit diagram



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.

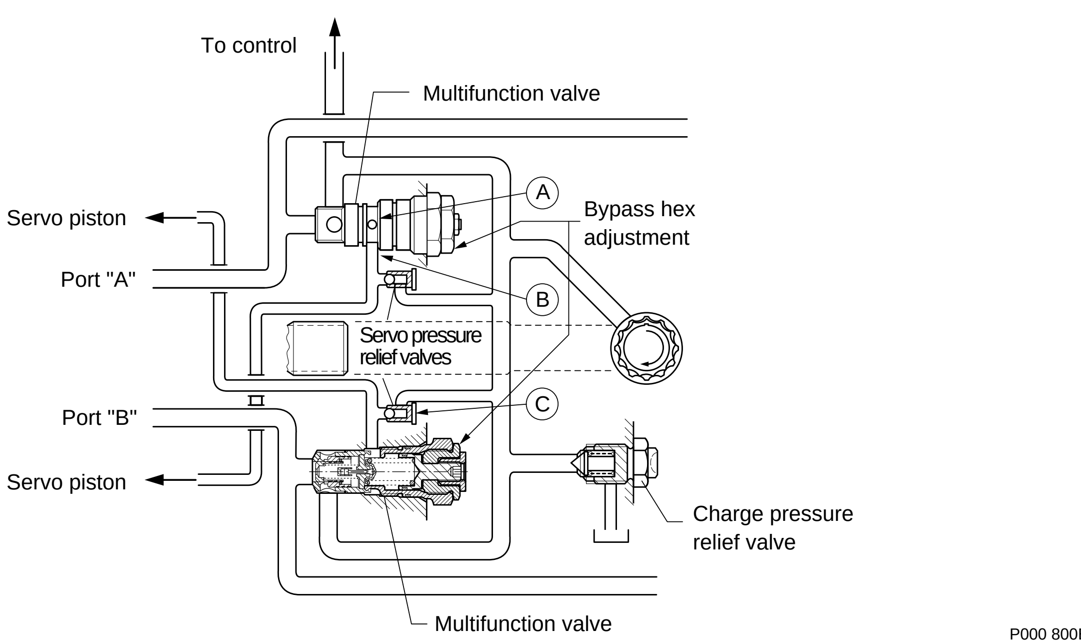
Overpressure Protection

The Series 90 pumps are designed with a sequence pressure limiting system and high pressure relief valves (Figure 8). When the preset pressure is reached, the pressure limiter system acts to rapidly destroke the pump so as to limit the system pressure. Typical response is less than 90 ms. For unusually rapid load application, the high pressure relief valve is available to also 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.

Pressure Limiter Operation

Referring to Figure 8 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.

Figure 8: Multi-function valve, pressure limiter, pressure regulation, option 1



Options (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, a "down" vehicle may be moved to a service or repair location or winched on a trailer without operating the prime mover.

Series 90 pumps are designed with a bypass function. The bypass is operated by mechanically rotating the bypass hex on both multi-function valves three (3) turns counter-clockwise (CCW). Refer to figures 8 on page 14.

This connects working loop A and B and allows fluid to circulate without rotating the pump and prime mover.

Caution !

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

Series 90 pumps are available with an optional speed sensor for direct measurement of pump input speed.

A special magnetic speed ring is pressed onto the outside diameter of the cylinder block and a Hall effect sensor is located in the pump 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.

This sensor will operate with a supply voltage of 4.5 to 15 VDC, and requires a current of 12 mA at 5.0 VDC under no load. Maximum operating current is 30 mA at 1 kHz. Maximum operating frequency is 15 kHz. Output voltage in "High State" (VOH) is sensor supply voltage minus 0.5 VDC, minimum. Output voltage in "Low State" (VOL) is 0.5 VDC, maximum.

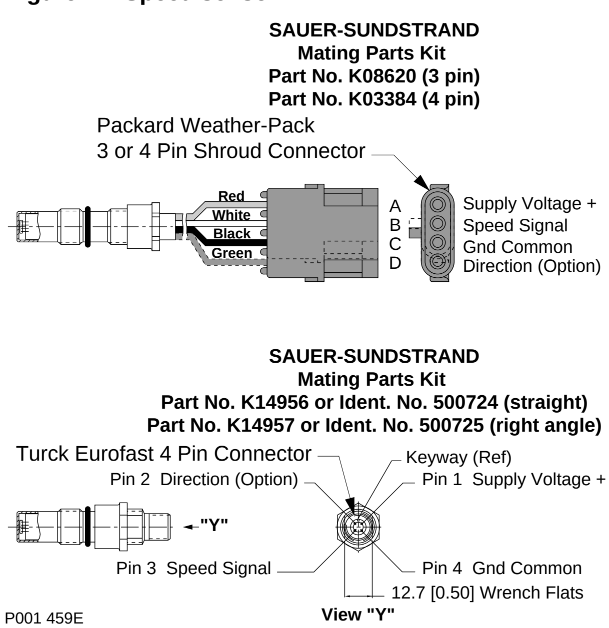
The sensor is available with a Packard Weather-Pack 3 or 4-pin sealed connector or a Turck Eurofast M12x1 4-pin connector.

Table 2: Pulse frequency

Frame Size	**030**	**042**	**055**	**075**
Pulses per revolution	43	48	52	58
Frame Size	**100**	**130**	**180**	**250**
Pulses per revolution	63	69	-	-

\- = not available

Figure 11: Speed sensor



Options (Continued)

Charge Pump

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

Rated charge pressure must be maintained at its specified pressure under all conditions of operation to prevent damage to the transmission.

Many factors influence the charge flow requirements and the resulting charge pump size selection. These factors include system pressure, pump speed, pump swashplate angle, type of fluid, temperature, size of heat exchanger, length and size of hydraulic lines, control response characteristics, auxiliary flow requirements, hydrostatic motor type, etc. When initially sizing and selecting hydrostatic units for an application, it is frequently not possible to have all the information necessary to accurately evaluate all aspects of charge pump size selection.

The following procedure will assist the designer in arriving at an initial charge pump size selection for a typical application, it is emphasized that unusual application conditions may require a more detailed review of charge pump sizing. Testing is recommended to verify that adequate charge pressure is maintained under actual operating conditions.

Charge Pump Sizing / Selection

The first step in approximating the proper size charge pump is to determine the charge flow requirements for the total system under different modes of operation.

The total charge flow requirements must include the flow requirements of the pump/ motor(s) and all auxiliary components which remove fluid from the system.

The charge pump sizing must consider the pump and motor(s) operating at their maximum operating pressure and also when the pump is operating at minimum speed.

A) Charge Flow Requirement - Pump

Determine the pump speed, minimum and operating, and maximum system pressure at these speeds. If the pump speed is less than 1 000 min^{-1}, use the data published for 1 000 min^{-1}.

Referring to the figure 12 on page 17, “Charge Flow Requirement - Pump,” determine the flow factor Fp at the desired flow requirement for the pump:

$$Qp = \frac{Fp \times Frame\ Size \times 3.785}{75} = \text{l/min, Charge Flow Requested - Pump}$$

$$Qp = \frac{Fp \times Frame\ Size}{75} = \text{gpm, Charge Flow Requested - Pump}$$

Frame Size in (cm^3/rev)

B) Charge Flow Requirements - Motor

Determine the motor speeds and maximum system pressure. Referring to the accompanying figure 13, “Charge Flow Requirement - Motor”, determine the flow factor of the motor Fm.

Using the following equation, determine charge flow requirements for the motor Qm.

$$Qm = \frac{Fm \times Frame\ Size \times 3.785}{75} = \text{l/min, Charge Flow Requested - Motor}$$

$$Qm = \frac{Fm \times Frame\ Size}{75} = \text{gpm, Charge Flow Requested - Motor}$$

C) Total Charge Flow Requirements

The total charge flow requirements Qt is the sum of the flow requirements of each of the components in system; namely:

Qt= Qp + Qm1 + Qm2 + Qaux = l/min,

(Tot. Charge Flow Req.)

D) Determine Required Charge Pump Size

- Referring to the accompanying figure 14, “Charge Pump Flow”, select the correct charge pump requirements determined above and the pump input speed.
- Refer to the “Charge Pump Size/ Availability and Speed Limits” chart to verify that the maximum speed limit of the selected charge pump is not be exceeded.
- If the desired size noted in the chart is not available, always select the next size larger charge pump.
- If the standard size charge pumps are not adequate to meet the flow requirements of the system, a Gear Pump can be mounted to the auxiliary mounting pad to provide the necessary additional flow.

System features and conditions which may invalidate the above calculations include (but not limited to):

- continuous operation at low input speeds (< 1 500 min^{-1})
- high shock loadings
- excessively long system lines (> 3 m [9.8 ft])
- auxiliary flow requirements
- use of high torque low speed motors

If any of the above conditions exist, contact SAUER-SUNDSTRAND Application Engineering.

Table 3: Available charge pump sizes and speed limits

Charge pump size			Rated speed
	cm^3	(in^3)	min^{-1} (rpm)
A	8	(0.50)	4 200
B	11	(0.69)	4 200
C	14	(0.86)	4 200
D	17	(1.03)	3 900
E	20	(1.20)	3 600
F	26	(1.60)	3 300
F	26	(1.60)	3 100 (130 pump)
H	34	(2.07)	3 100
J	47	(2.82)	2 600
K	65	(3.90)	2 300

Options (Continued)

Charge Pump Maps

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)

Figure 12: Charge flow requirements - pump

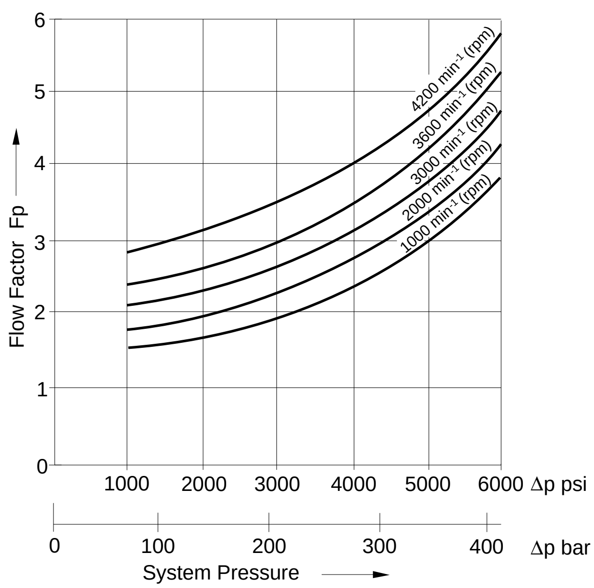


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Figure 13: Charge flow requirements - motor

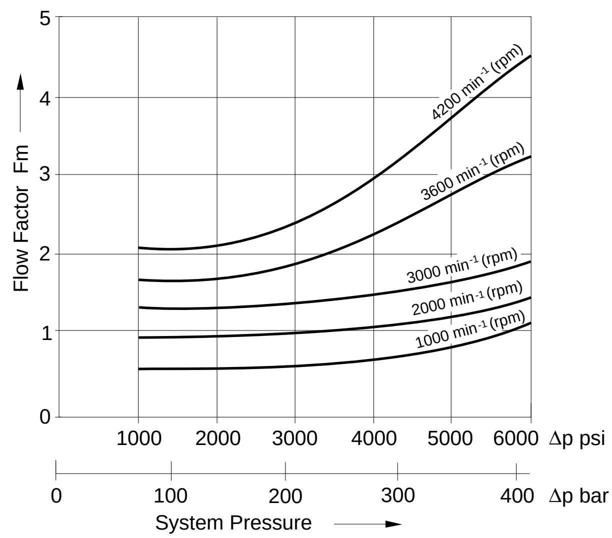

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Figure 14: Charge pump output flow

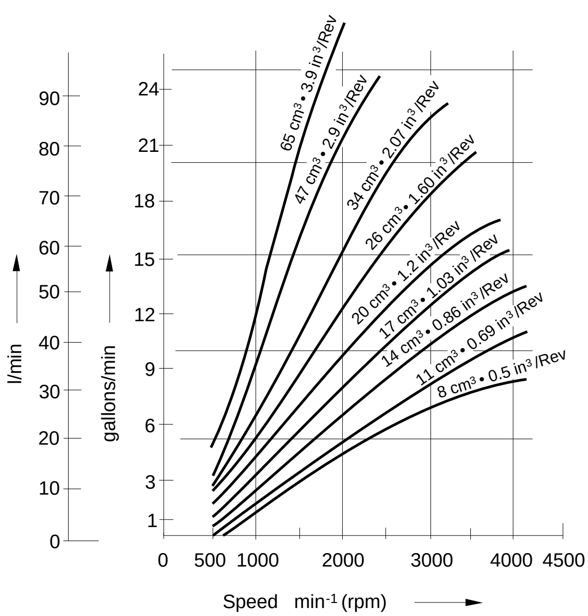

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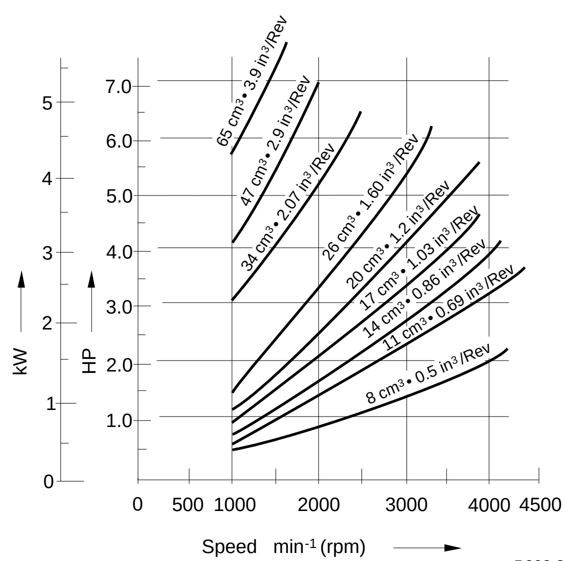
Figure 15: Charge pump power requirements



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Options (Continued)

Shaft Availability and Torque Ratings

Figure 16: Torques for auxiliary mounting pads

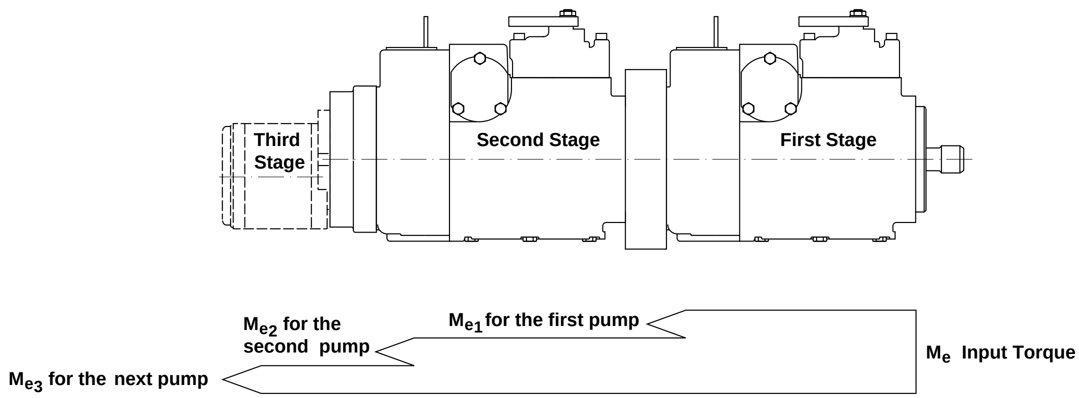


Table 4: Shaft availability and torque ratings

Shaft Description	Option Code	**Frame Size Availability** Rated Torque [**Nm** (lbf•in)]							
		030	**042**	**055**	**075**	**100**	**130**	**180**	**250**
13 teeth 16/32 pitch Spline	**C2**	**260** (2 300)	—	—	—	—	—	—	—
15 teeth 16/32 pitch Spline	**C3**	**530** (4 700)	**530** (4 700)	—	—	—	—	—	—
19 teeth 16/32 pitch Spline	**C5**	—	**900** (8 000)	—	—	—	—	—	—
21 teeth 16/32 pitch Spline	**C6**	—	—	**1 130** (10 000)	—	—	—	—	—
23 teeth 16/32 pitch Spline	**C7**	—	—	—	**1 580** (14 000)	**1 580** (14 000)	—	—	—
27 teeth 16/32 pitch Spline	**C8**	—	—	—	—	—	**2 938** (26 000)	**2 938** (26 000)	**3 600** (32 000)
13 teeth 8/16 pitch Spline	**F1**	—	—	—	—	**1 810** (16 000)	**1 810** (16 000)	+ **1 810** (16 000)	+ **1 810** (16 000)
14 teeth 12/24 pitch Spline	**S1**	—	—	**735** (6 500)	**735** (6 500)	+ **735** (6 500)	—	—	—

— = Shaft option not available
\+ = not recommended for front pump in tandem configurations

Options (Continued)

Auxiliary Mounting Pads

Table 5: Auxiliary mounting pad specifications

Mounting Pad Size	Option Code	Internal Spline Size	Spline Engagement min. mm (in.)	Rated Torque Nm (lbf•in)
SAE A	**A**	9 teeth 16/32 pitch	13.5 (.53)	107 (950)
SAE B	**B**	13 teeth 16/32 pitch	14.2 (.56)	256 (2 200)
SAE B - B	**V**	15 teeth 16/32 pitch	16.1 (.63)	347 (2 990)
SAE C	**C**	14 teeth 12/24 pitch	18.3 (.72)	663 ❊ (5 700)❊
SAE D	**D**	13 teeth 8/16 pitch	20.8 (.82)	1 186 (10 500)
SAE E	**E**	13 teeth 8/16 pitch	20.8 (.82)	1 637 (14 500)
SAE H	**H**	27 teeth 16/32 pitch	27.0 (1.06)	22 362 (19 805)

❊ For the 055 pump the rated torque is limited to 445 Nm (3 830 lbf•in)

Mating Auxiliary Pumps

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.

Figure 17

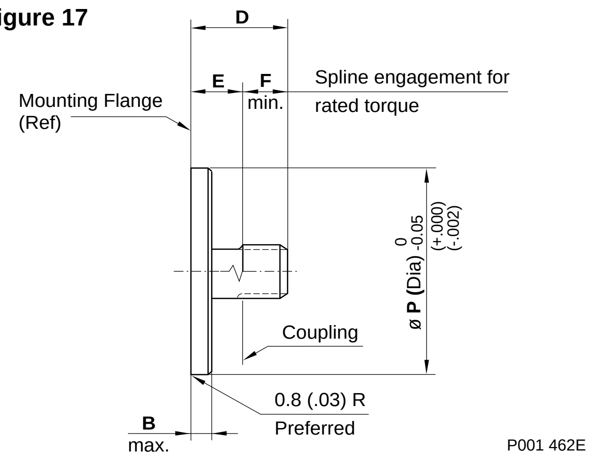


Table 6: Auxiliary Pump Dimensions [mm (in.)]

Flange Size	**ø P** Dia	**B** max.	**D**	**E**	**F** min.
SAE A	82.55 (3.250)	7.4 (.29)	32 (1.26)	See Dimensions	13.5 (.53)
SAE B	101.6 (4.000)	10.7 (.42)	41 (1.61)		14.2 (.56)
SAE B - B	101.6 (4.000)	10.7 (.42)	46 (1.81)		16.1 (.63)
SAE C	127.0 (5.000)	14.3 (.56)	56 (2.20)		18.3 (.72)
SAE D	152.4 (6.000)	14.3 (.56)	75 (2.95)		20.8 (.82)
SAE E	165.1 (6.500)	18.0 (.71)	75 (2.95)		20.8 (.82)
SAE H	165.1 (6.500)	18.0 (.71)	75 (2.95)		27.0 (1.06)

External Load Limits

Shaft Loads

Normal bearing B10 life in hours is indicated in the accompany table at a continuous differential pressure of 240 bar (3 500 psi), 1 800 min^{-1} (rpm) shaft speed, maximum displacement, and no external shaft side load. The data below is based on a 50 % forward, 50 % reverse duty cycle, standard charge pump size, and standard charge pressure.

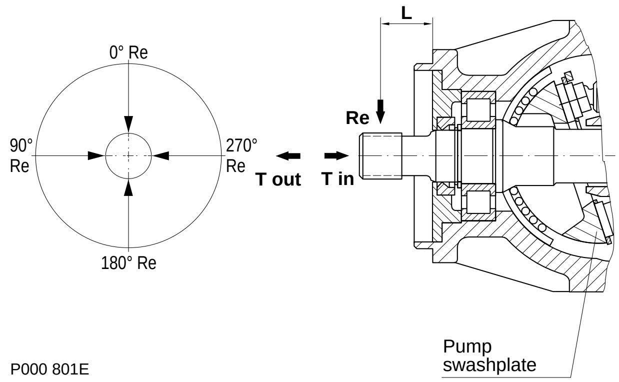
Table 7: Bearing life

Frame Size	Bearing Life - B10 hrs
030	10 040
042	18 060
055	22 090
075	22 970
100	22 670
130	17 990
180	16 150
250	12 020

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 side load (Re), based on the maximum external moment (Me) and the distance (L) from the mounting flange to the load, may be determined from the table and diagram below. Thrust (axial) load limits are also shown.

Figure 18: External shaft load orientation



Maximum Allowable Radial Side Load, **Re = Me / L**

All external shaft loads will have an effect on bearing life. In applications where external shaft loads can not be avoided, the impact on bearing life may be minimized by orientating the load to the 90 or 270 degree position.

Please contact Sauer-Sundstrand Application Engineering for an evaluation of unit bearing life if:

- continuously applied external loads exceed 25 % of the maximum allowable radial side load, Re.
- the pump swashplate is positioned on one side of center all or most of the time.
- the unit bearing life (B10) is critical.

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

Table 8: External shaft load

Frame Size		030	042	055	075	100	130	180	250
Max. Allowable External Loads									
1) External Moment (Me)	Nm lbf•in	**112** 991	**126** 1 114	**101** 893	**118** 1 043	**126** 1 114	**140** 1 238	**161** 1 424	**176** 1 556
2) Max. Shaft Thrust in (T in)	N lbf	**2 900** 652	**2 635** 592	**3 340** 750	**4 300** 966	**5 160** 1 160	**5 270** 1 184	**7 000** 1 573	**7 826** 1 759
3) Max. Shaft Thrust out (T out)	N lbf	**1 330** 299	**1 020** 229	**910** 204	**930** 209	**1 000** 224	**688** 154	**1 180** 265	**1 693** 380

External Load Limits (Continued)

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.

Estimating Overhung Load Moments

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

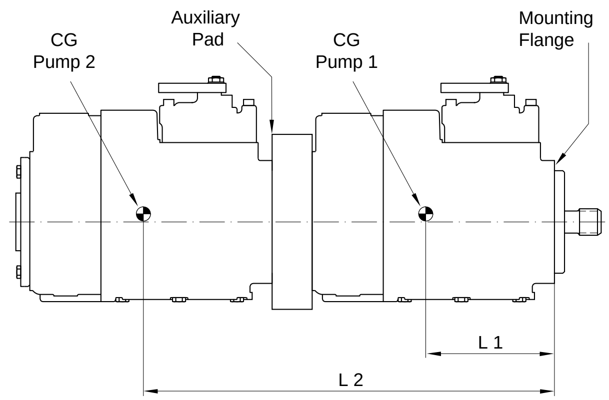
$$M_R = G_R \, (W_1L_1 + W_2L_2 + ... + W_nL_n)$$
$$M_S = G_S \, (W_1L_1 + W_2L_2 + ... + W_nL_n)$$

Where:

M_R = Rated load moment [Nm]
M_S = Shock load moment [Nm]
G_R = Rated (vibratory) acceleration ("g"s) * [m/s²]
G_S = Maximum shock acceleration ("g"s) * [m/s²]

* Calculations will be carried out by multiphying the gravity (g = 9.81 m/s²) with a given factor. This factor depends on the application.

Figure 19: Overhung load moments



P001 290E

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

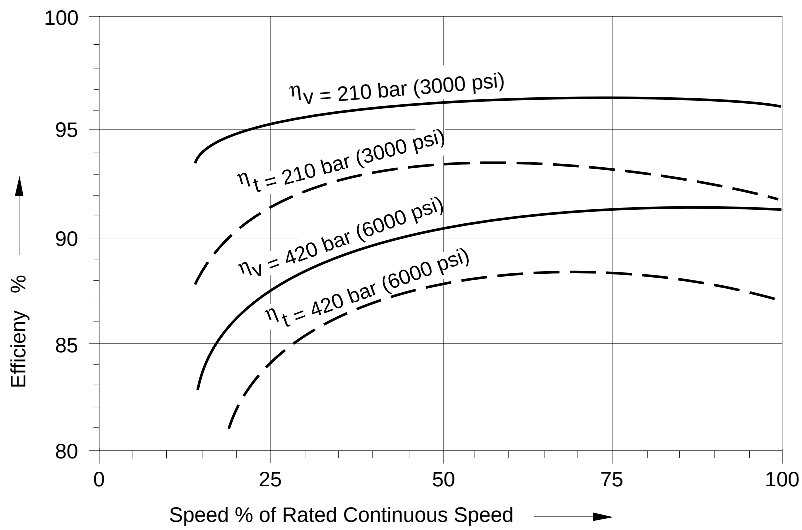
Table 9: Allowable overhung load moments

Frame Size	Rated Moment M_R		Shock Load Moment M_S	
	Nm	lbf•in	Nm	lbf•in
030	860	7 600	3 020	26 700
042	860	7 600	3 020	26 700
055	1 580	14 000	5 650	50 000
075	1 580	14 000	5 650	50 000
100	1 580	14 000	5 650	50 000
130	3 160	28 000	10 730	95 000
180	6 070	54 000	20 600	182 000
250	6 070	54 000	20 600	182 000

Efficiency Graphs

Figure 20 shows typical overall and volumetric efficiencies for series 90 pump with system pressures of 210 and 420 bar (3 000 and 6 000 psi) speed corresponding to rated speed, and a fluid viscosity of 8 mm²/s (cSt) {50 SUS}.

Figure 20: Overall efficiency and volumetric efficiency at maximum displacement



P000 791E

The following performance maps show typical overall efficiencies for series 90 pumps with system pressures of 70 to 420 bar (1 000 to 6 000 psi) and at 2/3 of its rated speed varying between 1/4 to maximum displacement (Figure 22).
These efficiency maps can be used for all frame sizes.

Figure 21: Overall efficiency at max. displ. of pump

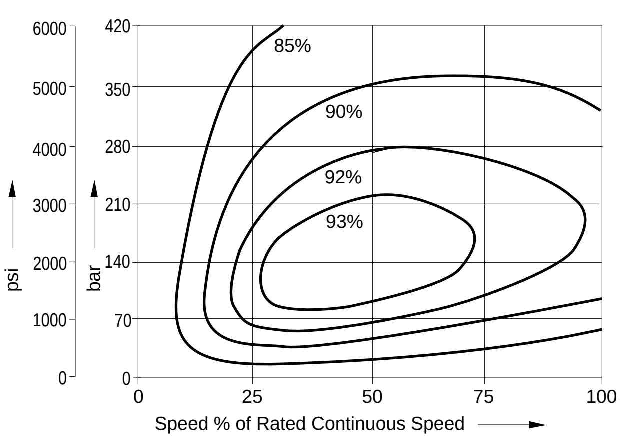


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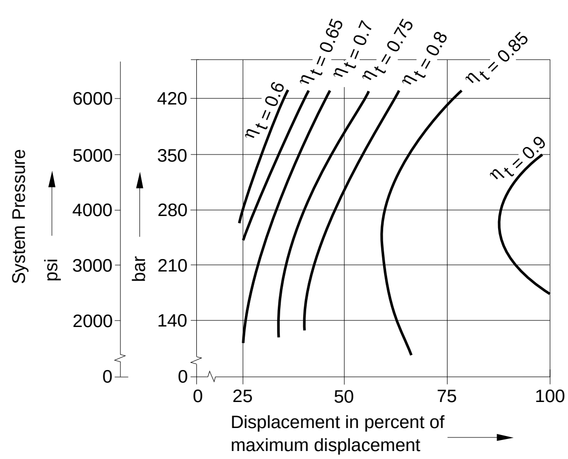
Figure 22: Pump overall efficiency at 2/3 rated speed



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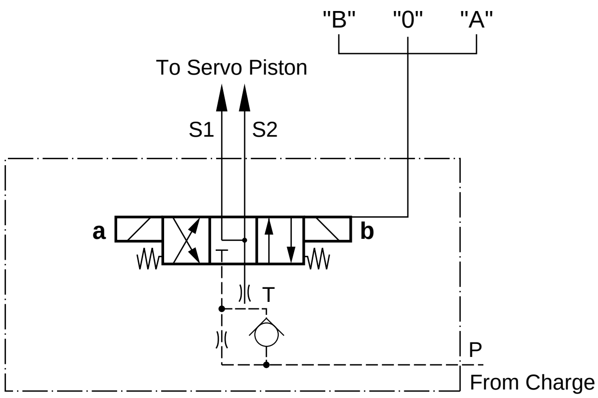
Notes

Controls - Circuit Diagram, Nomenclature and Description

3-Position (FNR) Electric Control, Options DC, DD

The 3-Position (FNR) control uses an electric input signal to switch the pump to a full stroke position.

Figure 23.1: 3-Position electric control hydraulic schematic



S1 = Servo Side 1
S2 = Servo Side 2

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Figure 23.2: Pump displacement vs electrical signal

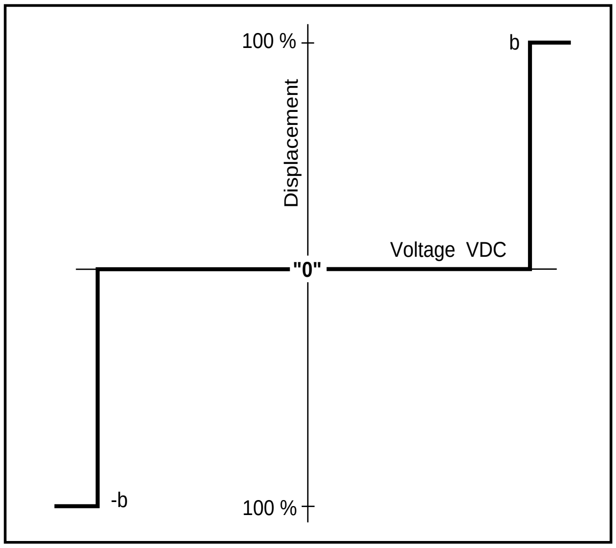

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Table 10: Electric input signal direct current

Configuration	b
DC	12 VDC
DD	24 VDC

Figure 24: Solenoid Connector

Solenoid plug face for DIN 43650 Connector

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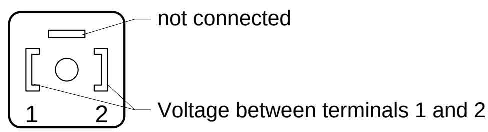
Mating Parts Kit
Part No. K09129



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Controls - Circuit Diagram, Nomenclature and Description (Continued)

3-Position (FNR) Electric Control, Options DC, DD (Continued)

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.**

Typical response times between neutral and full flow at the following conditions:

Δp =	210 bar	(3 000 psi)
Temperature =	50 °C	(122 °F)
Charge Pressure =	24 bar	(340 psi)

Table 11: Typical response times

Frame Size	Maximum Time Seconds (Smallest Orifice) Option 01	Minimum Time Seconds (No Orifice) Option 00
030	1.5	0.60
042	1.9	0.22
055	3.6	0.27
075	3.7	0.32
100	4.8	0.42
130	7.5	0.70
180	7.5	0.55
250	9.0	1.0

Table 12: Pump output flow direction vs. control voltage

Input Shaft Rotation	CW		CCW	
Signal at Magnet	a	b	a	b
Port A Flow	Out	In	In	Out
Port B Flow	In	Out	Out	In

Refer to dimensions for port locations

Controls - Circuit Diagram, Nomenclature and Description (Continued)

Electric Displacement Control (EDC), Options KA, KP

The electric displacement control uses an electrohydraulic Pressure Control Pilot valve to control the pilot pressure. The Pressure Control Pilot valve 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 of the Electric Control:

- 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 pilot valve case lengthens control life by preventing moisture ingression and dampening component vibrations.
- All electrical displacement controls are equipped with dual coil pilot valves. 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 with a given input signal.
- The swashplate is coupled to a mechanism. The control valve hydraulically connects the ends of the servo piston to drain when an electric input signal is not present.
- These features result in:
  - Simple, low cost design.
  - Pump will return 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.

Figure 25: Electric displacement control hydraulic schematic

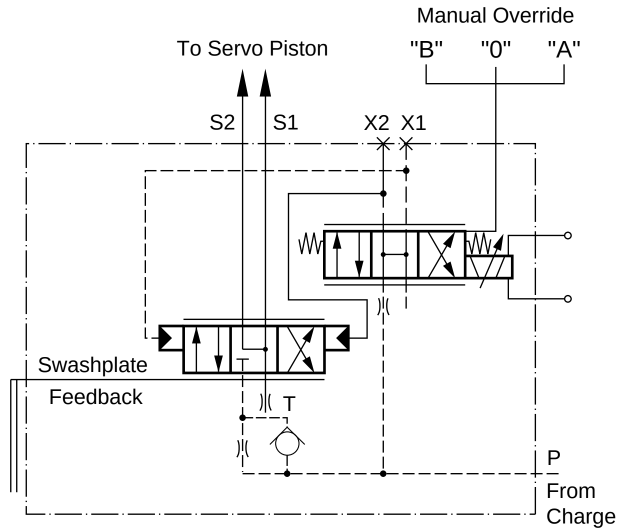

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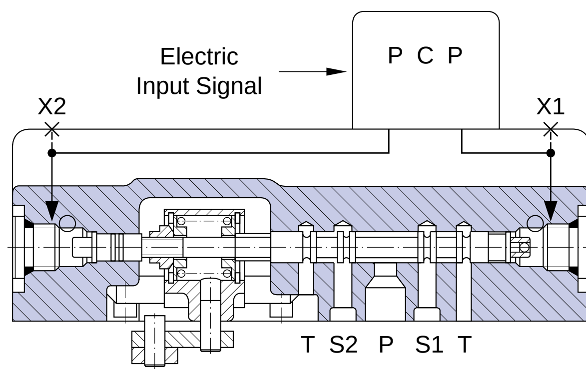
Figure 26: Cross-section of electric displacement control valve



S1 = Servo Side 1
S2 = Servo Side 2

P000 809

Controls - Circuit Diagram, Nomenclature and Description (Continued)

Electric Displacement Control (EDC), Options KA, KP (Continued)

Table 13

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	A C & B D

Maximum input current under any condition: 250 mA
Coil resistance at 24 °C (75 °F): A - B coil → 20 Ω
C - D coil → 16 Ω

Figure 27: Pump displacement vs electrical signal current

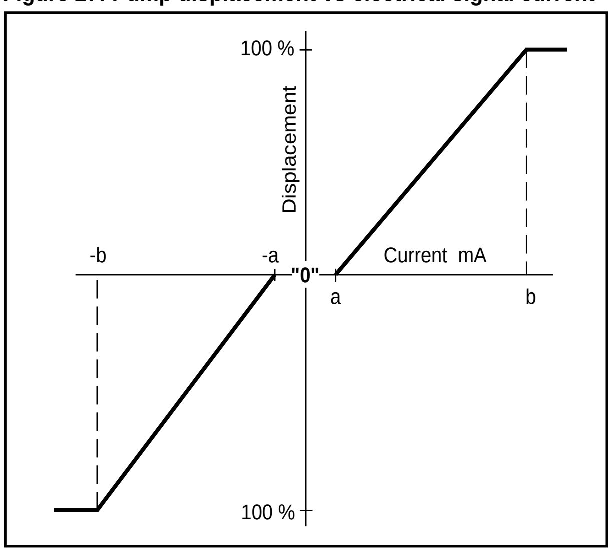


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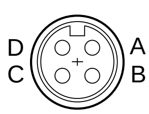
Figure 28: Connectors

MS Connector (Option EA)
MS 3102C-14S-2P



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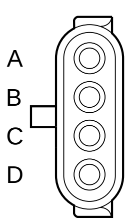
Mating Parts Kit
Part No. K08106
or
Ident. No. 615062

Packard Weather-Pack (Option EP)
4-way shroud connector



SAUER-SUNDSTRAND
Mating Parts Kit
Part No. K03384
(Female Terminals)

P001 464E

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.**

Typical response times between neutral and full flow at the following conditions:

Δp =	210 bar	(3 000 psi)
Temperature =	50 °C	(122 °F)
Charge Pressure =	24 bar	(340 psi)

Table 14: Typical response times

Frame Size	Maximum Time Seconds (Smallest Orifice) Option 01	Minimum Time Seconds (No Orifice) Option 00
030	1.5	0.60
042	1.9	0.22
055	3.6	0.27
075	3.7	0.32
100	4.8	0.42
130	7.5	0.70
180	7.5	0.55
250	9.0	1.0

Table 15: 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.	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

EDC using Dual Coils in Series (B and C Common)				
Input Shaft Rotation	CW		CCW	
Positive Current to Term.	A	D	A	D
Port A Flow	Out	In	In	Out
Port B Flow	In	Out	Out	In

Refer to dimensions for port locations

Controls - Circuit Diagram, Nomenclature and Description (Continued)

Hydraulic Displacement Control (HDC), Option HF

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, will activate the valve and supply pressure to the servo piston, maintaining the swashplate in its preset position.

Features and Benefits of the Hydraulic 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 allows 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 mechanism. The control valve hydraulically connects the ends of the servo piston to drain when an electric input signal is not present.
- These features result in:
  - Simple - low cost design.
  - Pump will return 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.

Figure 29: Hydraulic displacement control hydraulic schematic

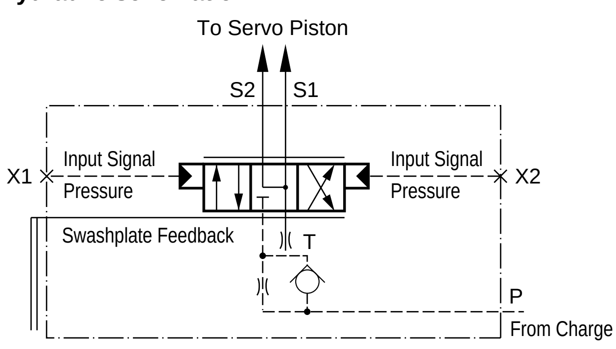
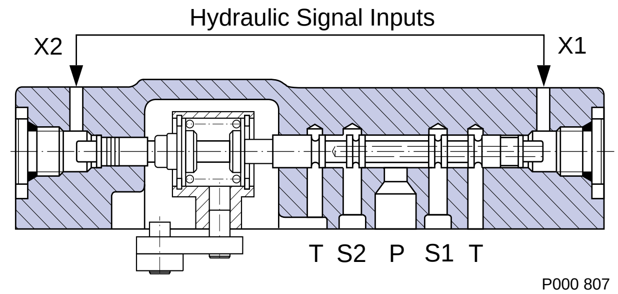


Figure 30: Cross-section of hydraulic displacement control valve



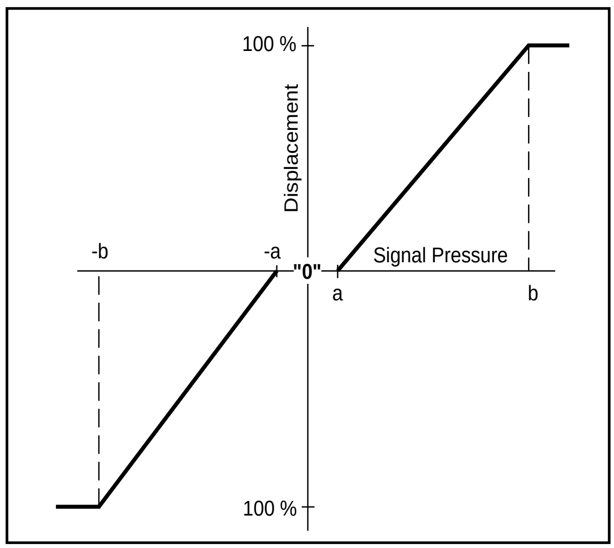
S1 = Servo Side 1
S2 = Servo Side 2

Control Signal Requirements
Maximum allowable signal pressure is 60 bar (870 psi).

Table 16: Hydraulic signal pressure range

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

Figure 31: Pump displacement vs input signal pressure



P001 014E

Table 17: 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

Refer to dimensions for port locations

Controls - Circuit Diagram, Nomenclature and Description (Continued)

Hydraulic Displacement Control (HDC), Option HF (Continued)

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 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.**

Typical response times between neutral and full flow at the following conditions:

Δp =	210 bar	(3 000 psi)
Temperature =	50 °C	(122 °F)
Charge Pressure =	24 bar	(340 psi)

Table 18: Typical response times

Frame Size	Maximum Time Seconds (Smallest Orifice) Option 01	Minimum Time Seconds (No Orifice) Option 00
030	1.5	0.60
042	1.9	0.22
055	3.6	0.27
075	3.7	0.32
100	4.8	0.42
130	7.5	0.70
180	7.5	0.55
250	9.0	1.0

Manual Displacement Control (MDC), Options MA, MB

The manual displacement control device 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.

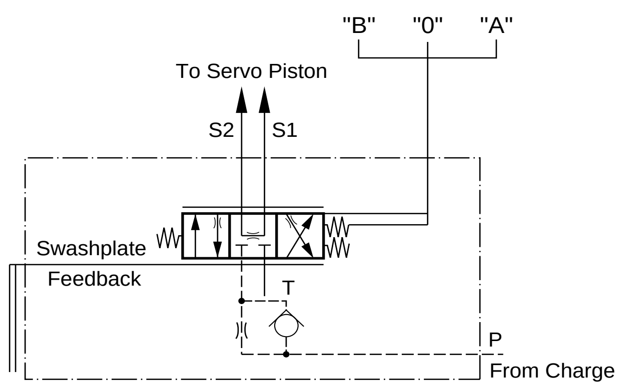
The manual displacement control has a mechanical feedback mechanism which moves a servo valve in the proper relationship to the input signal and the angular position of the swashplate.

The manual displacement 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 Control:

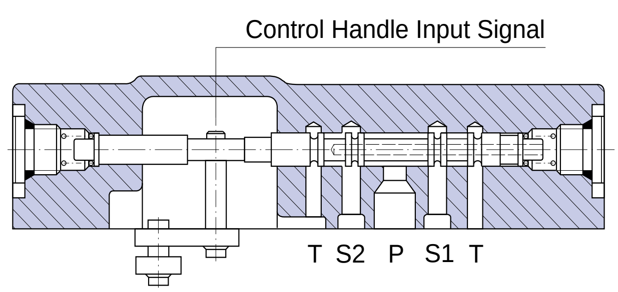
- Precision parts provide repeatable, accurate displacement settings with a given input signal.
- The manual displacement control is a high gain control: With only small movement of the control handle (input signal), the servo valve moves to full open position porting max. flow to the servo cylinder. 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.
- 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.
- These features result in:
  - Pump will return to neutral after prime mover shuts down.
  - Pump will return to neutral if external control linkage fails at the control handle or if there is a loss of charge pressure.

Figure 32: Manual displacement control hydraulic schematic



P000 805E

Figure 33: Cross-section of manual displacement control valve



P000 804E

S1 = Servo Side 1
S2 = Servo Side 2

Controls - Circuit Diagram, Nomenclature and Description (Continued)

Manual Displacement Control (MDC), Options MA, MB (Continued)

External Control Handle Requirements
Torque required to move handle to maximum displacement is 0.68 to 0.9 Nm (6 to 8 lbf•in).
Torque required to hold handle at given displacement is 0.34 to 0.57 Nm (3 to 5 lbf•in).
Torque required to overcome the override mechanism is 1.1 to 2.3 Nm (10 to 20 lbf•in) with the maximum torque required for full forward to full reverse movement.
Maximum allowable input torque is 17 Nm (150 lbf•in)

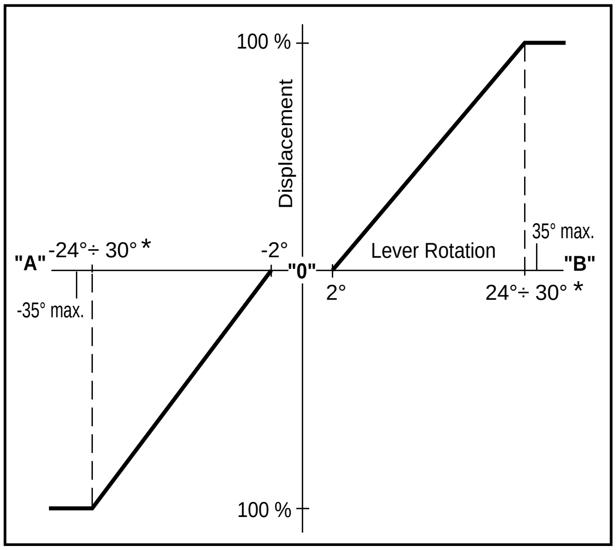
Table 19: Pump output flow direction vs. control handle rotation

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

Refer to dimensions for port locations

Response Time
see next page.

Figure 34: Pump displacement vs control lever rotation



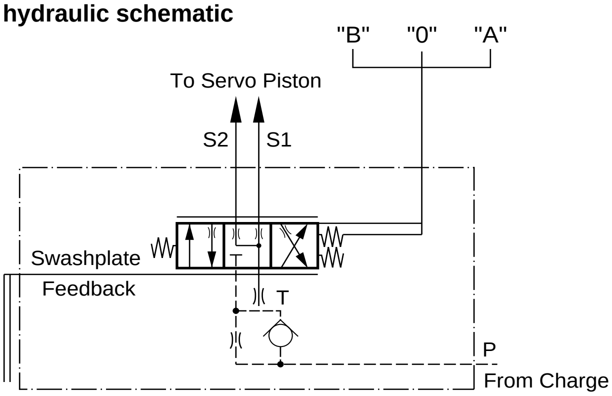
* Actual angle see dimensions.

P001 013E

Non-linear Manual Displacement Control (MDC), Option NA

The manual displacement control device 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 manual displacement 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.

Figure 35: Non-linear manual displacement control hydraulic schematic



P001 412E

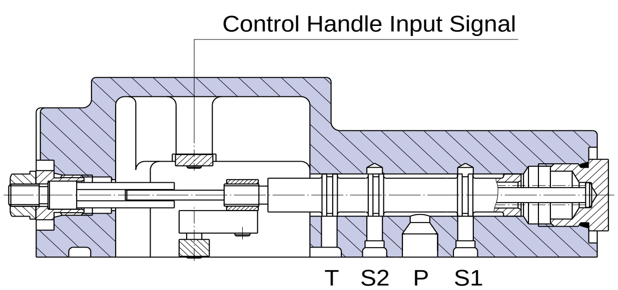
Features and Benefits of the Non-linear Manual Control:

- 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 max. 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.
- These features result in:
  - Pump that is returned to neutral after prime mover shut down.
  - Pump that is returned to neutral if external control linkage fails at the control handle.
  - If there is loss of charge pressure pump returns to neutral.

Controls - Circuit Diagram, Nomenclature and Description (Continued)

Non-linear Manual Displacement Control (MDC), Option NA (Continued)

Figure 36: Cross-section of non-linear manual displacement control valve

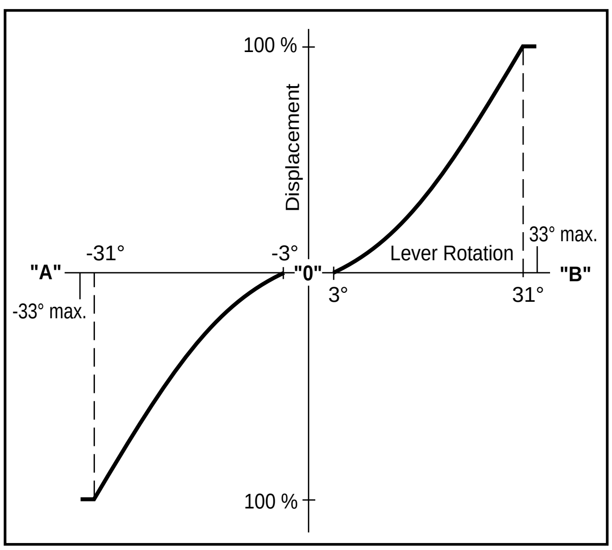


S1 = Servo Side 1
S2 = Servo Side 2

P001 410E

External Control Handle Requirements
Torque required to move handle to maximum displacement is 0,68 to 0,9 Nm (6 to 8 lbf•in).
Maximum allowable input torque is 17 Nm (150 lbf•in).

Figure 37: Pump displacement vs control lever rotation



P001 411E

Table 20: 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

Refer to dimensions for port locations

Response Time
(applies also for Option MA and MB)
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.**

Typical response times between neutral and full flow at the following conditions:

Δp =	210 bar	(3 000 psi)
Temperature =	50 °C	(122 °F)
Charge Pressure =	24 bar	(340 psi)

Table 21: Typical response times

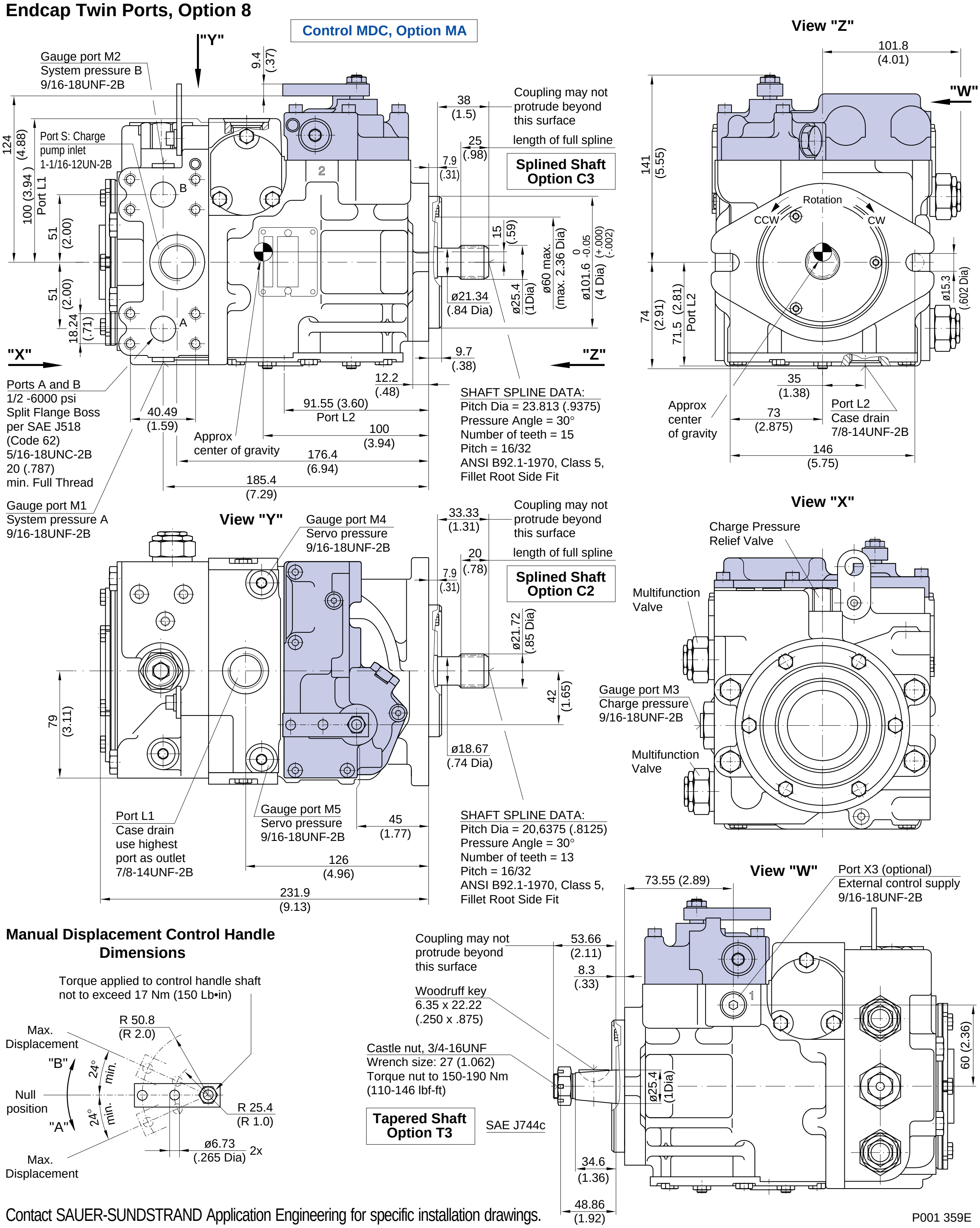
Frame Size	Maximum Time Seconds (Smallest Orifice) Option 01	Minimum Time Seconds (No Orifice) Option 00
030	1.5	0.60
042	1.9	0.22
055	3.6	0.27
075	3.7	0.32
100	4.8	0.42
130	7.5	0.70
180	7.5	0.55
250	9.0	9.0

Dimensions • Frame Size 030

Figure 38: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC)

mm
(in.)

Endcap Twin Ports, Option 8



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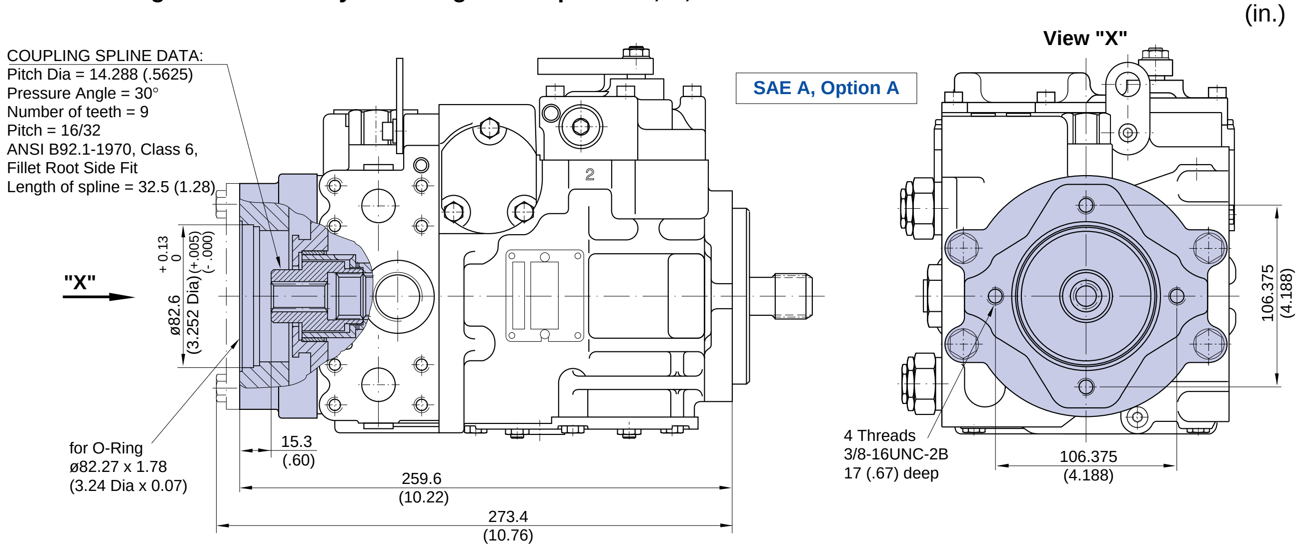
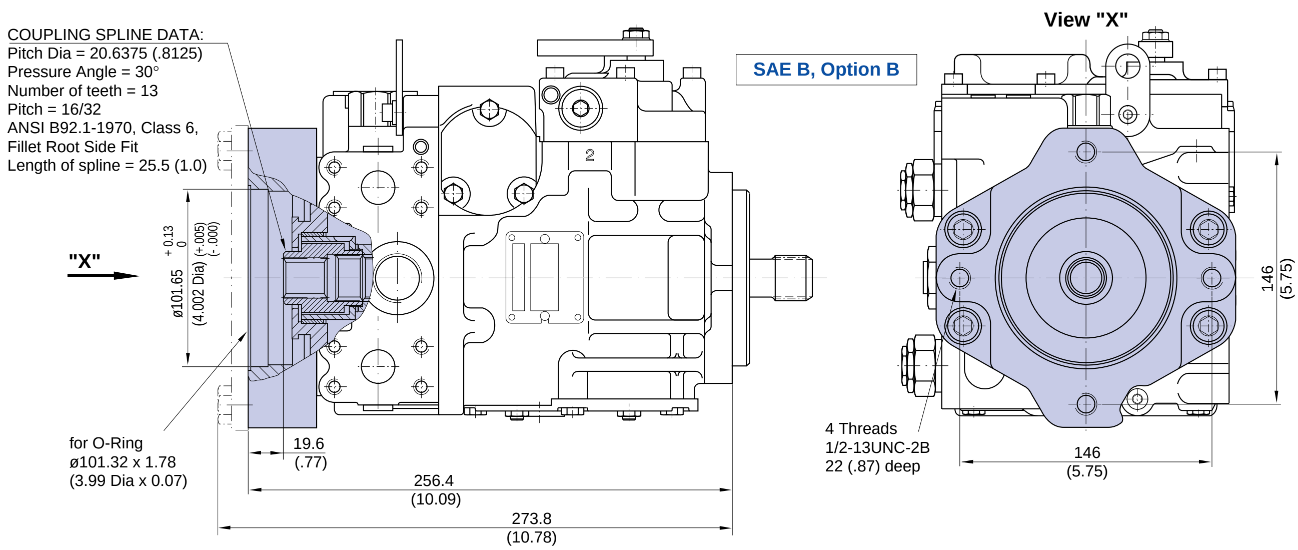
P001 359E

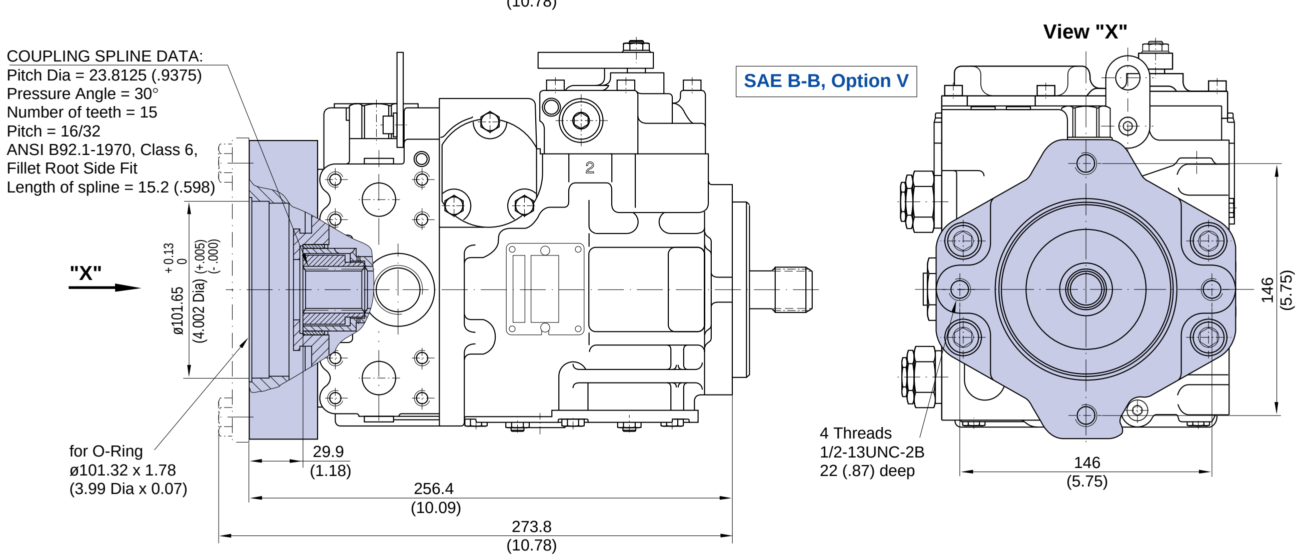
Dimensions • Frame Size 030 (Continued)

Continued Figure 38: Auxiliary Mounting Pad - Options A, B, V

mm
(in.)



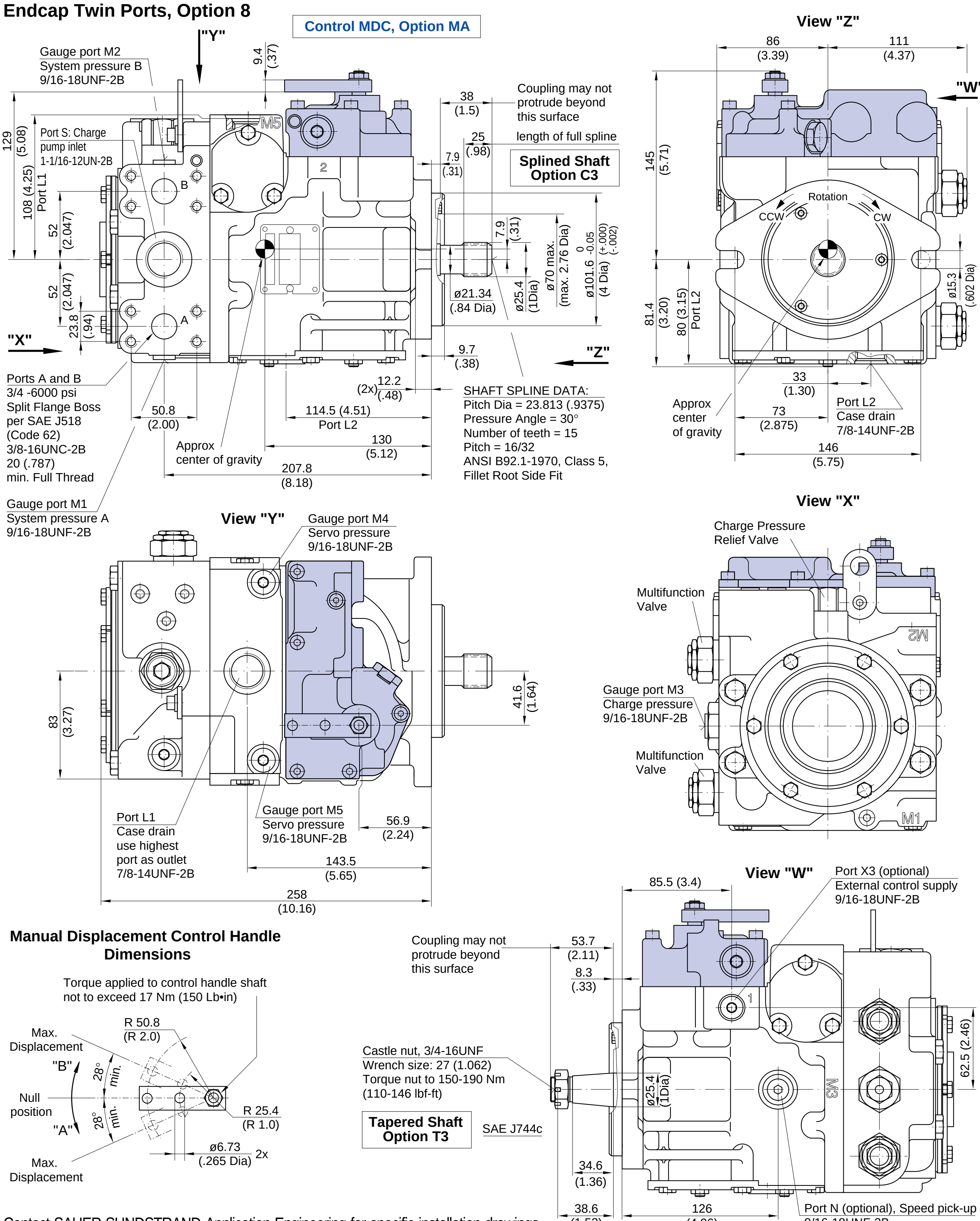




P001 360E

Dimensions • Frame Size 042

Figure 39: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC) mm (in.)

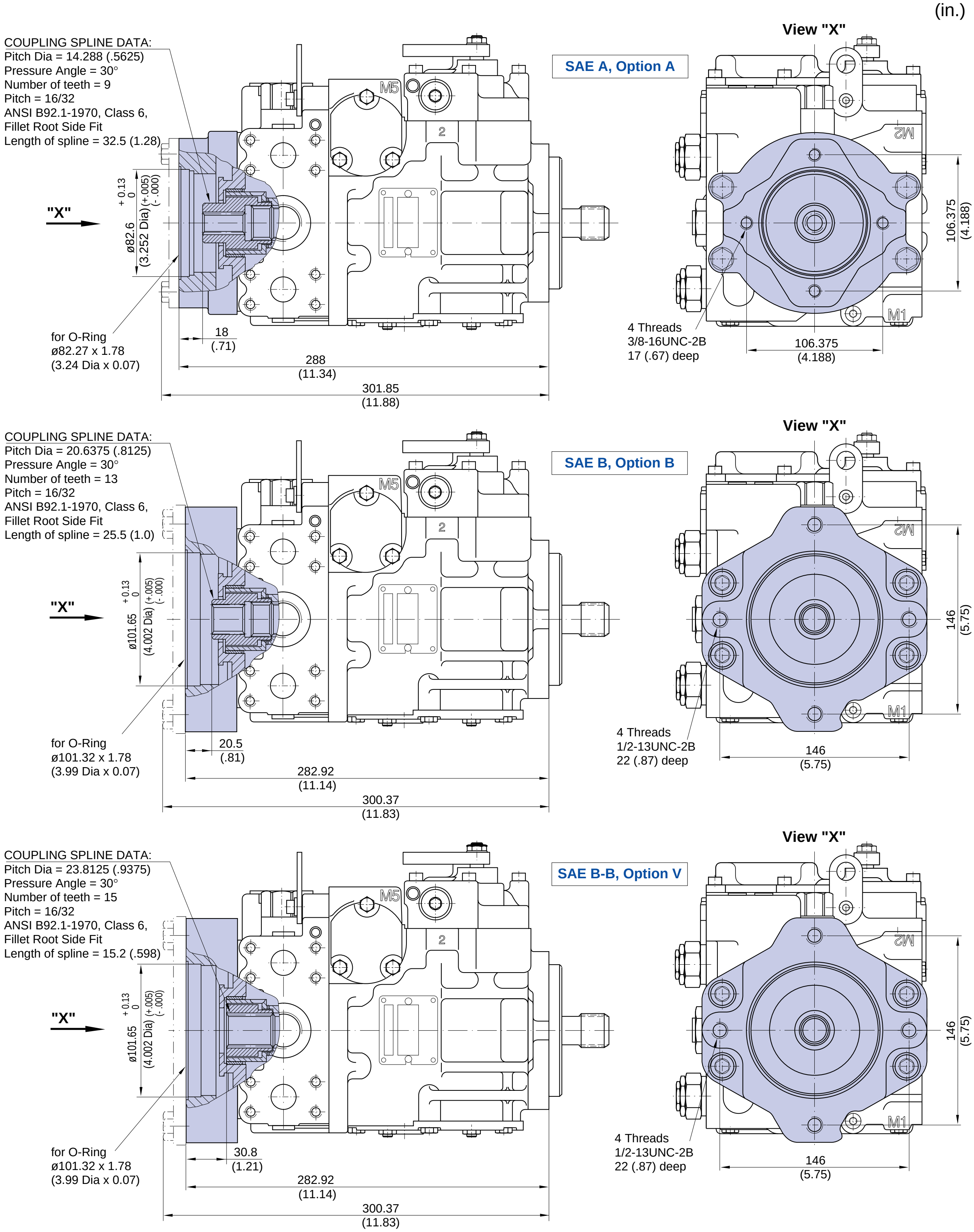


Contact SAUER-SUNDSTRAND Application Engineering for specific installation drawings.

Dimensions • Frame Size 042 (Continued)

Continued Figure 39: Auxiliary Mounting Pad - Options A, B, V

mm
(in.)



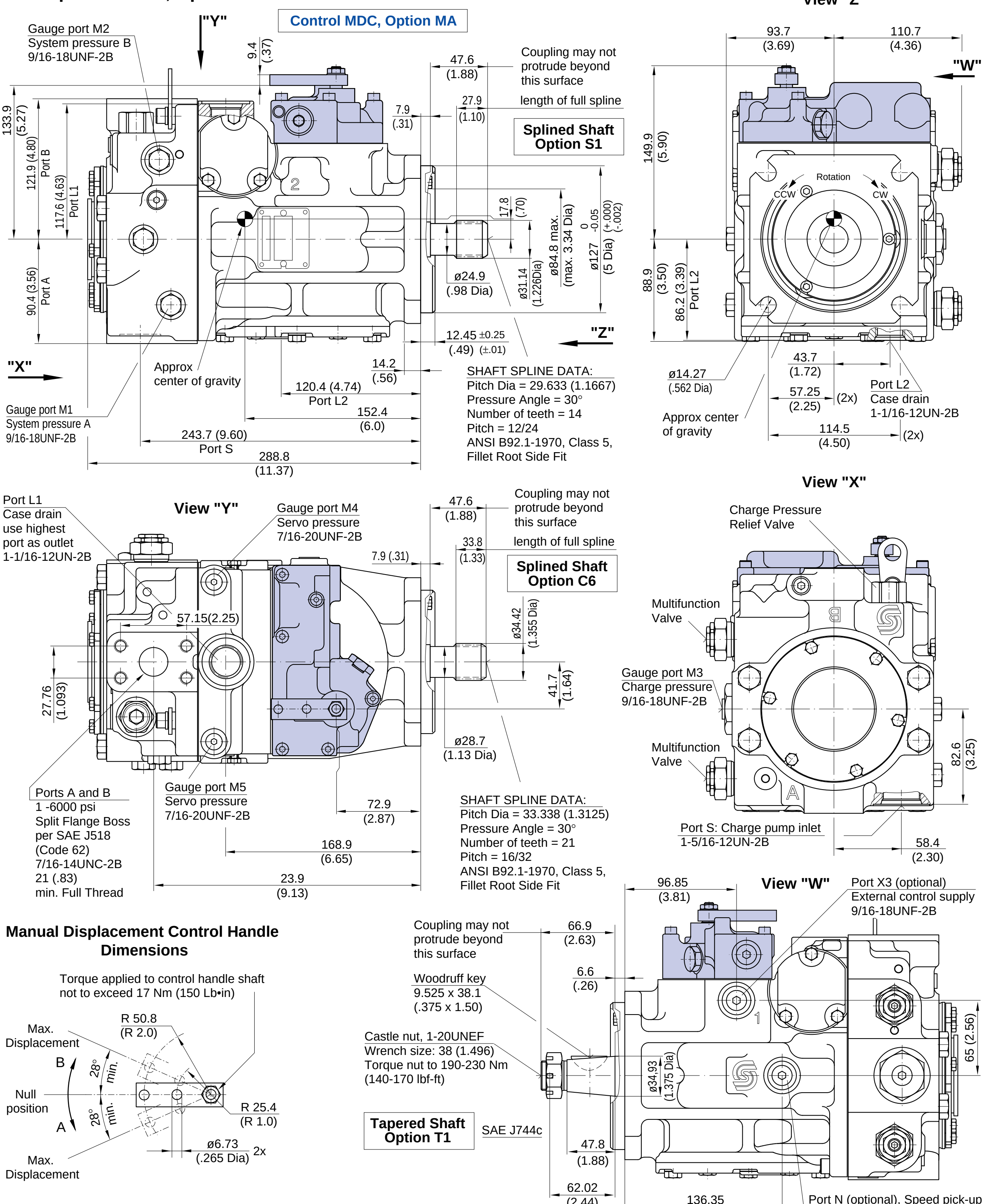
P001 362E

Dimensions • Frame Size 055

Figure 40: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC)

mm
(in.)

Endcap Side Ports, Option 6

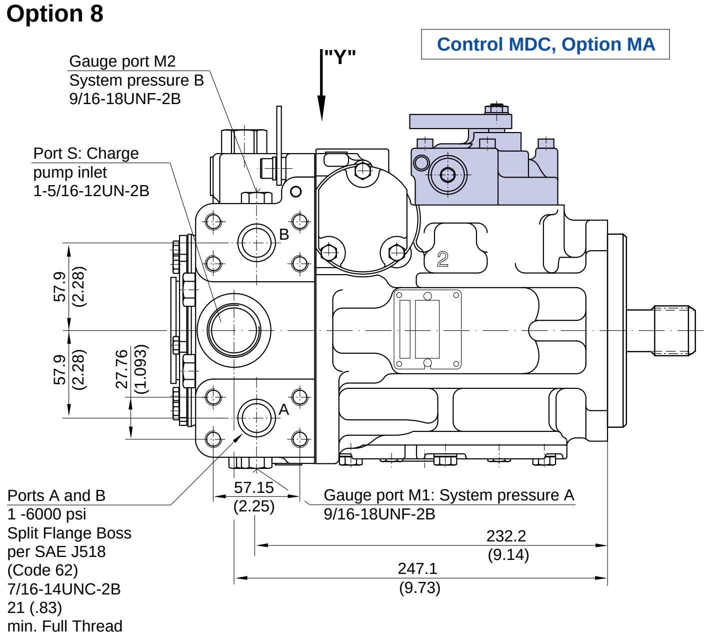


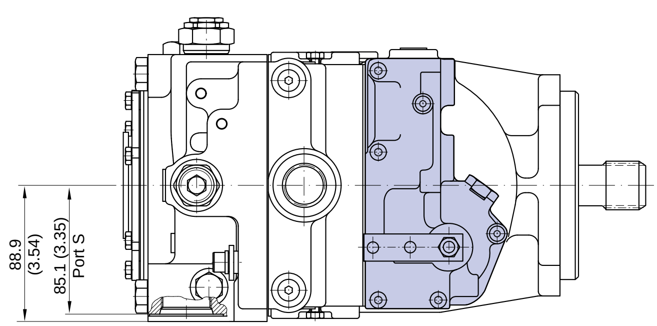
Contact SAUER-SUNDSTRAND Application Engineering for specific installation drawings.

Dimensions • Frame Size 055 (Continued)

Continued Figure 40: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC) mm (in.)

Endcap Twin Ports, Option 8





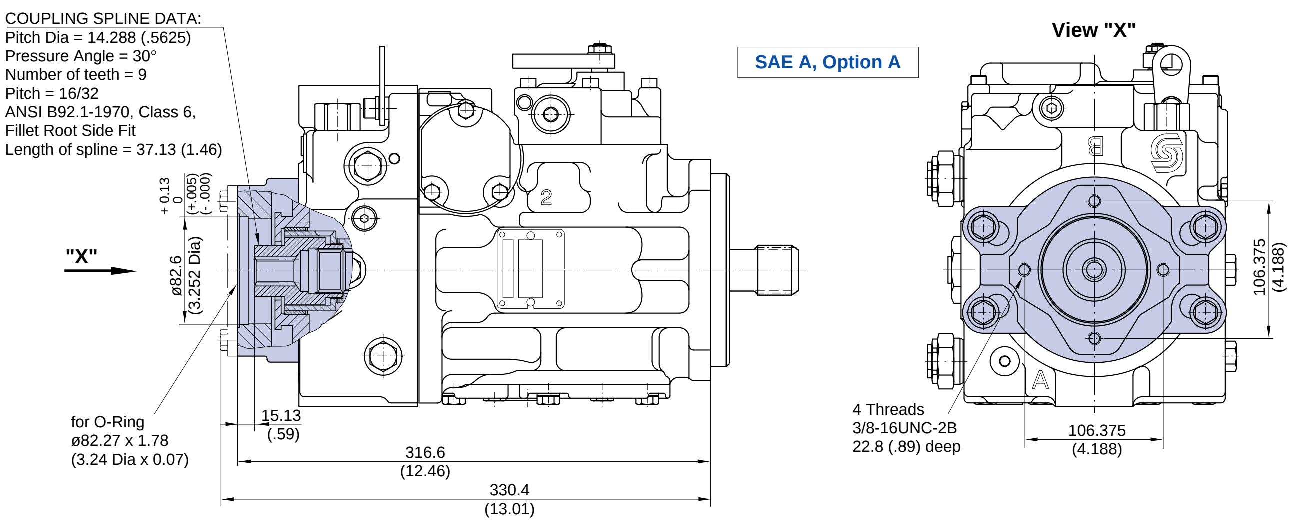
View "Y"

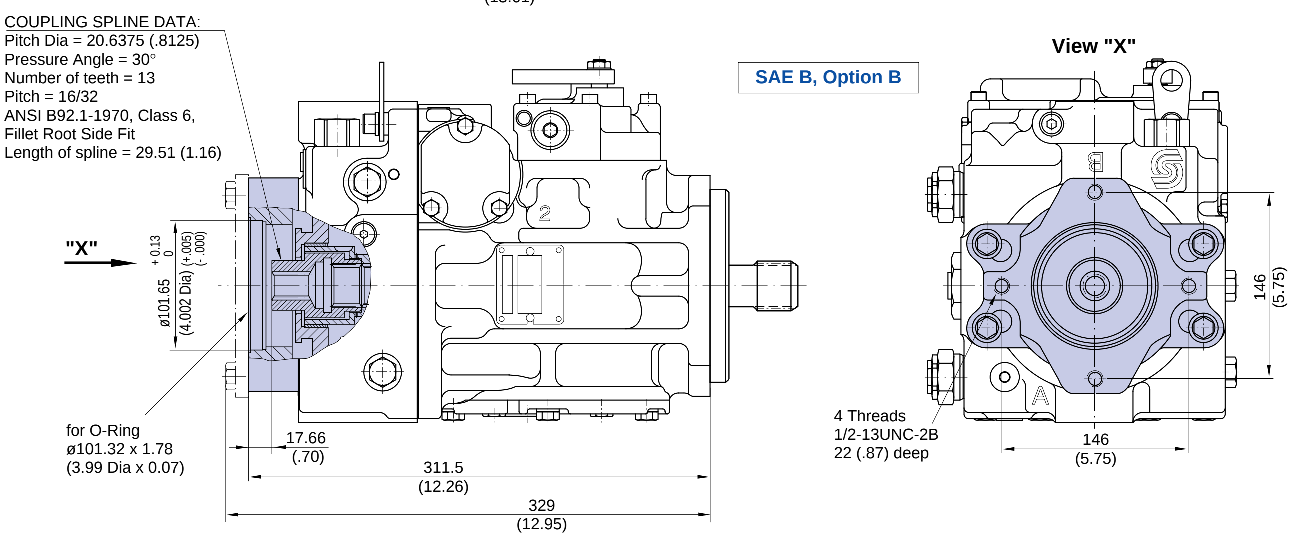
P001 386E

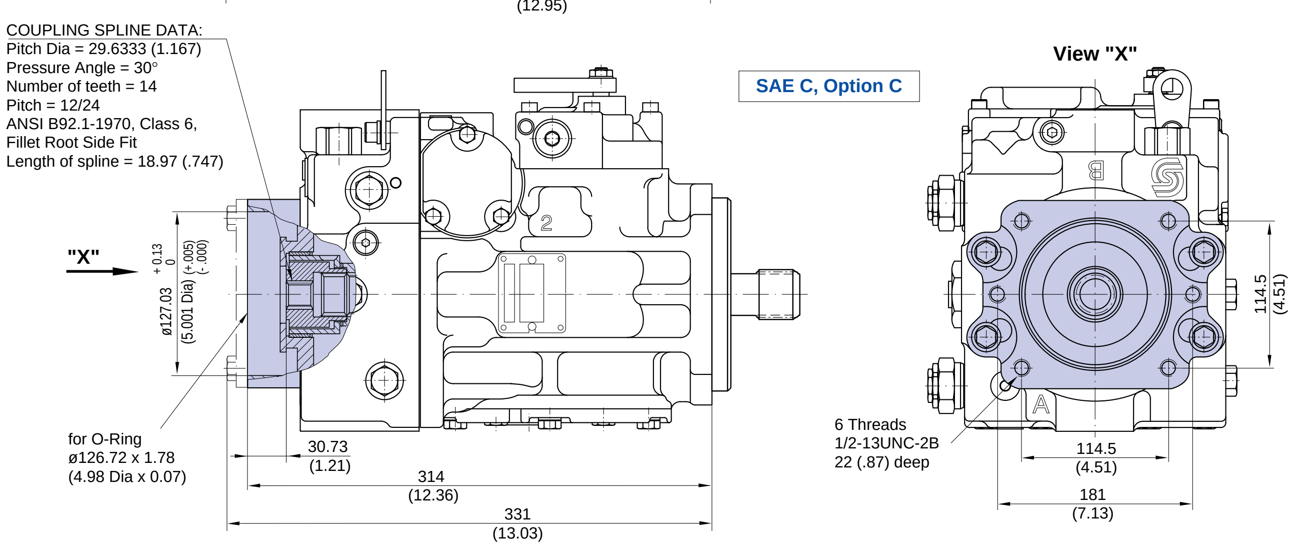
Dimensions • Frame Size 055 (Continued)

Continued Figure 40: Auxiliary Mounting Pad - Options A, B, C, V

mm
(in.)





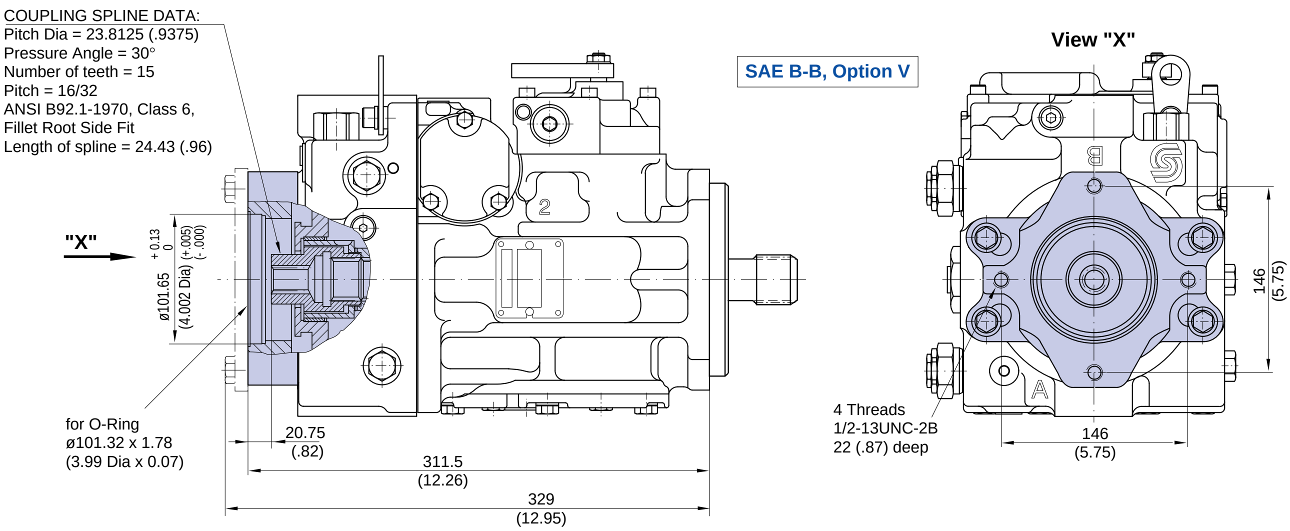


P001 387E

Dimensions • Frame Size 055 (Continued)

Continued Figure 40: Auxiliary Mounting Pad - Options A, B, C, V

mm
(in.)



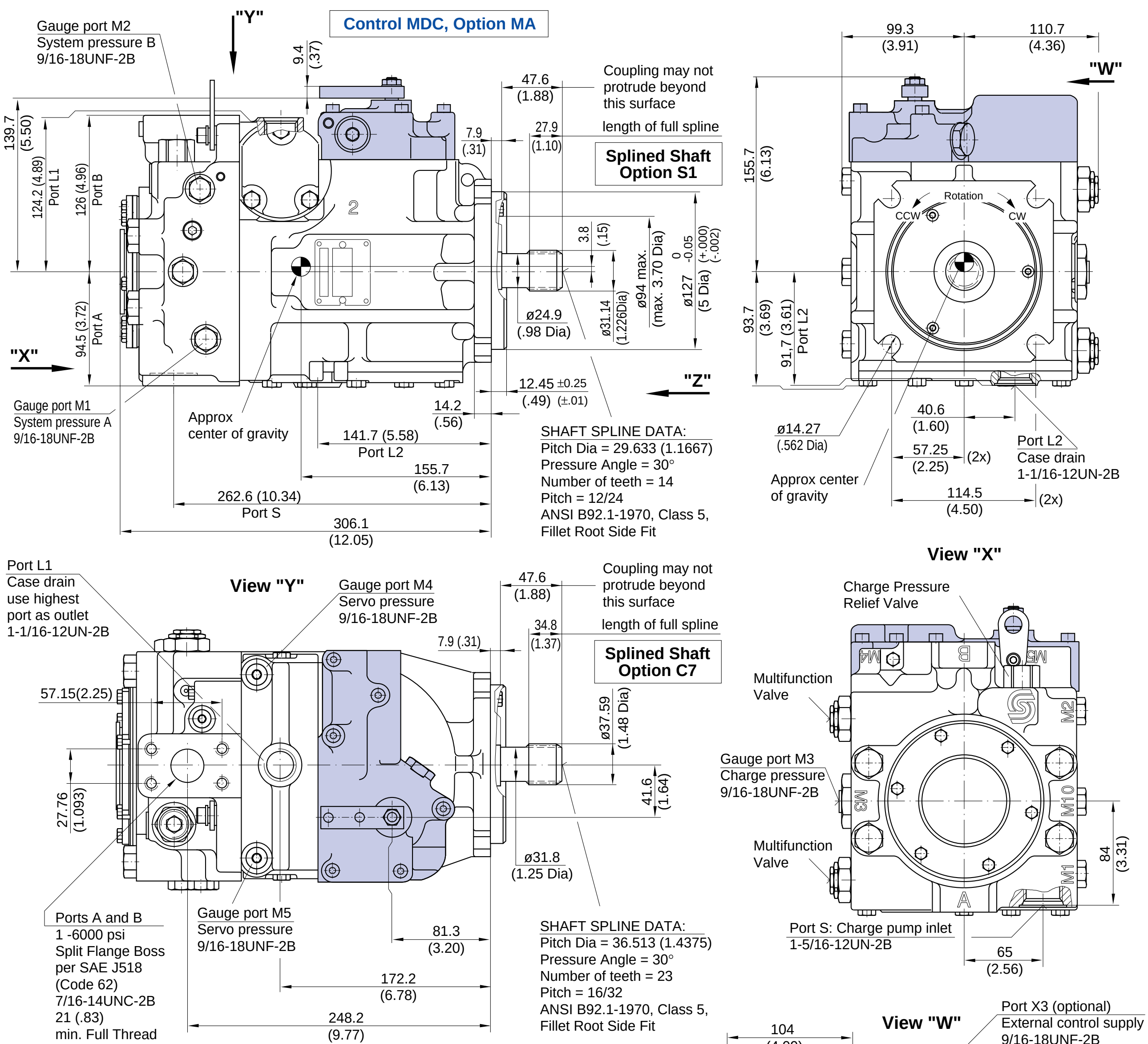
P001 387E/1

Dimensions • Frame Size 075

Figure 41: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC)

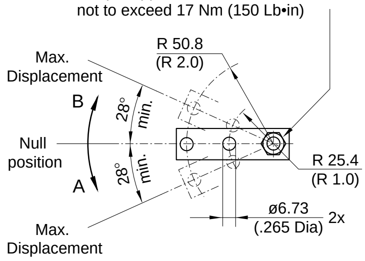
mm
(in.)

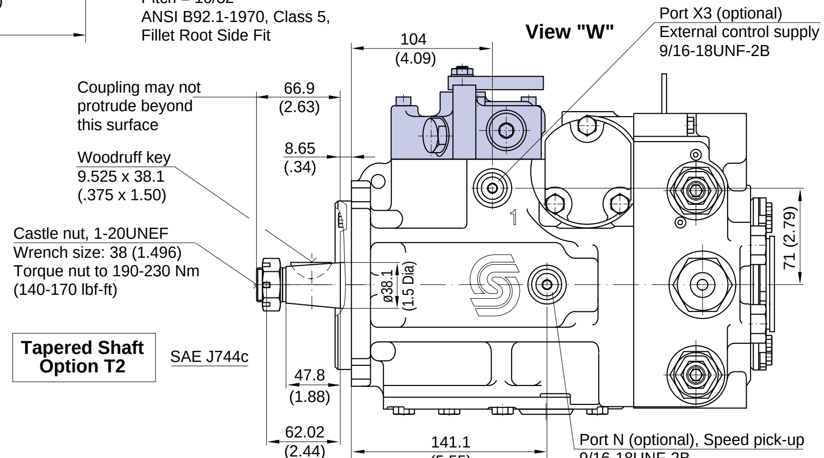
Endcap Side Ports, Option 6



Manual Displacement Control Handle Dimensions

Torque applied to control handle shaft not to exceed 17 Nm (150 Lb•in)





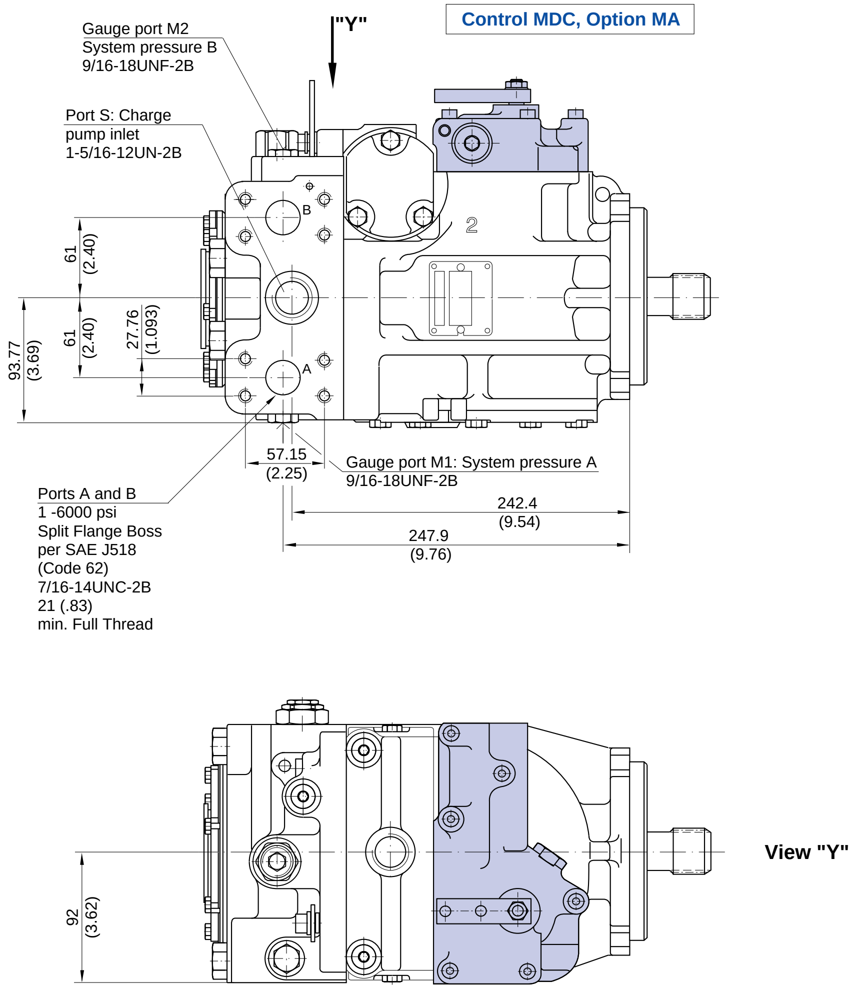
Contact SAUER-SUNDSTRAND Application Engineering for specific installation drawings.

P001 380E

Dimensions • Frame Size 075 (Continued)

Continued Figure 41: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC) mm (in.)

Endcap Twin Ports, Option 8

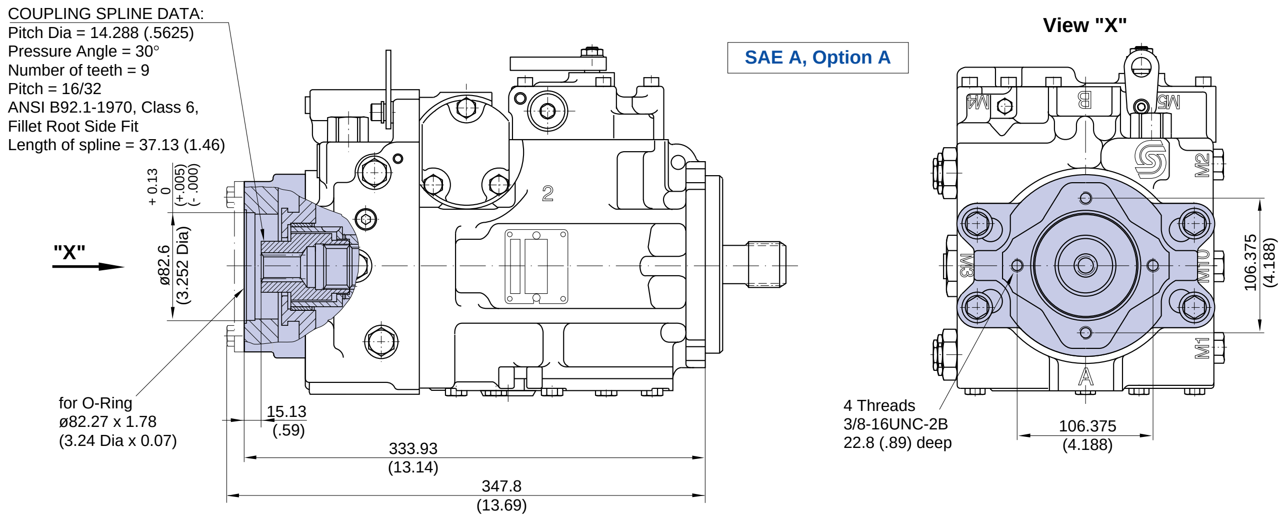


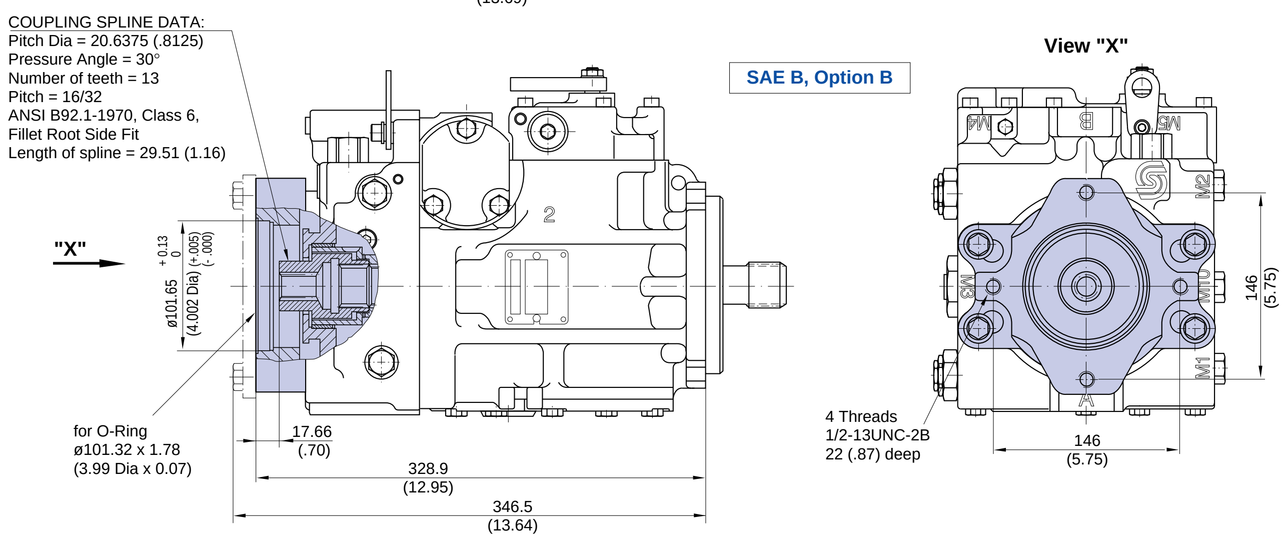
P001 381E

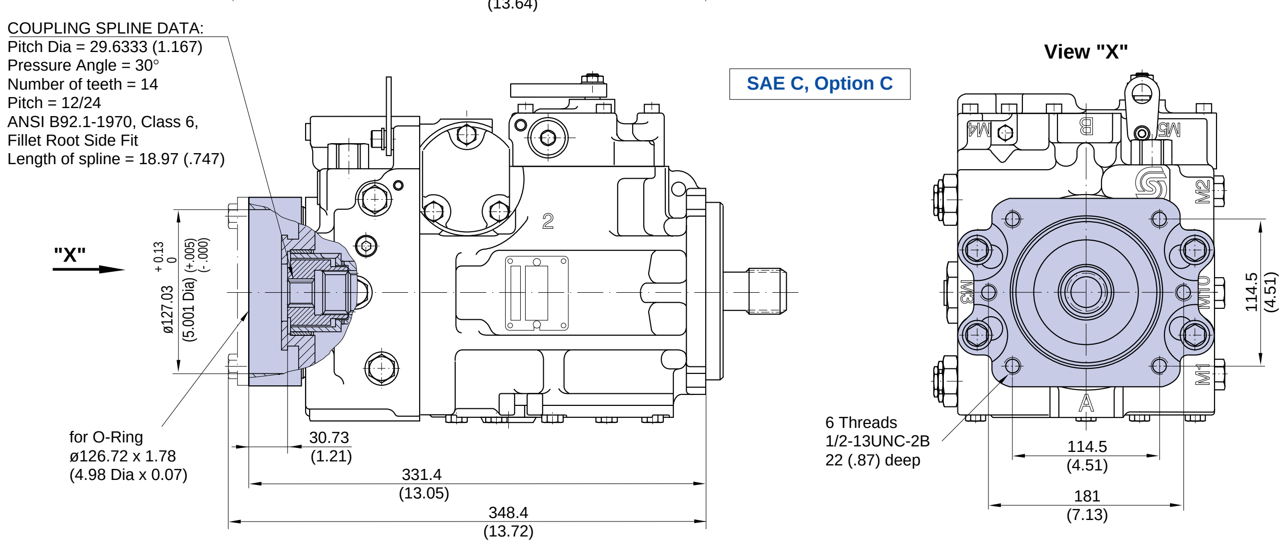
Dimensions • Frame Size 075 (Continued)

Continued Figure 41: Auxiliary Mounting Pad - Options A, B, C, V

mm
(in.)





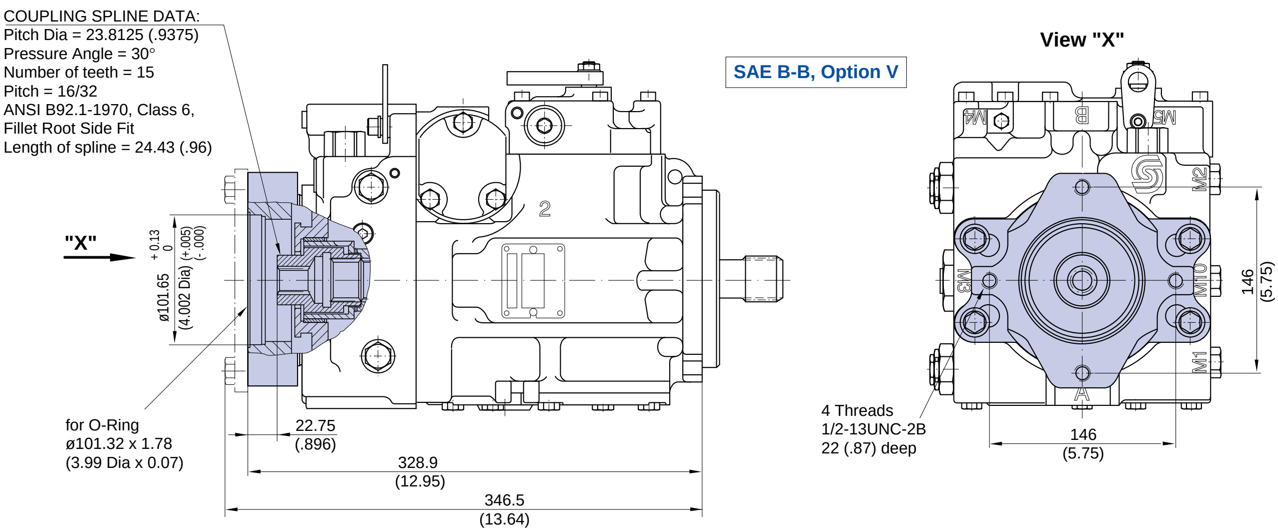


P001 384E

Dimensions • Frame Size 075 (Continued)

Continued Figure 41: Auxiliary Mounting Pad - Options A, B, C, V

mm
(in.)



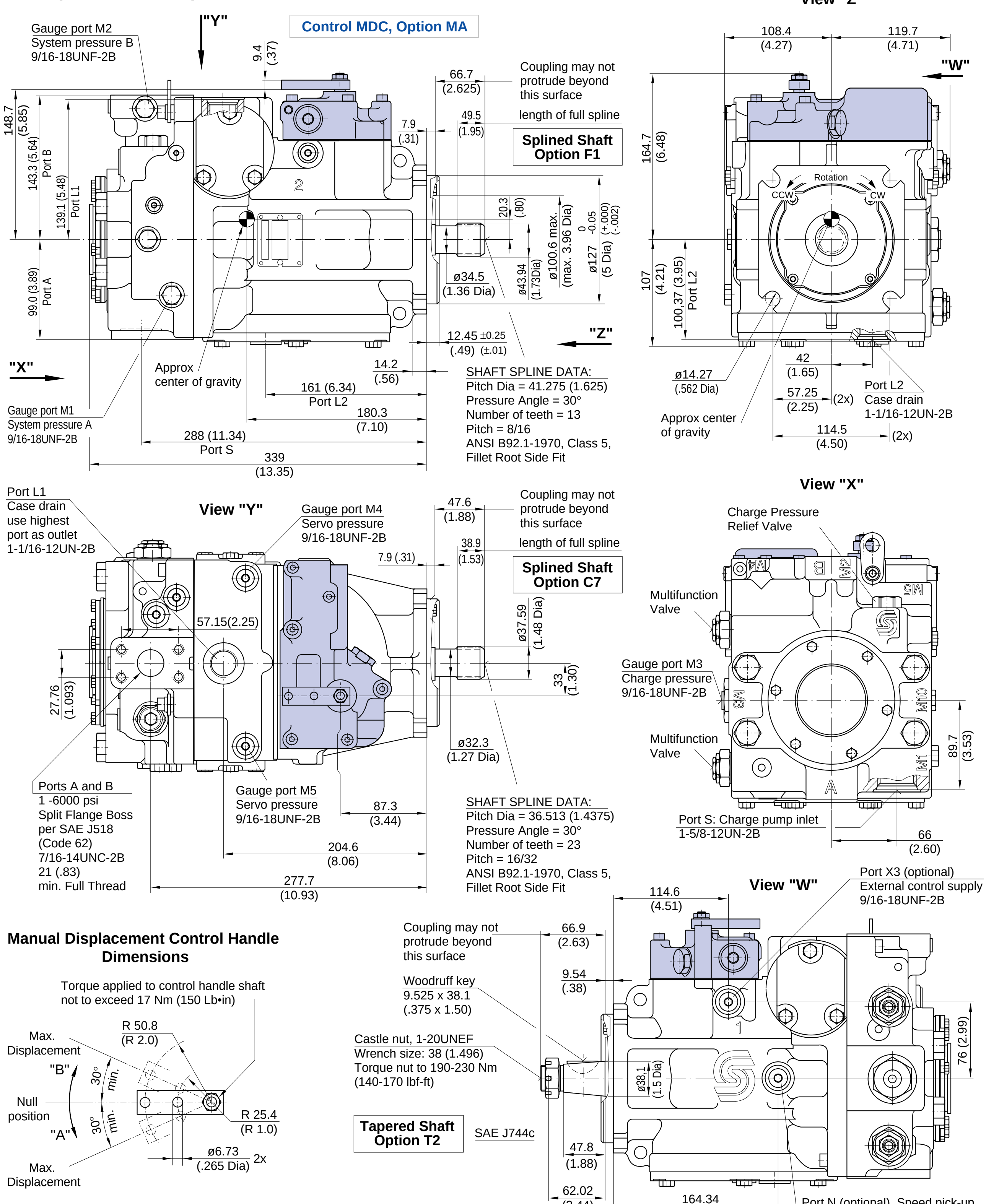
P001 384E/1

Dimensions • Frame Size 100

Figure 42: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC)

mm
(in.)

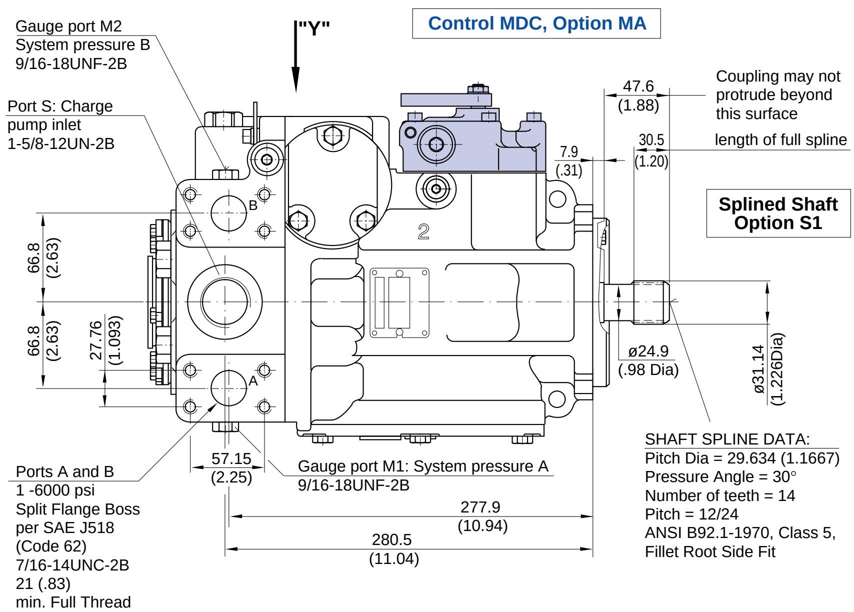
Endcap Side Ports, Option 6

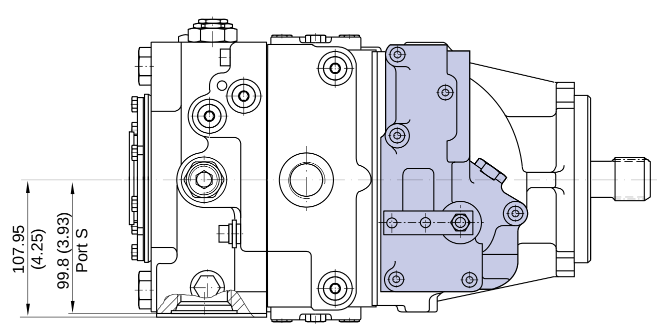


Dimensions • Frame Size 100 (Continued)

Continued Figure 42: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC) mm (in.)

Endcap Twin Ports, Option 8





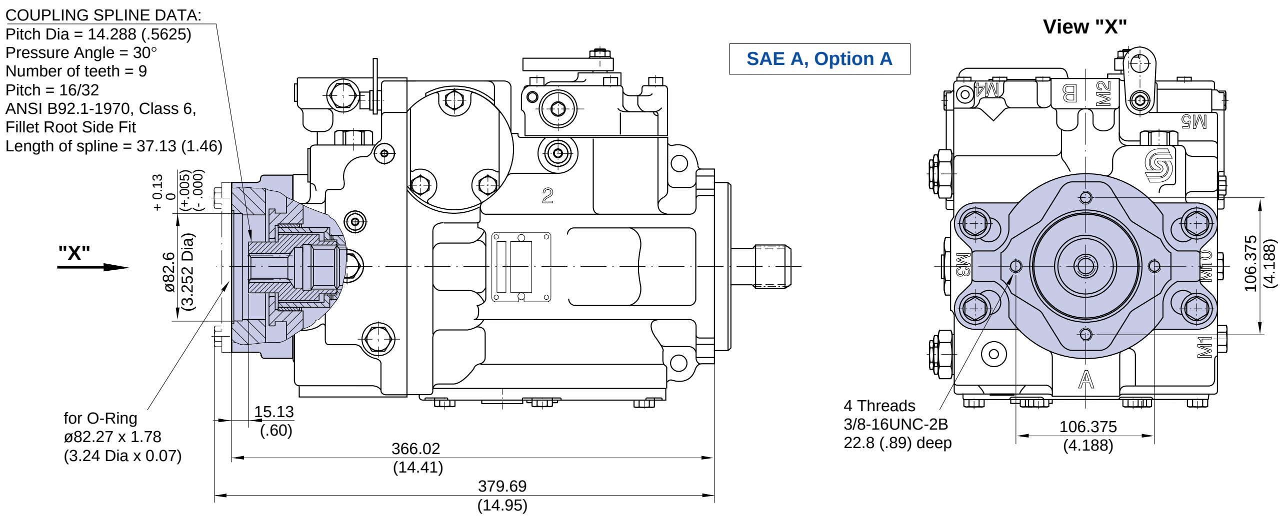
View "Y"

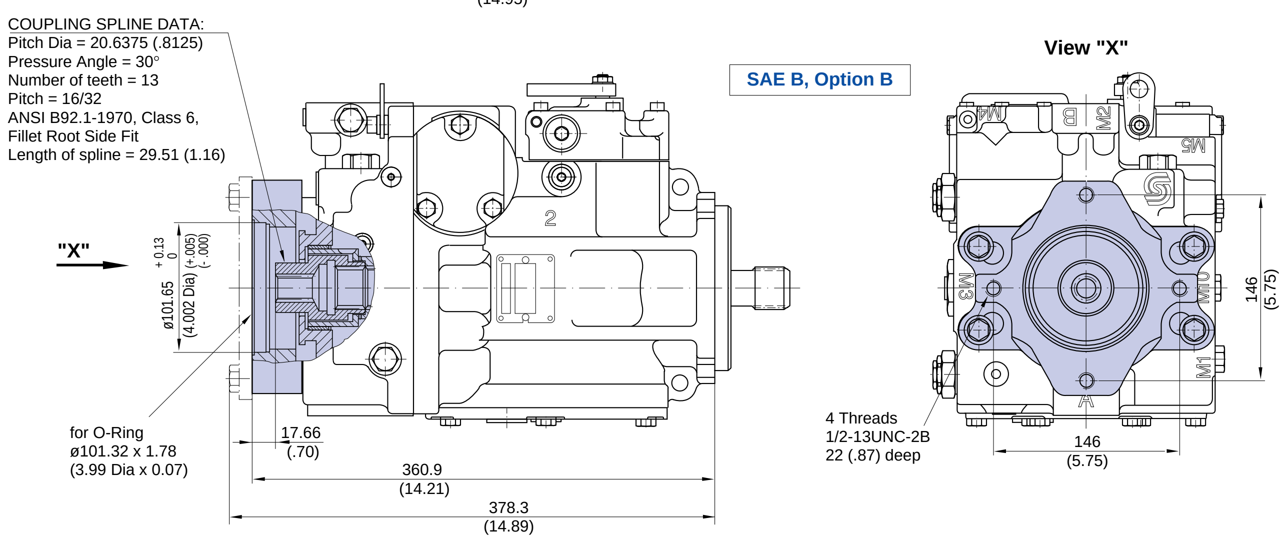
P001 378E

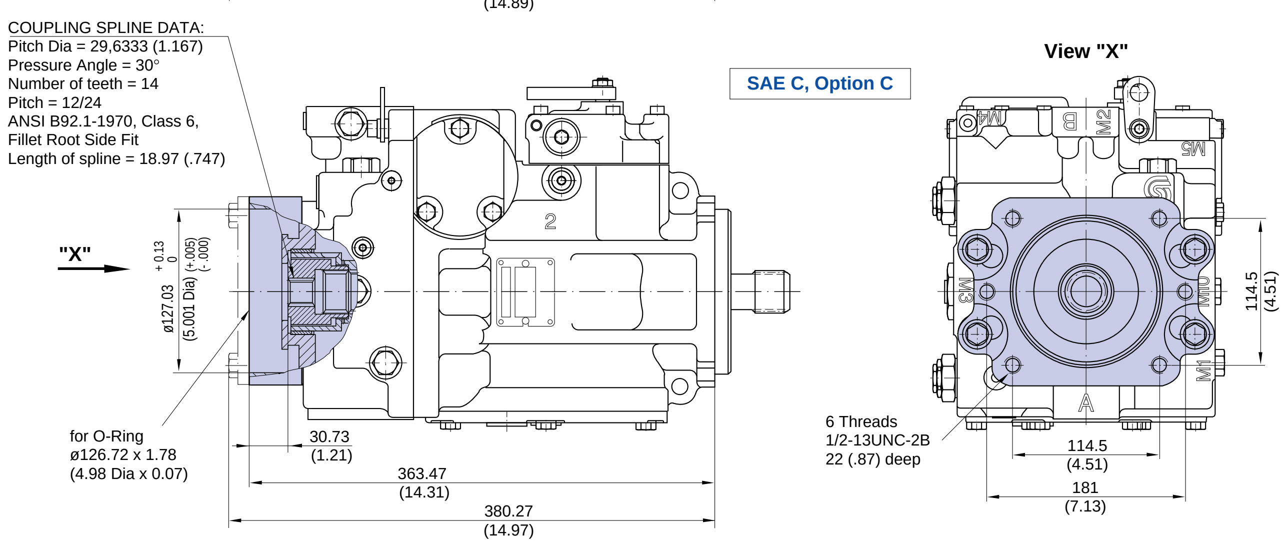
Dimensions • Frame Size 100 (Continued)

Continued Figure 42: Auxiliary Mounting Pad - Options A, B, C, V

mm
(in.)





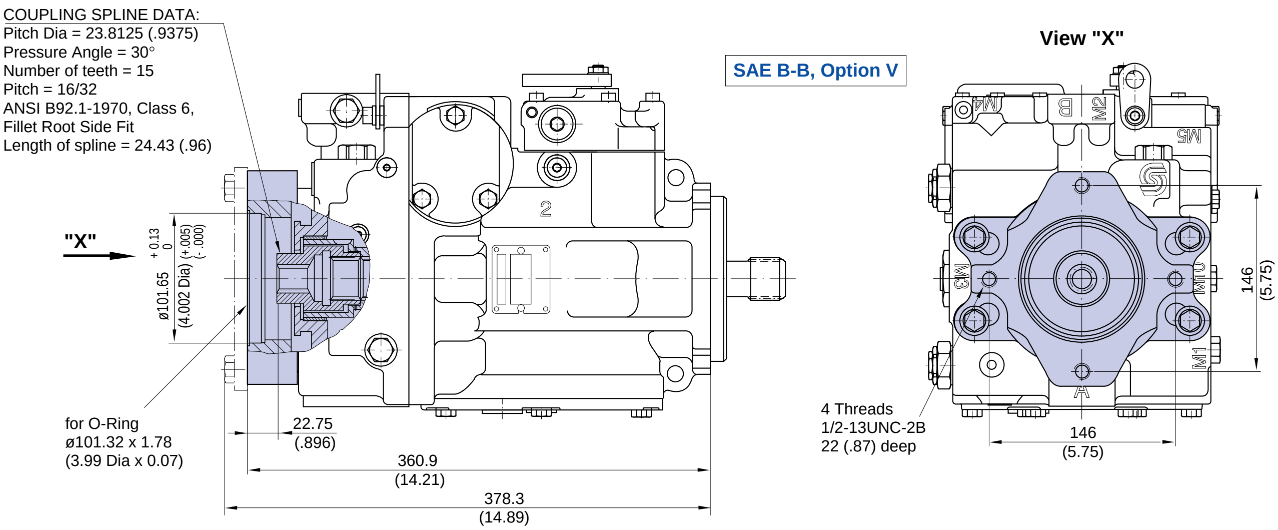


P001 379E

Dimensions • Frame Size 100 (Continued)

Continued Figure 42: Auxiliary Mounting Pad - Options A, B, C, V

mm
(in.)



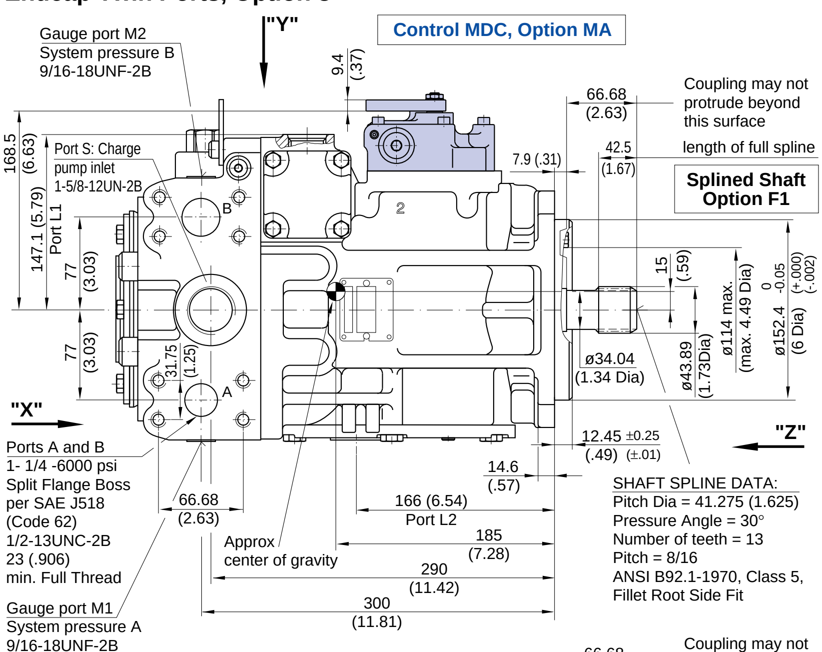
P001 379E/1

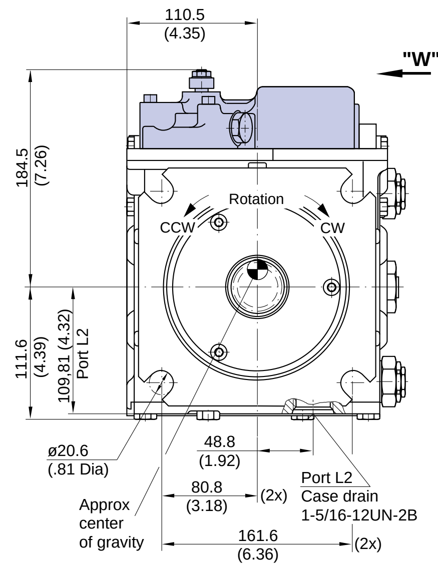
Dimensions • Frame Size 130

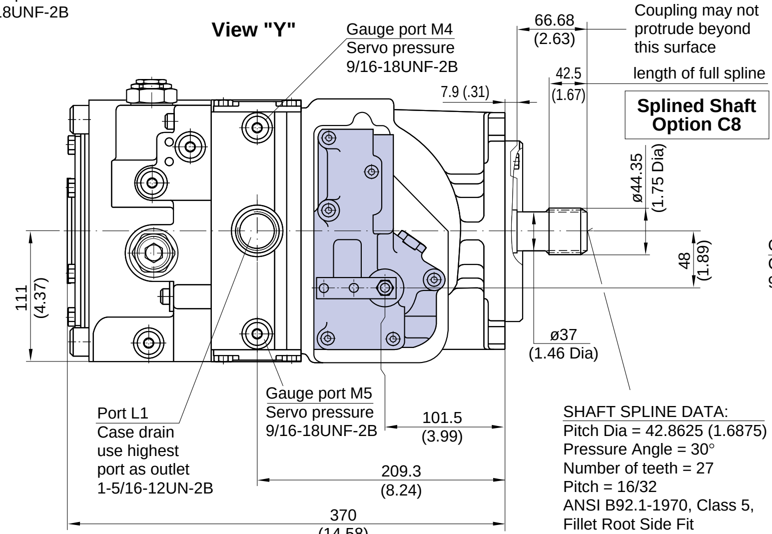
Figure 43: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC)

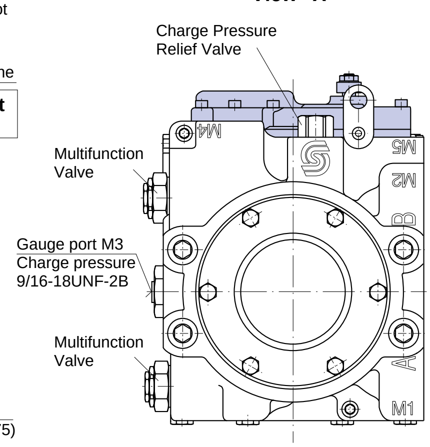
mm
(in.)

Endcap Twin Ports, Option 8

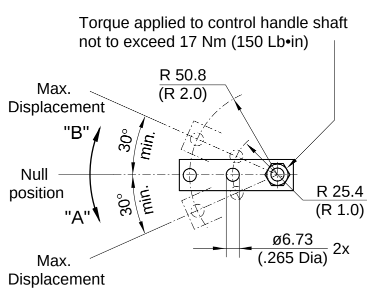


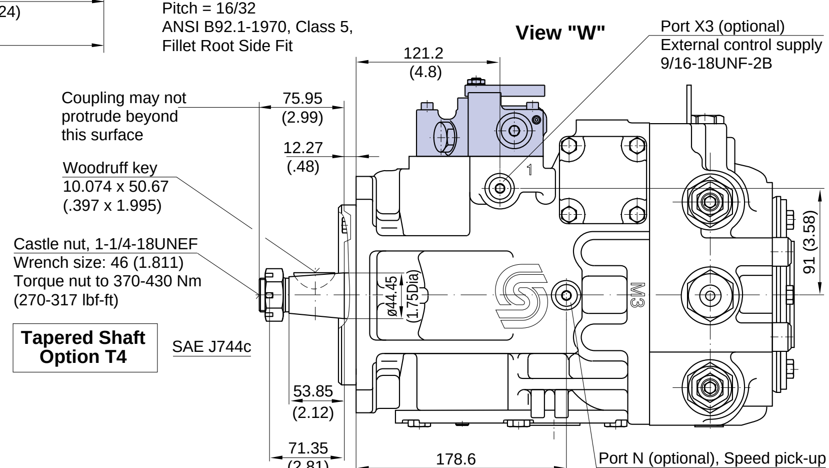






Manual Displacement Control Handle Dimensions





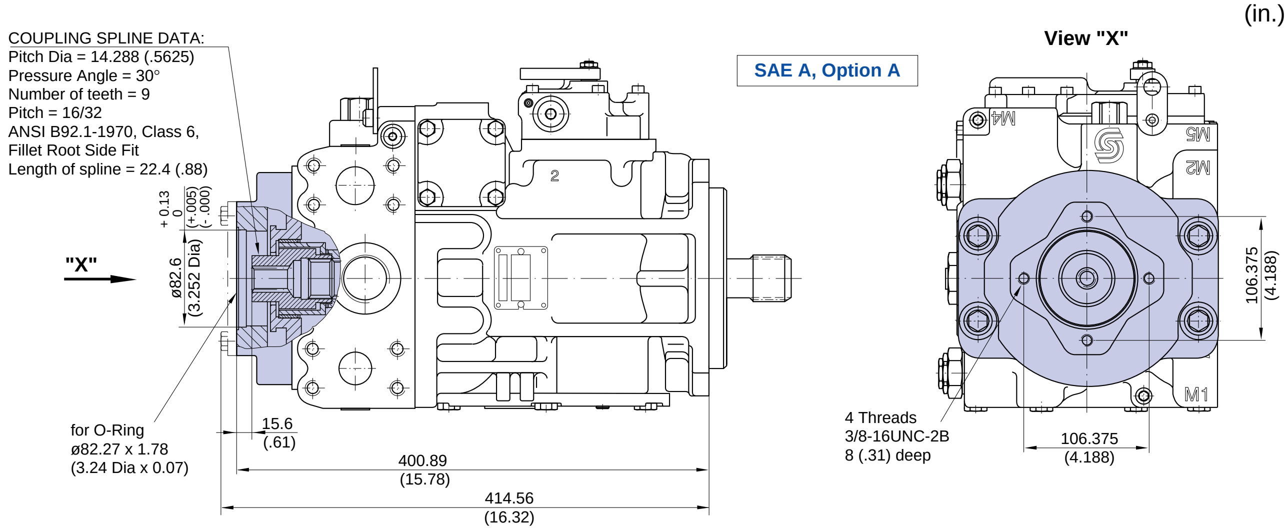
P001 373E

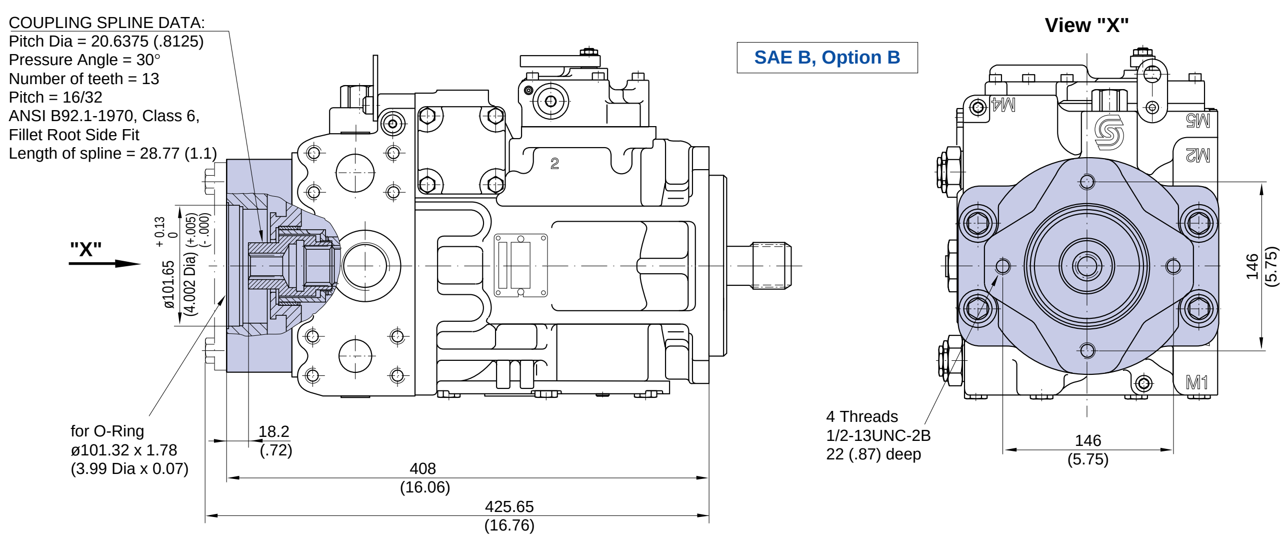
Contact SAUER-SUNDSTRAND Application Engineering for specific installation drawings.

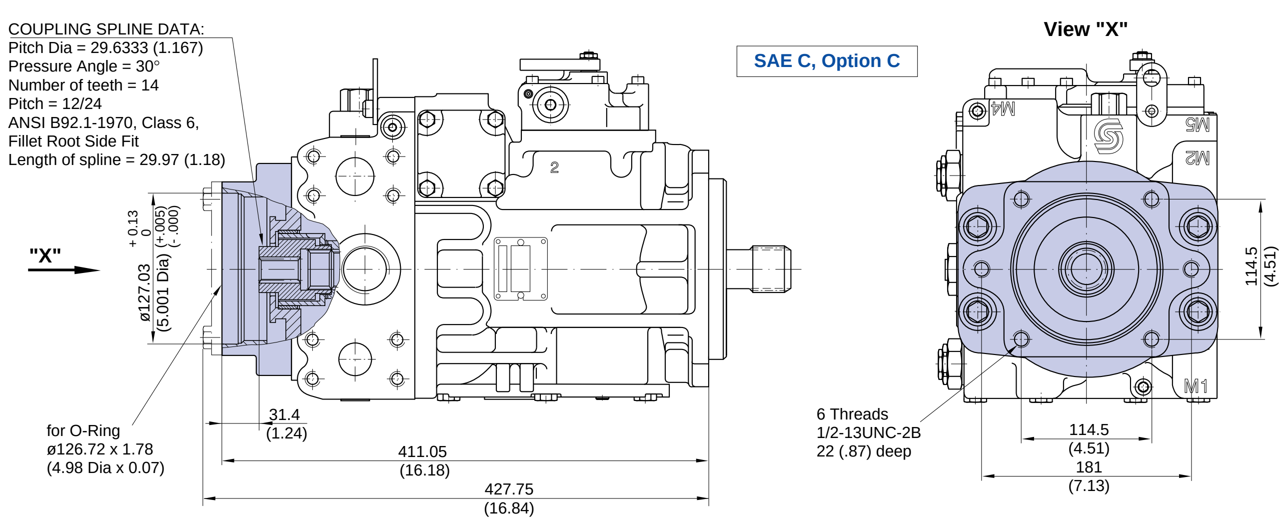
Dimensions • Frame Size 130 (Continued)

Continued Figure 43: Auxiliary Mounting Pad - Options A, B, C, D, V

mm
(in.)





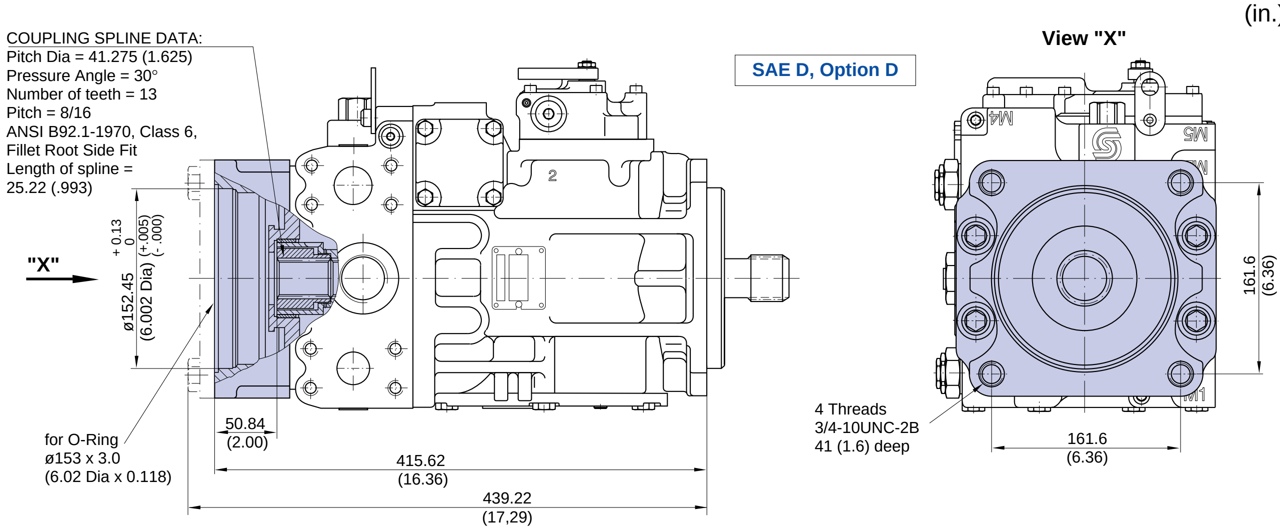


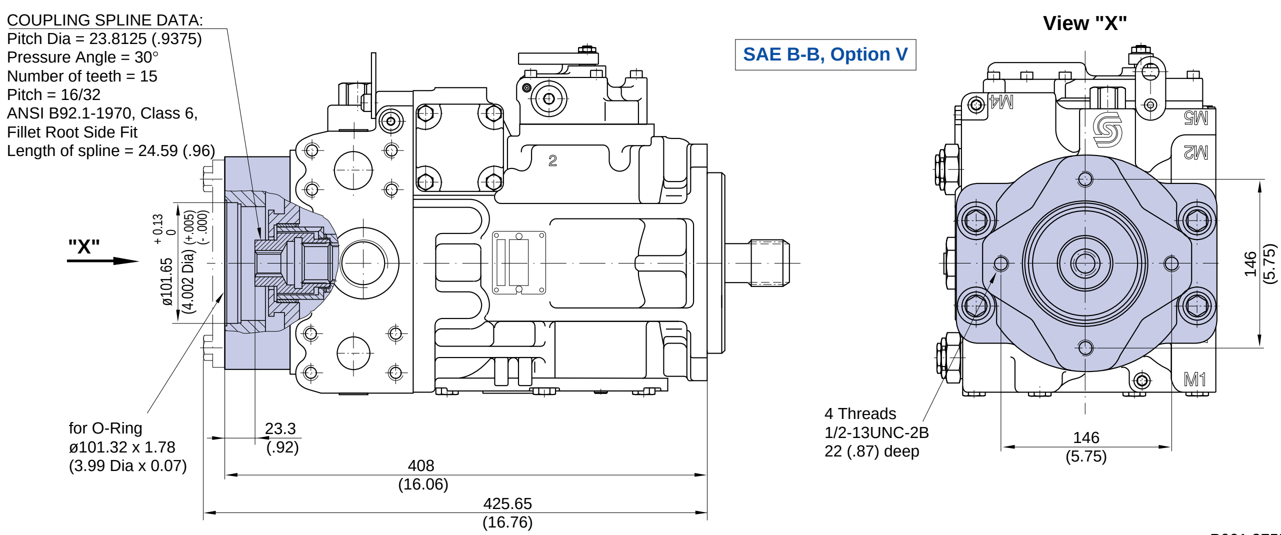
P001 374E

Dimensions • Frame Size 130 (Continued)

Continued Figure 43: Auxiliary Mounting Pad - Options A, B, C, D, V

mm
(in.)





P001 375E

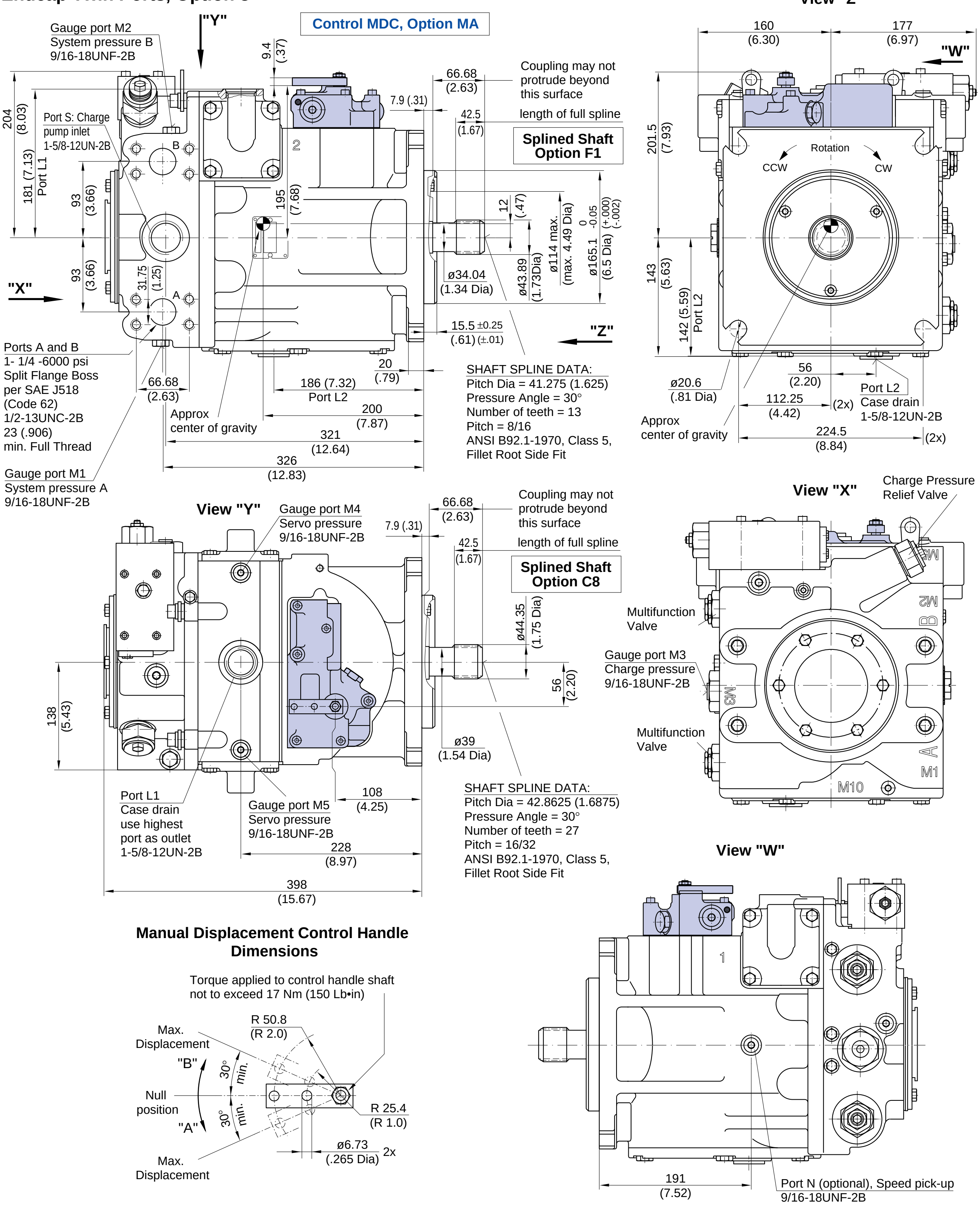
Notes

Dimensions • Frame Size 180

Figure 44: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC)

mm
(in.)

Endcap Twin Ports, Option 8



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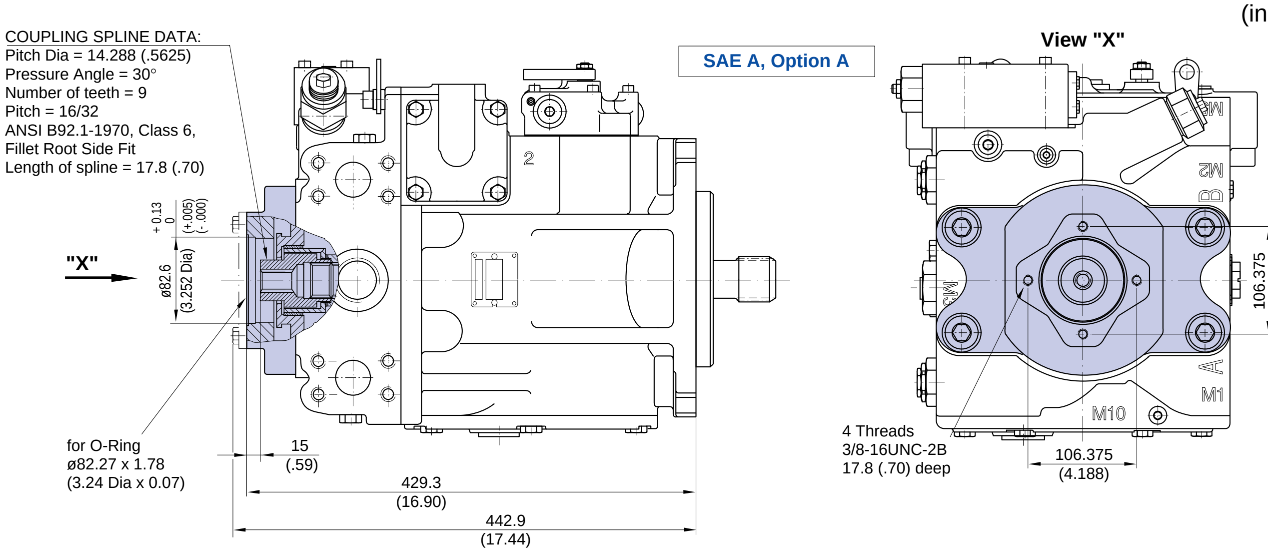
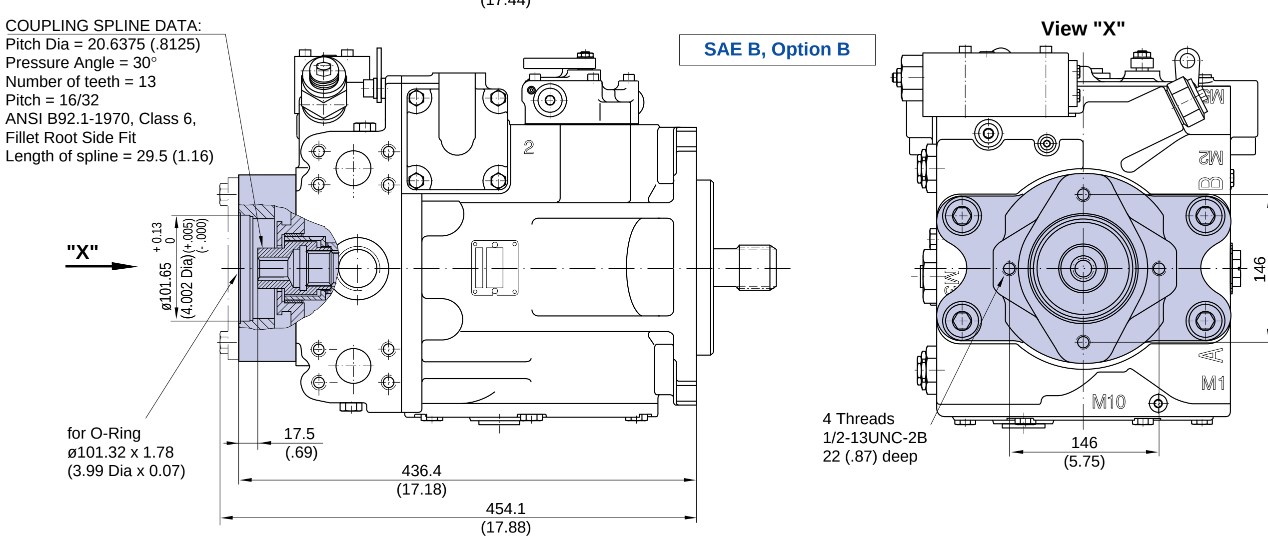
P001 376E

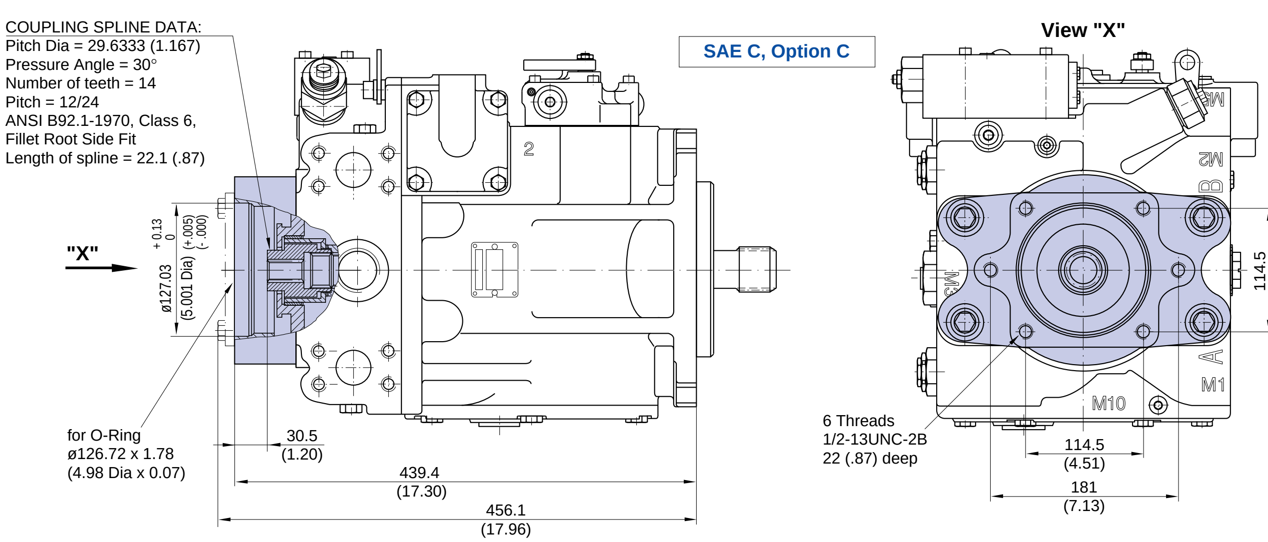
Dimensions • Frame Size 180 (Continued)

Continued Figure 44: Auxiliary Mounting Pad - Options A, B, C, D, E, H, V

mm
(in.)





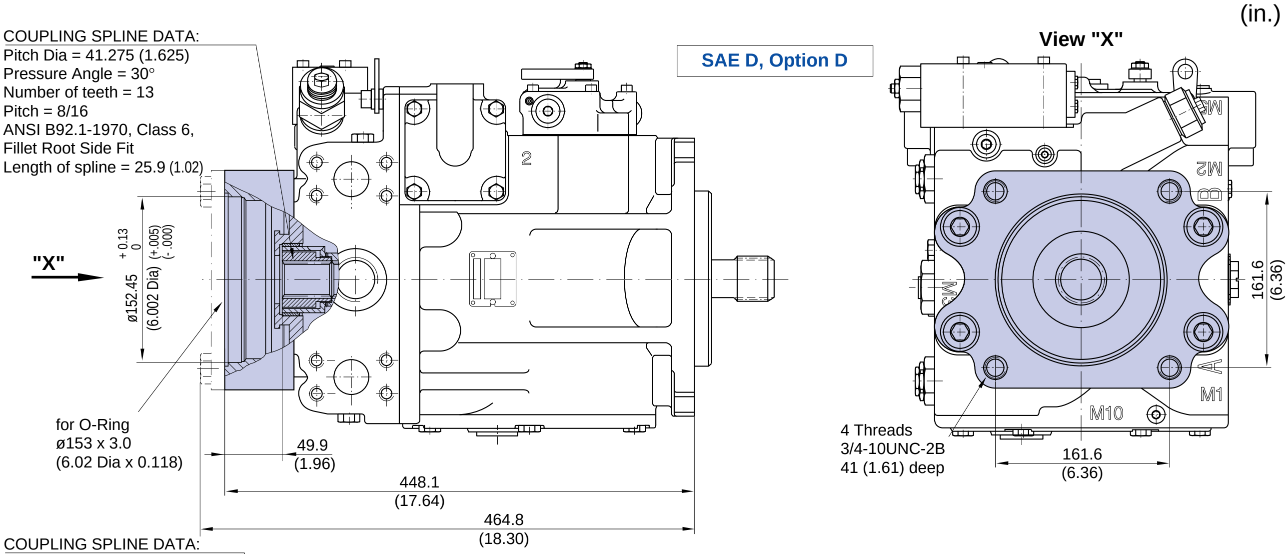


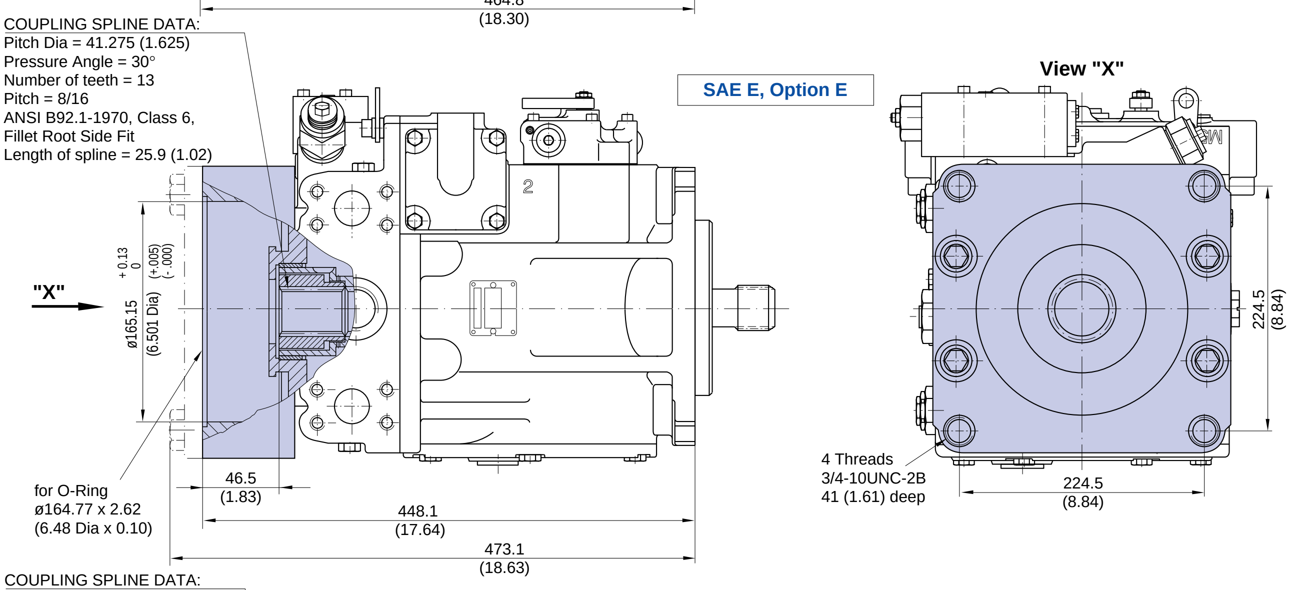
P001 388E

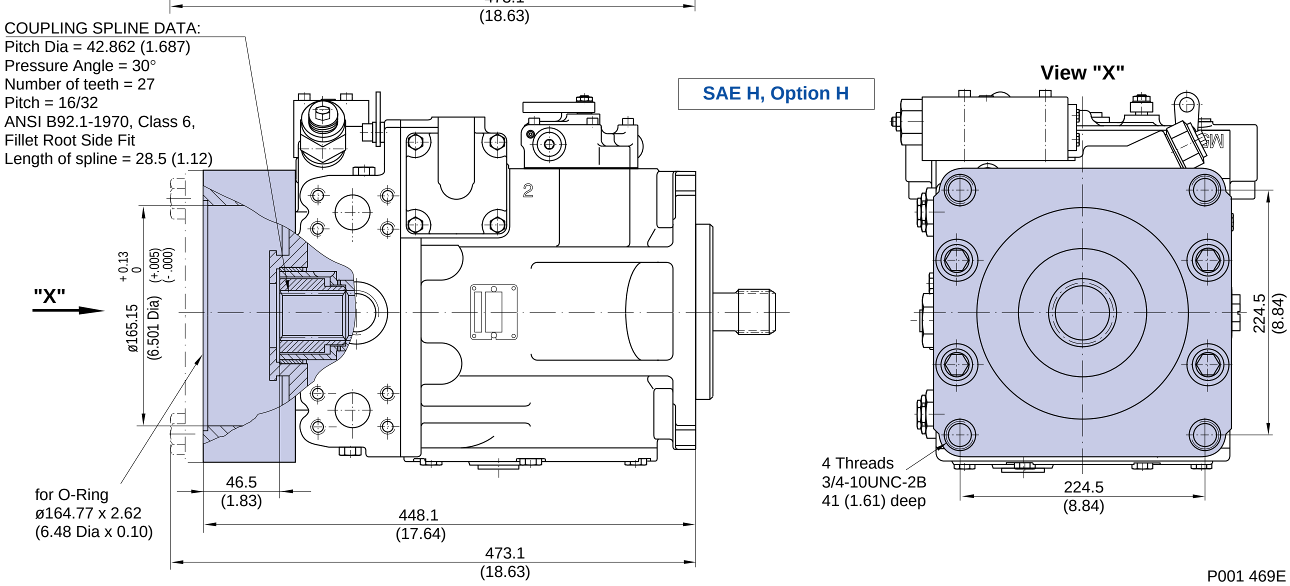
Dimensions • Frame Size 180 (Continued)

Continued Figure 44: Auxiliary Mounting Pad - Options A, B, C, D, E, H, V

mm
(in.)





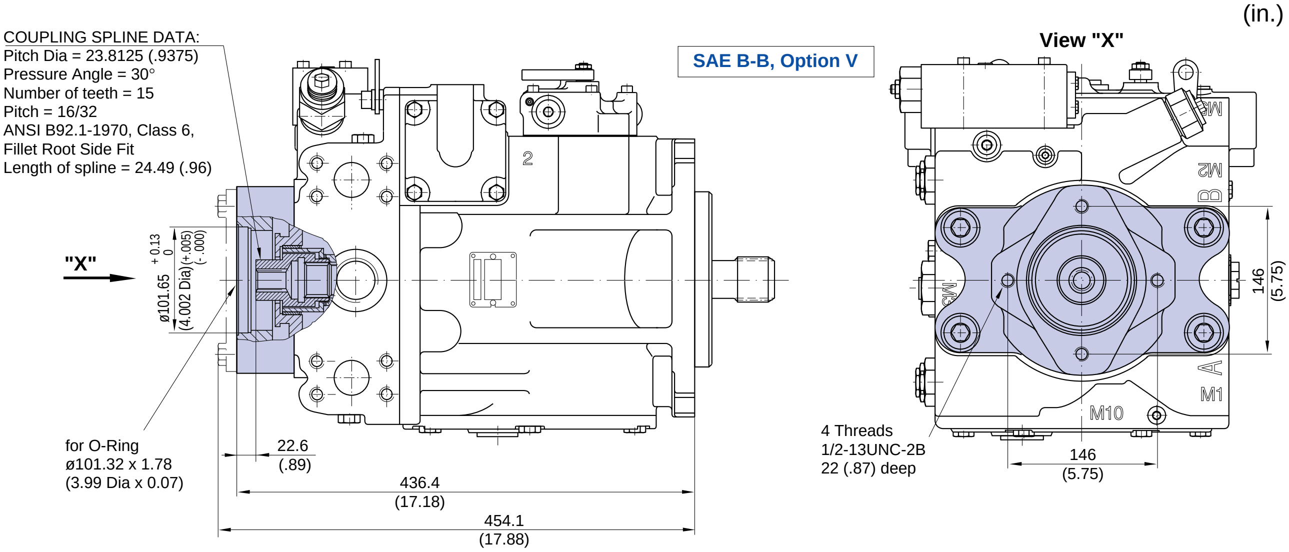


P001 469E

Dimensions • Frame Size 180 (Continued)

Continued Figure 44: Auxiliary Mounting Pad - Options A, B, C, D, E, H, V

mm
(in.)



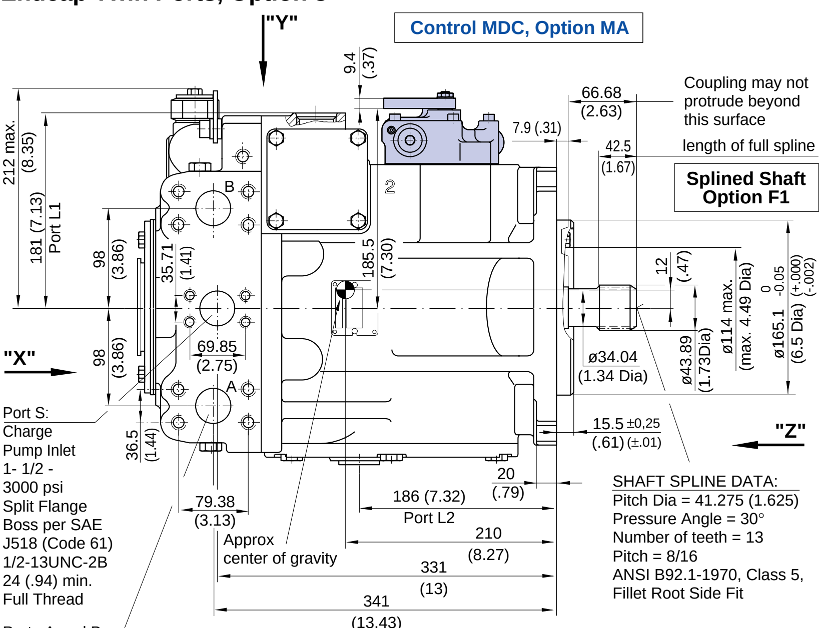
P001 469E/1

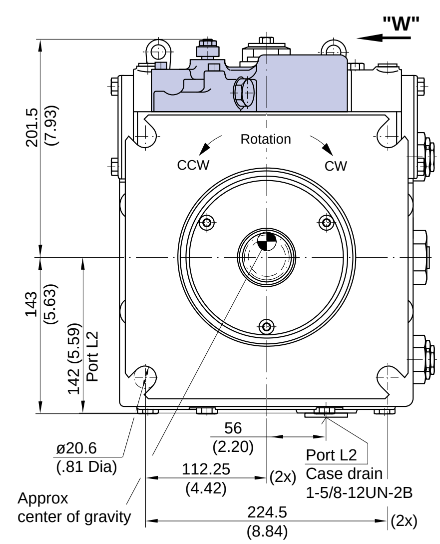
Dimensions • Frame Size 250

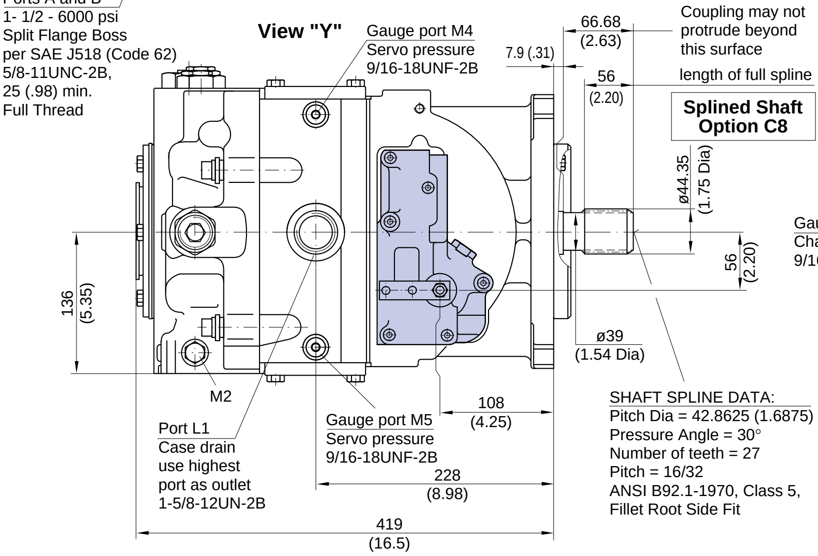
Figure 45: Axial Piston Variable Displacement Pump with Manual Displacement Control (MDC)

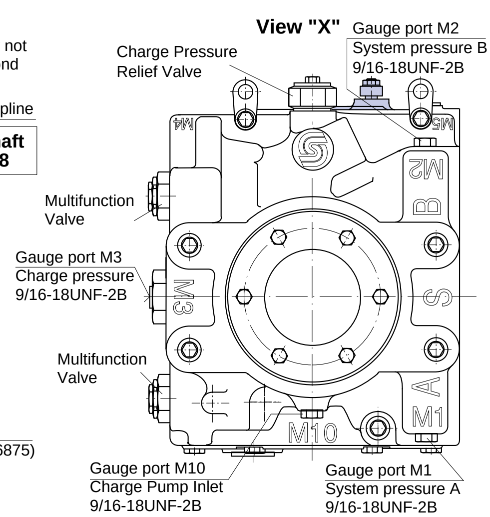
mm
(in.)

Endcap Twin Ports, Option 8

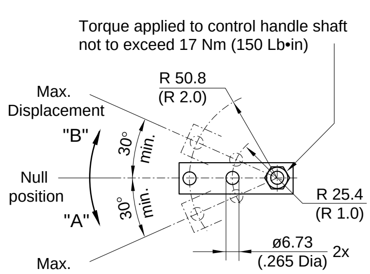


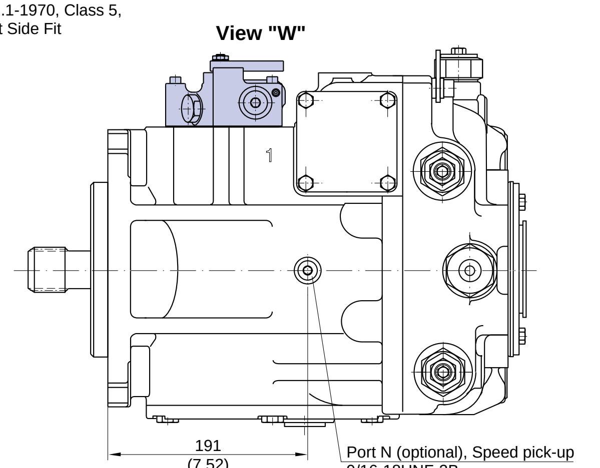






Manual Displacement Control Handle Dimensions





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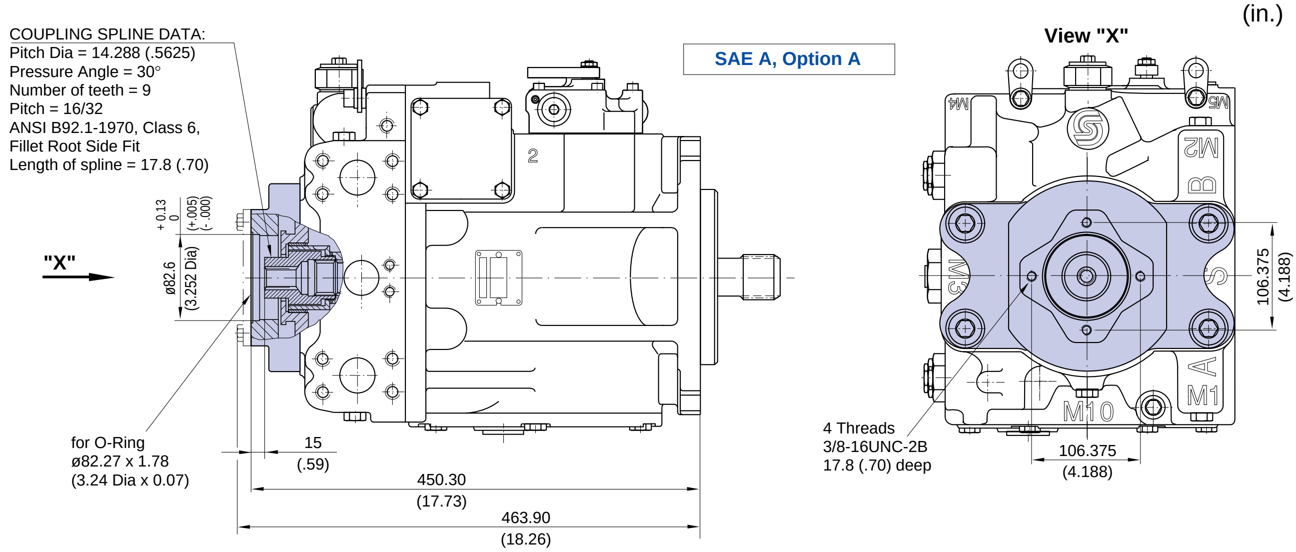
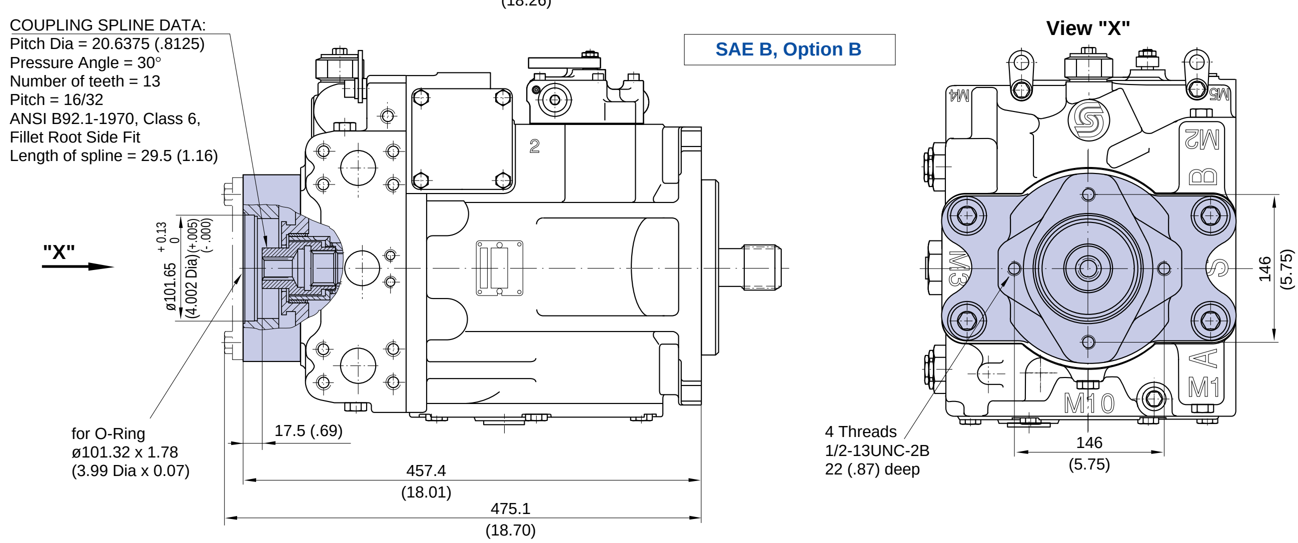
P001 465E

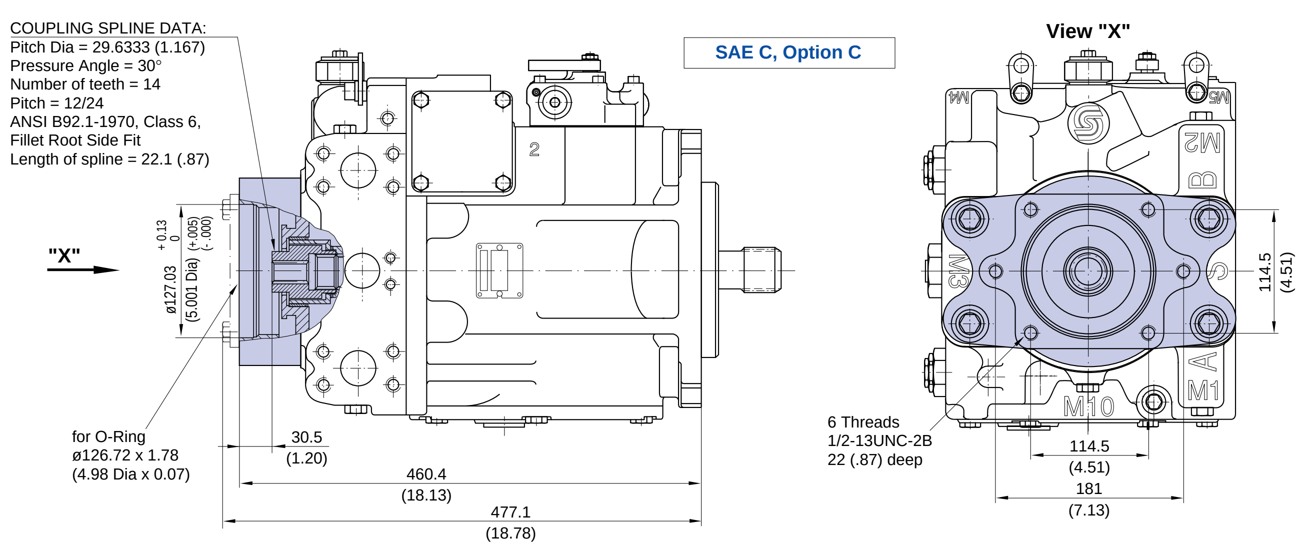
Dimensions • Frame Size 250 (Continued)

Continued Figure 45: Auxiliary Mounting Pad - Options A, B, C, D, E, H, V

mm
(in.)







P001 466E

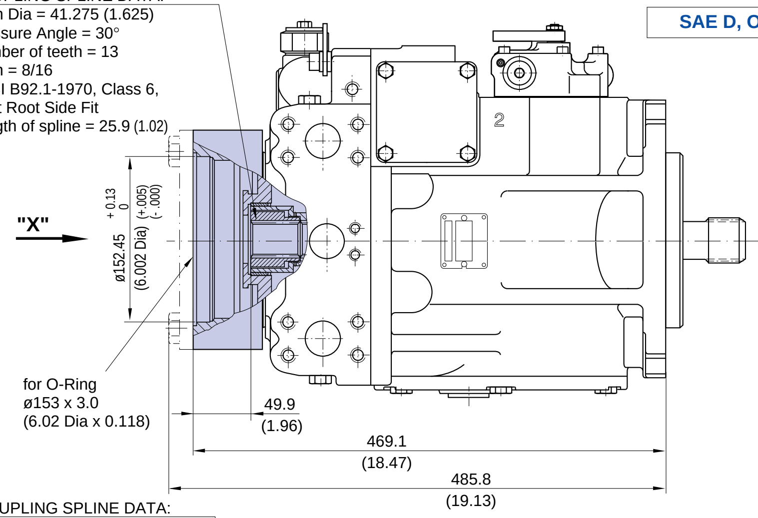
Dimensions • Frame Size 250 (Continued)

Continued Figure 45: Auxiliary Mounting Pad - Options A, B, C, D, E, H, V

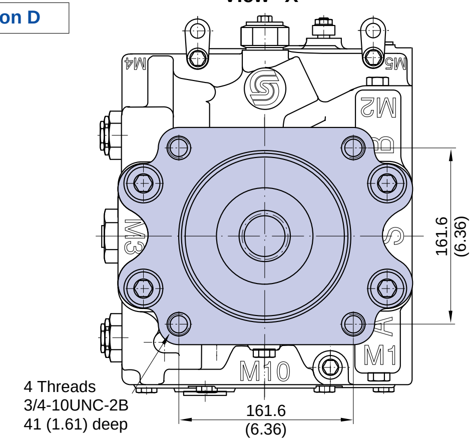
mm
(in.)

COUPLING SPLINE DATA:
Pitch Dia = 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)

SAE D, Option D

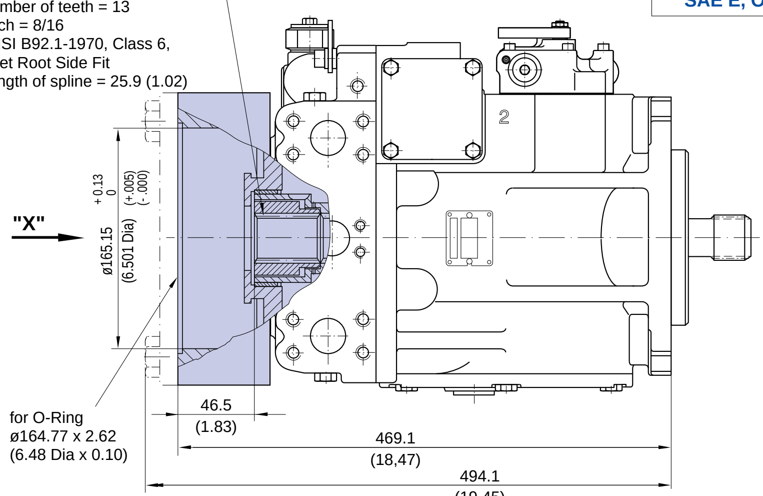


View "X"

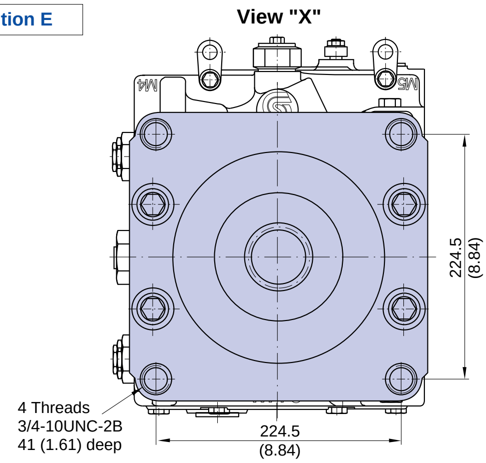


COUPLING SPLINE DATA:
Pitch Dia = 41.275 (1.625)
Pressure Angle = 30°
Number of teeth = 13
Pitch = 8/16
ANSI B92.1-1970, Class 6,
Fillet Root Side Fit
Length of spline = 25.9 (1.02)

SAE E, Option E

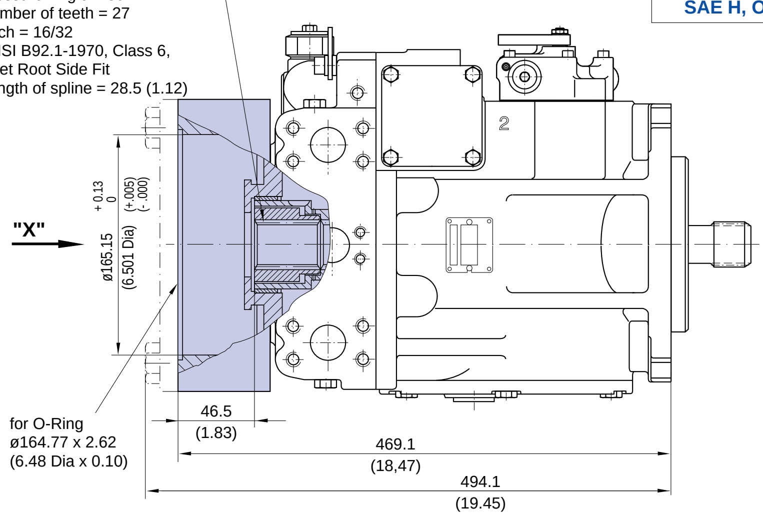


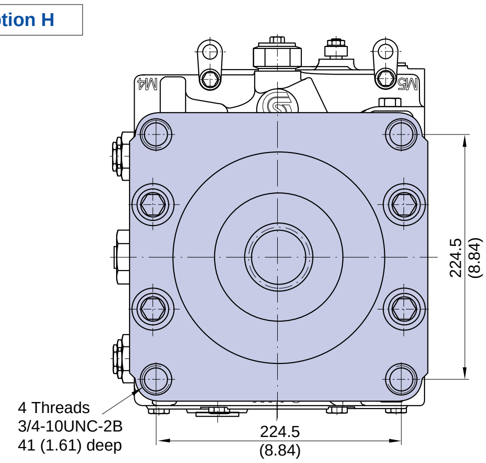
View "X"



COUPLING SPLINE DATA:
Pitch Dia = 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)

SAE H, Option H



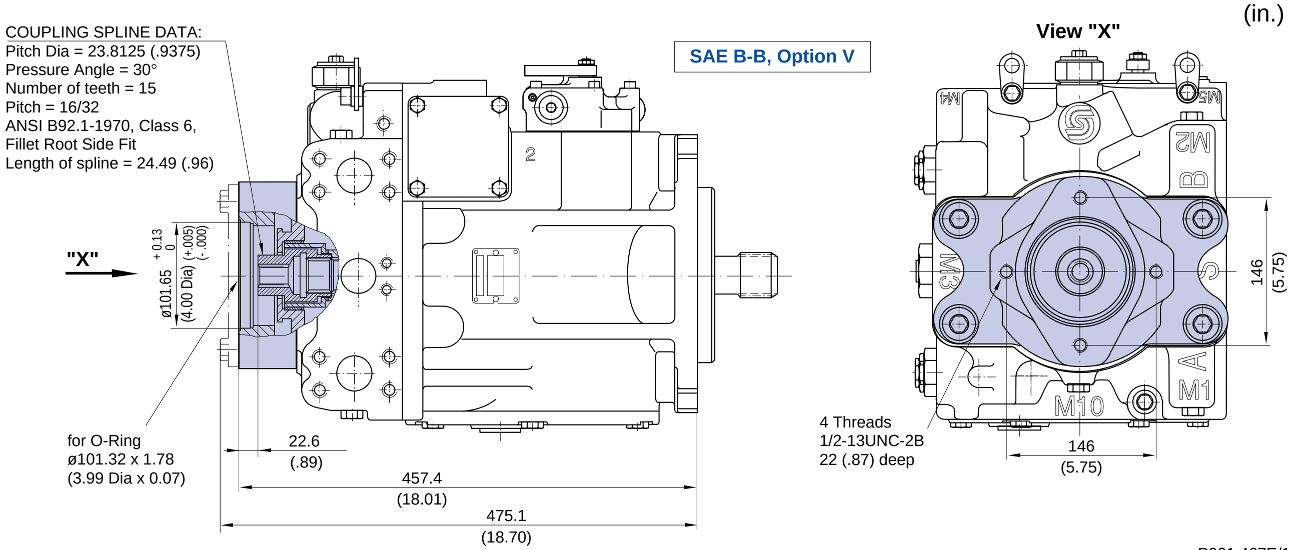


P001 467E

Dimensions • Frame Size 250 (Continued)

Continued Figure 45: Auxiliary Mounting Pad - Options A, B, C, D, E, H, V

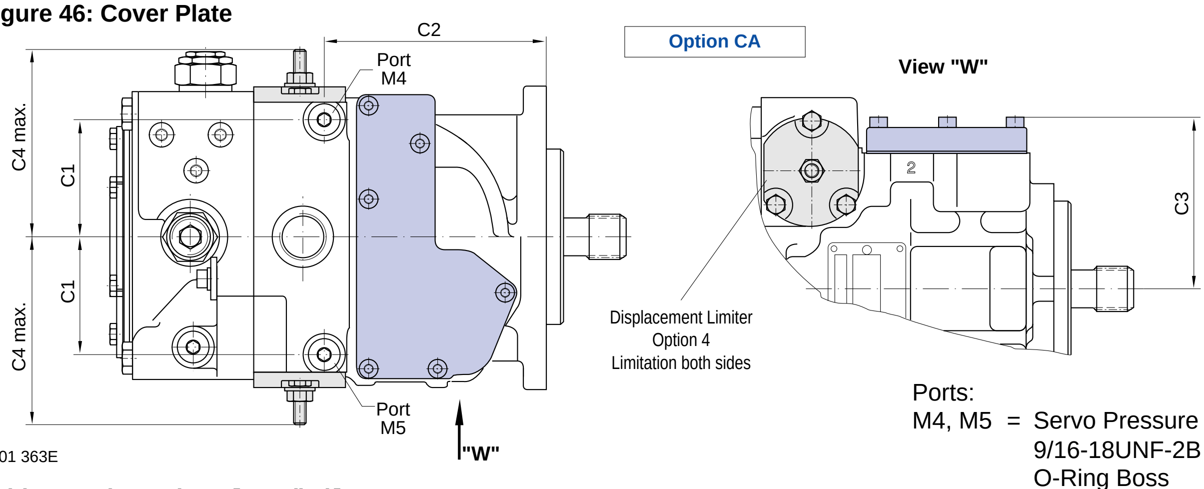
mm
(in.)



P001 467E/1

Dimensions • Controls, Displacement Limiter

Figure 46: Cover Plate

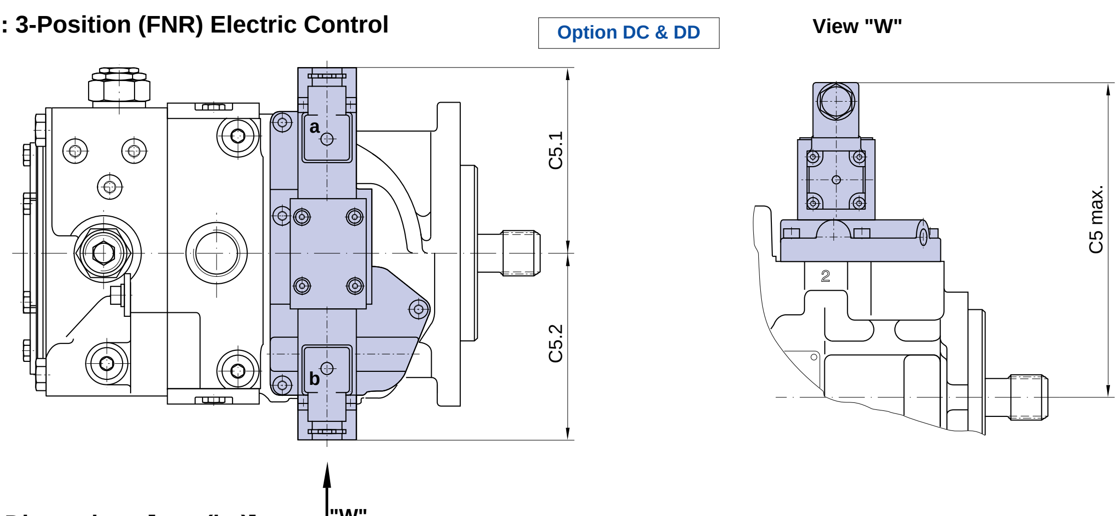


P001 363E

Table 22: Dimensions [mm (in.)]

Frame Size	C1	C2	C3	C4 max. [Option 4]
030	63.5 (2.50)	140.5 (5.53)	95.5 (3.76)	106 (4.17)
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)

Figure 47: 3-Position (FNR) Electric Control



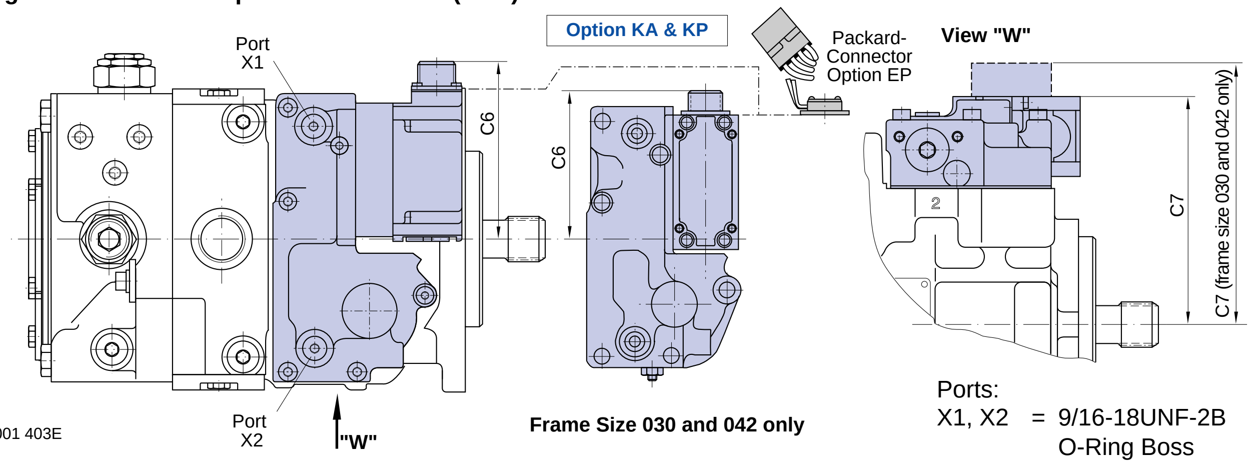
P001 399E

Table 23: Dimensions [mm (in.)]

Frame Size	C5 max.	C5.1	C5.2
030	190.5 (7.50)	110.2 (4.34)	112.8 (4.44)
042	194.5 (7.66)	110.2 (4.34)	112.8 (4.44)
055	198.6 (7.82)	110.2 (4.34)	112.8 (4.44)
075	204.4 (8.05)	110.2 (4.34)	112.8 (4.44)
100	213.3 (8.40)	101.6 (4.00)	121.4 (4.78)
130 (Option DC only)	232.2 (9.14)	116.6 (4.59)	106.4 (4.19)

Dimensions • Controls (Continued)

Figure 48: Electric Displacement Control (EDC) with MS-Connector or Packard-Connector



P001 403E

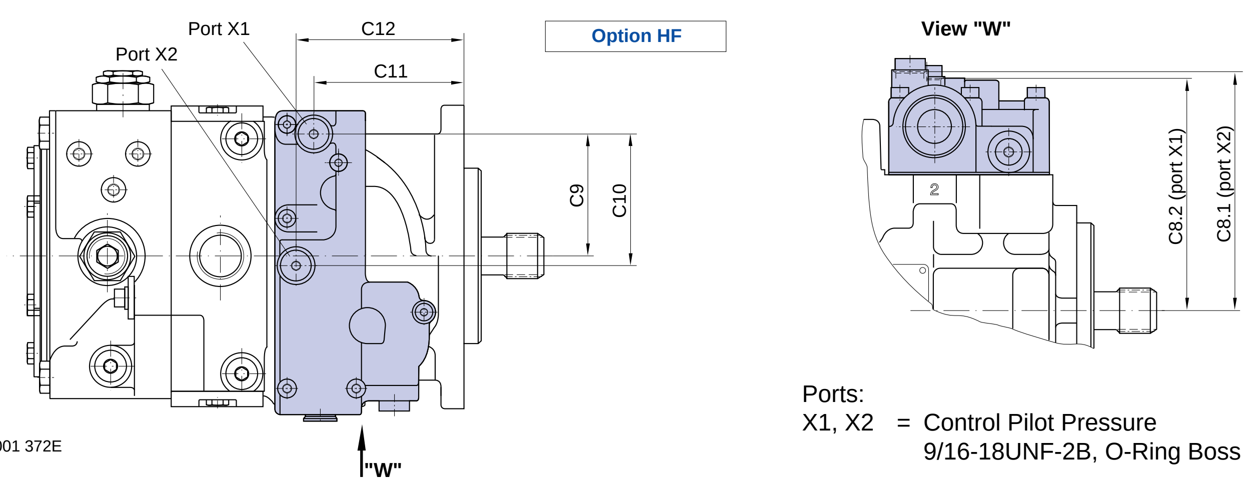
Frame Size 030 and 042 only

Ports:
X1, X2 = 9/16-18UNF-2B O-Ring Boss

Table 24: Dimensions [mm (in.)]

Frame Size	C6	C7
030	95.3 (3.75)	173.5 (6.83)
042	95.3 (3.75)	173.5 (6.83)
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 / 250	93.4 (3.68)	190.0 (7.48)

Figure 49: Hydraulic Displacement Control (HDC)



P001 372E

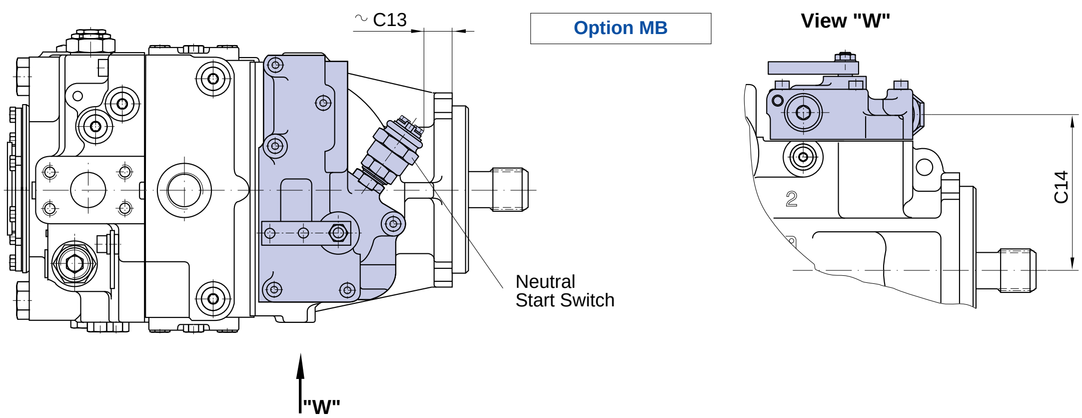
Ports:
X1, X2 = Control Pilot Pressure
9/16-18UNF-2B, O-Ring Boss

Table 25: Dimensions [mm (in.)]

Frame Size	C8.1	C8.2	C9	C10	C11	C12
030	135.0 (5.31)	131.0 (5.15)	71.0 (2.79)	75.7 (2.98)	77.6 (3.05)	87.2 (3.43)
042	139.0 (5.47)	135.0 (5.31)	71.0 (2.79)	75.7 (2.98)	89.6 (3.52)	99.2 (3.90)
055	143.0 (5.63)	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)	139.9 (5.50)	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)

Dimensions • Controls (Continued)

Figure 50: Manual Displacement Control (MDC) with Neutral Start Switch

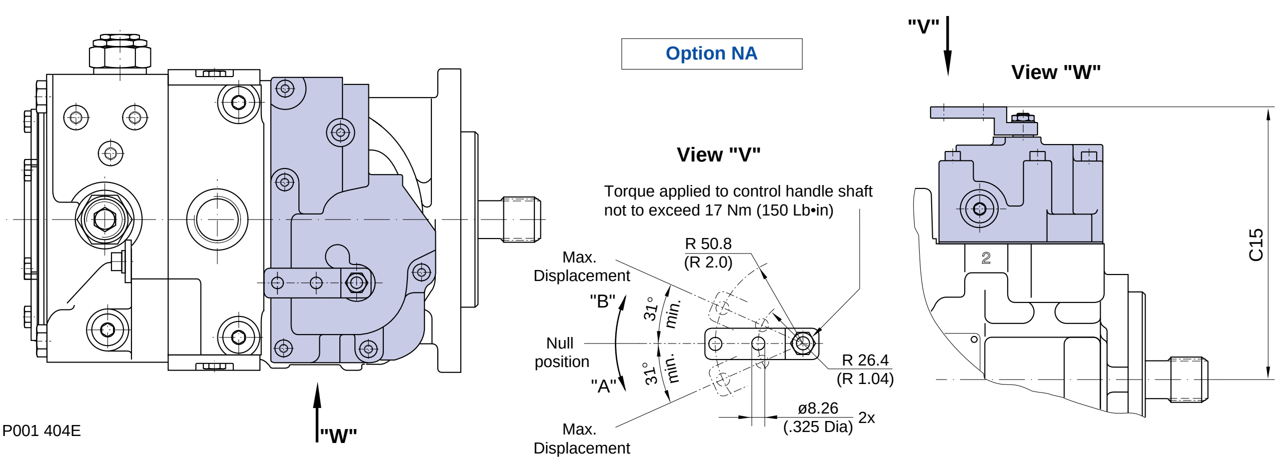


P001 364E

Table 26: Dimensions [mm (in.)]

Frame Size	~ C13	C14
042	0.4 (.016)	96.0 (3.78)
055	18.0 (.71)	100.0 (3.94)
075	25.0 (.98)	106.9 (4.21)
100	31.0 (1.22)	115.8 (4.56)
130	45.0 (1.77)	134.5 (5.29)
180	52.0 (2.04)	151.8 (5.97)
250	52.0 (2.04)	151.8 (5.97)

Figure 51: Non-Linear Manual Displacement Control (MDC)



P001 404E

Table 27: Dimensions [mm (in.)]

Frame Size	C15
075	178.9 (7.04)
100	187.8 (7.39)
130	206.7 (8.14)

Dimensions • Filtration

Figure 52: Integral Pressure Filter

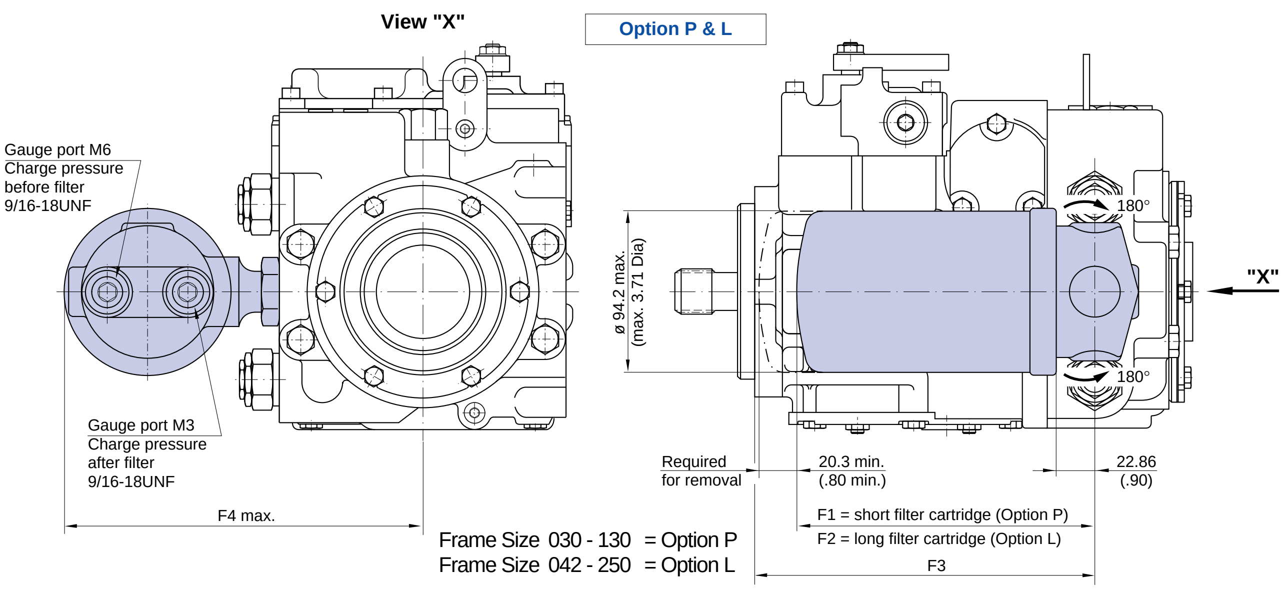
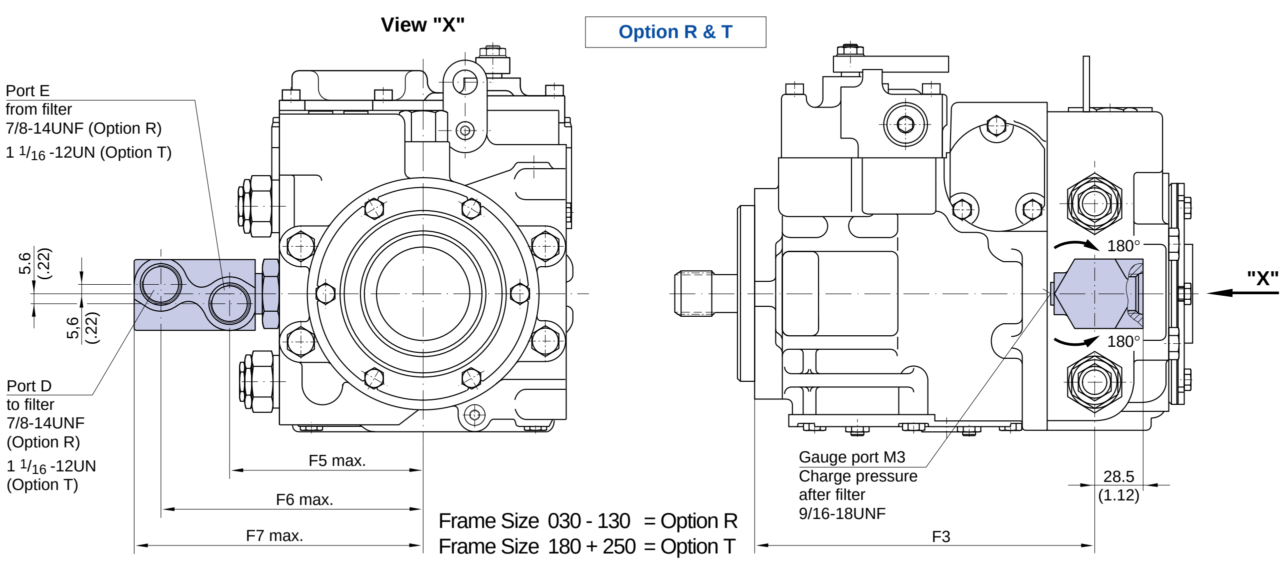


Figure 53: Remote Pressure - without filter



P001 357E

Table 28: Dimensions [mm (in.)]

Frame Size	F1	F2	F3	F4 max.	F5 max.	F6 max.	F7 max.
030	174.5 (6.87)	-	176.8 (6.96)	203.0 (7.99)	107.7 (4.24)	147.7 (5.81)	163.0 (6.42)
042	174.5 (6.87)	262.6 (10.34)	201.4 (7.93)	208.0 (8.19)	112.7 (4.44)	152.7 (6.01)	168.0 (6.61)
055	174.5 (6.87)	262.6 (10.34)	240.9 (9.48)	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)	270.5 (10.65)	214.4 (8.44)	119.1 (4.69)	159.1 (6.26)	174.4 (6.86)
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)	233.0 (9.17)	137.7 (5.42)	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)

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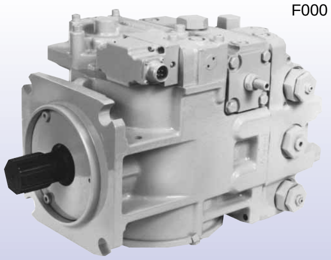
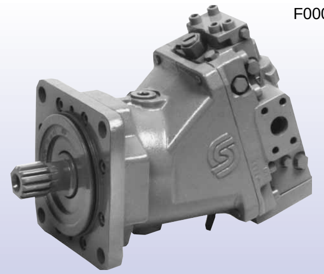


Heavy Duty Axial Piston Pumps and Motors

F000 691

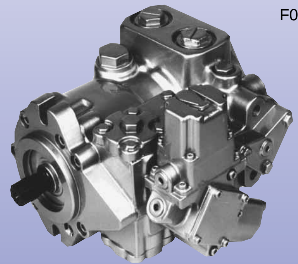


Heavy Duty Bent Axis Variable Motors

F000 686

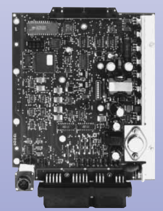
Cartridge Motors/ Compact Wheel Drives

F000 685

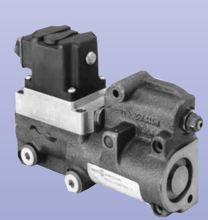


Medium Duty Axial Piston Pumps and Motors

F000 688

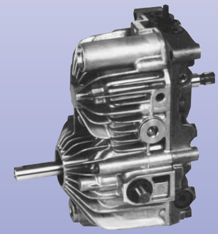


F000 690



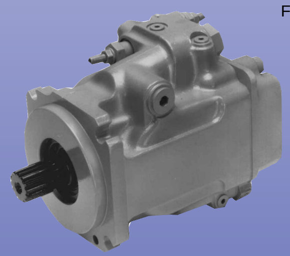
Microcontrollers and Electrohydraulic Controls

F000 684



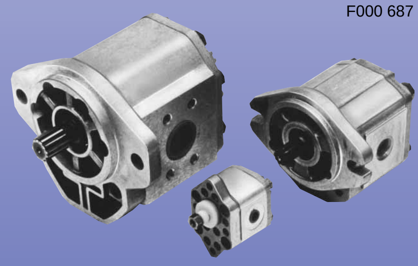
Hydrostatic Transmission Packages

F000 689



Open Circuit Axial Piston Pumps

F000 687



Gear Pumps and Motors

F000 693

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