# Series 90 Axial Piston Pumps

## Technical Information

### Revisions

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<tr>
<th>Date</th>
<th>Page</th>
<th>Changed</th>
<th>Rev.</th>
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<tr>
<td>March 2010</td>
<td>Various</td>
<td>Fix O-ring dimensions in dimension drawings</td>
<td>FE</td>
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<tr>
<td>December 2009</td>
<td>Various</td>
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<td>FD</td>
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<tr>
<td>August 2008</td>
<td>8</td>
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<td>July 2007</td>
<td>Various</td>
<td>Minor edits and dimension changes</td>
<td>FB</td>
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<tr>
<td>March 2004</td>
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<td>Revision F</td>
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Series 90 Axial Piston Pumps
Technical Information
General description

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.
Series 90 Axial Piston Pumps
Technical Information
General description

**Series 90 pump cross-section**

- **Slider block**
- **Servo piston**
- **Servo arm**
- **Displacement control**
- **Cradle bearing**
- **Charge pump**
- **Swashplate**
- **Cradle guide**
- **Piston**
- **Slipper**
- **Feedback linkage**
- **Roller bearing**
- **Shaft seal**
- **Input shaft**

**Name plate**

- **Model Code**
- **Serial Number**
- **Made in USA**
- **Place of Manufacture**

---

**Design**

- **Model Code**: 90L055
- **Serial Number**: N - 88 - 246 - 67890
- **Made in USA**
- **Place of Manufacture**: P106 648E
This configuration shows a hydrostatic transmission using a Series 90 axial piston variable displacement pump and a Series 90 fixed displacement motor.
### FEATURES AND OPTIONS

<table>
<thead>
<tr>
<th>Feature</th>
<th>Unit</th>
<th>Feature</th>
<th>Unit</th>
<th>Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement</td>
<td>cm³/rev</td>
<td>Flow at rated speed</td>
<td>l/min</td>
<td>042  055 075 100 130 180 250</td>
</tr>
<tr>
<td></td>
<td>[in³]/rev</td>
<td>(theoretical)</td>
<td>[US gal/min]</td>
<td>2.56</td>
</tr>
<tr>
<td>Torque at maximum displacement</td>
<td>N·m/bar</td>
<td></td>
<td></td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>[lbf•in/1000 psi]</td>
<td></td>
<td></td>
<td>410</td>
</tr>
<tr>
<td>Mass moment of inertia of rotating components</td>
<td>kg·m²</td>
<td></td>
<td></td>
<td>0.0023</td>
</tr>
<tr>
<td></td>
<td>[slug•ft²]</td>
<td></td>
<td></td>
<td>0.0017</td>
</tr>
<tr>
<td>Mounting (per SAE J744)</td>
<td></td>
<td></td>
<td></td>
<td>B</td>
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</table>

### OPERATING PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Parameter</th>
<th>Unit</th>
<th>Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input speed</td>
<td>min⁻¹ (rpm)</td>
<td>System pressure</td>
<td>bar [psi]</td>
<td>042  055 075 100 130 180 250</td>
</tr>
<tr>
<td>Minimum</td>
<td>500</td>
<td>Maximum</td>
<td>420  [6000]</td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>4200</td>
<td>Minimum low loop</td>
<td>10  [150]</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>4600</td>
<td>Inlet pressure (charge inlet)</td>
<td>bar (abs.)</td>
<td>0.7  [9]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>[in. Hg vac.]</td>
<td>0.2  [24]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Case pressure</td>
<td>bar [psi]</td>
<td>3  [40]</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>5  [75]</td>
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Series 90 42cc pumps are not available in North America
## FLUID SPECIFICATIONS

<table>
<thead>
<tr>
<th>Fluid Specifications</th>
<th>Minimum</th>
<th>Continuous</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Viscosity</strong> mm²/sec (cSt) [SUS]</td>
<td>7 [49]</td>
<td>12-80 [70-370]</td>
<td>1600 [7500]</td>
</tr>
<tr>
<td><strong>Temperature °C [°F]</strong></td>
<td>-40 [-40]</td>
<td>104 [220]</td>
<td>115 [240]</td>
</tr>
<tr>
<td><strong>Filtration</strong></td>
<td>18/13 or better per ISO 4406</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency (suction filtration)</td>
<td>$\beta_{10,20} = 75$ ($\beta_{10} \geq 2$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency (charge filtration)</td>
<td>$\beta_{10,20} = 75$ ($\beta_{10} \geq 10$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recommended inlet screen size</td>
<td>100-125 µm [0.0039-0.0049 in]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Series 90 Axial Piston Pumps  
Technical Information  
Operating parameters

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-9884, when determining speed limits for a particular application.

⚠️ Warning
Untended 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 ingestion 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 ratio \( \beta_x \). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a \( \beta \)-ratio within the range of \( \beta_{35-40} = 75 (\beta_{10} \geq 2) \) 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 \( \beta \)-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 \( \beta_x \)-ratio is a measure of filter efficiency defined by ISO 4572. It is defined as the ratio of the number of particles greater than a given diameter ("x" in microns) upstream of the filter to the number of these particles downstream of the filter.
Series 90 Axial Piston Pumps
Technical Information

System design parameters

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.

**SI units**

Output flow \( Q = \frac{V_s \cdot n \cdot \eta_v}{1000} \quad \text{(l/min)} \)

Input torque \( M = \frac{V_s \cdot \Delta p}{20 \cdot \pi \cdot \eta_m} \quad \text{(N\cdotm)} \)

Input power \( P = \frac{M \cdot n \cdot \pi}{30 \,000} = \frac{Q \cdot \Delta p}{600 \cdot \eta_t} \quad \text{(kW)} \)

**US units**

Output flow \( Q = \frac{V_s \cdot n \cdot \eta_v}{231} \quad \text{(US gal/min)} \)

Input torque \( M = \frac{V_s \cdot \Delta p}{2 \cdot \pi \cdot \eta_m} \quad \text{(lbf\cdotin)} \)

Input power \( P = \frac{M \cdot n \cdot \pi}{198 \,000} = \frac{Q \cdot \Delta p}{1714 \cdot \eta_t} \quad \text{(hp)} \)

\( V_s \) = Displacement per revolution (cm\(^3\)/rev)

\( \Delta p \) = \( p_o - p_i \) (system pressure) (bar)

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

\( \eta_v \) = Volumetric efficiency

\( \eta_m \) = Mechanical efficiency

\( \eta_t \) = Overall efficiency (\( \eta_v \cdot \eta_m \))
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 ($R_e$), is based on the maximum external moment ($M_e$), and the distance ($L$) from the mounting flange to the load. It may be determined using the table and formula below. Thrust (axial) load limits are also shown.

$$R_e = \frac{M_e}{L}$$

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 ($R_e$).
- 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.

### Allowable external shaft load

<table>
<thead>
<tr>
<th>Parameter</th>
<th>042</th>
<th>055</th>
<th>075</th>
<th>100</th>
<th>130</th>
<th>180</th>
<th>250</th>
</tr>
</thead>
<tbody>
<tr>
<td>External moment ($M_e$)</td>
<td>126</td>
<td>118</td>
<td>126</td>
<td>140</td>
<td>161</td>
<td>176</td>
<td>176</td>
</tr>
<tr>
<td>N·m [lb·ft]</td>
<td>[1114]</td>
<td>[1043]</td>
<td>[1114]</td>
<td>[1238]</td>
<td>[1424]</td>
<td>[1556]</td>
<td></td>
</tr>
<tr>
<td>Maximum shaft thrust in ($T_{in}$)</td>
<td>2635</td>
<td>3340</td>
<td>4300</td>
<td>5160</td>
<td>5270</td>
<td>7000</td>
<td>7826</td>
</tr>
<tr>
<td>N [lbf]</td>
<td>[592]</td>
<td>[750]</td>
<td>[996]</td>
<td>[1160]</td>
<td>[1184]</td>
<td>[1573]</td>
<td>[1759]</td>
</tr>
<tr>
<td>Maximum shaft thrust out ($T_{out}$)</td>
<td>1020</td>
<td>910</td>
<td>930</td>
<td>1000</td>
<td>688</td>
<td>1180</td>
<td>1693</td>
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<tr>
<td>N [lbf]</td>
<td>[229]</td>
<td>[204]</td>
<td>[209]</td>
<td>[224]</td>
<td>[154]</td>
<td>[265]</td>
<td>[380]</td>
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### SHAFT AVAILABILITY AND TORQUE RATINGS

**Shaft availability and torque ratings**

<table>
<thead>
<tr>
<th>Shaft description and option code</th>
<th>Shaft availability and torque ratings N(\cdot)m [lbf(\cdot)in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 teeth 16/32 pitch spline C3</td>
<td>530 [4700]</td>
</tr>
<tr>
<td>19 teeth 16/32 pitch spline C5</td>
<td>900 [8000]</td>
</tr>
<tr>
<td>21 teeth 16/32 pitch spline C6</td>
<td>—  1130 [10 000]</td>
</tr>
<tr>
<td>23 teeth 16/32 pitch spline C7</td>
<td>—  1580 [14 000]</td>
</tr>
<tr>
<td>27 teeth 16/32 pitch spline C8</td>
<td>—  2938 [26 000]</td>
</tr>
<tr>
<td>13 teeth 8/16 pitch spline F1</td>
<td>—  1810 [16 000]</td>
</tr>
<tr>
<td>14 teeth 12/24 pitch spline S1</td>
<td>—  735 [6500]</td>
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<tr>
<td>1.375 Str key K1</td>
<td>—  768* [6800]</td>
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<tr>
<td>1.5 Str key K2</td>
<td>—  1130* [10 000]</td>
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<td>1.75 Str key K3</td>
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<td>1.375 tapered T1</td>
<td>—  768* [6800]</td>
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<tr>
<td>1.75 tapered T4</td>
<td>—  1582* [14 000]</td>
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<tr>
<td>1.00 tapered T3</td>
<td>497* [4400]</td>
</tr>
</tbody>
</table>

**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

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

Through torque diagram

Torque required by auxiliary pumps is additive. Ensure requirements don’t exceed shaft torque ratings.
Series 90 Axial Piston Pumps
Technical Information
Features and options

**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.

**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.

**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 Location**

<table>
<thead>
<tr>
<th>Pump Rotation</th>
<th>Displacement Limiter Mounted on Servo Side</th>
<th>Displacement Limitation at High Pressure Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>1 A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 B</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>1 B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 A</td>
<td></td>
</tr>
</tbody>
</table>
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.
Features and options

**MULTI-FUNCTION VALVES**

*Multifunction valve, pressure limiter, pressure regulation, option 1*

![Diagram of multifunction valves](image)

**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.
Series 90 Axial Piston Pumps
Technical Information
Features and options

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).

Pulse frequency

<table>
<thead>
<tr>
<th>Pulse per revolution</th>
<th>042</th>
<th>055</th>
<th>075</th>
<th>100</th>
<th>130</th>
<th>180</th>
<th>250</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48</td>
<td>52</td>
<td>58</td>
<td>63</td>
<td>69</td>
<td>77</td>
<td>85</td>
</tr>
</tbody>
</table>

Specifications

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

* 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.

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.
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.

<table>
<thead>
<tr>
<th>Charge pump size cm³ [in³]</th>
<th>Rated speed min⁻¹ (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 11 [0.69]</td>
<td>4200</td>
</tr>
<tr>
<td>C 14 [0.86]</td>
<td>4200</td>
</tr>
<tr>
<td>D 17 [1.03]</td>
<td>3900</td>
</tr>
<tr>
<td>E 20 [1.20]</td>
<td>3600</td>
</tr>
<tr>
<td>F 26 [1.60]</td>
<td>3300</td>
</tr>
<tr>
<td>G 26 [1.60]</td>
<td>3100 (130 cm³ pump)</td>
</tr>
<tr>
<td>H 34 [2.07]</td>
<td>3100</td>
</tr>
<tr>
<td>J 47 [2.82]</td>
<td>2600</td>
</tr>
<tr>
<td>K 65 [3.90]</td>
<td>2300</td>
</tr>
</tbody>
</table>

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)
### Auxiliary Mounting Pads Specifications

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

*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

<table>
<thead>
<tr>
<th>Flange size</th>
<th>Units</th>
<th>P diameter</th>
<th>B maximum</th>
<th>D</th>
<th>F minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAE A</td>
<td></td>
<td>82.55 [3.25]</td>
<td>7.4 [0.29]</td>
<td>32</td>
<td>13.5 [0.53]</td>
</tr>
<tr>
<td>SAE B</td>
<td></td>
<td>101.6 [4.00]</td>
<td>10.7 [0.42]</td>
<td>41</td>
<td>14.2 [0.56]</td>
</tr>
<tr>
<td>SAE B-B</td>
<td></td>
<td>101.6 [4.00]</td>
<td>10.7 [0.42]</td>
<td>46</td>
<td>16.1 [0.63]</td>
</tr>
<tr>
<td>SAE C</td>
<td></td>
<td>127.0 [5.00]</td>
<td>14.3 [0.56]</td>
<td>56</td>
<td>18.3 [0.72]</td>
</tr>
<tr>
<td>SAE D</td>
<td></td>
<td>152.4 [6.00]</td>
<td>14.3 [0.56]</td>
<td>75</td>
<td>20.8 [0.82]</td>
</tr>
<tr>
<td>SAE E 13 teeth</td>
<td></td>
<td>165.1 [6.50]</td>
<td>18.0 [0.71]</td>
<td>75</td>
<td>20.8 [0.82]</td>
</tr>
<tr>
<td>SAE E 27 teeth</td>
<td></td>
<td>165.1 [6.50]</td>
<td>18.0 [0.71]</td>
<td>75</td>
<td>27.0 [1.06]</td>
</tr>
</tbody>
</table>
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**

![Diagram of overhung load example](P104_290E)

**Estimating overhung load moments**

\[ M_R = G_R (W_1L_1 + W_2L_2 + \ldots + W_nL_n) \]

\[ M_S = G_S (W_1L_1 + W_2L_2 + \ldots + W_nL_n) \]

Where:

- \( M_R \) = Rated load moment (N•m)
- \( M_S \) = Shock load moment (N•m)
- \( G_R \) = Rated (vibratory) acceleration (G's) \* (m/sec^2)
- \( G_S \) = Maximum shock acceleration (G's) \* (m/sec^2)

* 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**

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Rated moment ((M_R))</th>
<th>Shock load moment ((M_S))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N•m</td>
<td>lb•in</td>
</tr>
<tr>
<td>042</td>
<td>860</td>
<td>7600</td>
</tr>
<tr>
<td>055</td>
<td>1580</td>
<td>14000</td>
</tr>
<tr>
<td>075</td>
<td>1580</td>
<td>14000</td>
</tr>
<tr>
<td>100</td>
<td>1580</td>
<td>14000</td>
</tr>
<tr>
<td>130</td>
<td>3160</td>
<td>28000</td>
</tr>
<tr>
<td>180</td>
<td>6070</td>
<td>54000</td>
</tr>
<tr>
<td>250</td>
<td>6070</td>
<td>54000</td>
</tr>
</tbody>
</table>
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

Voltage between terminals 1 and 2
Not connected

Pump displacement vs. electrical signal

Solenoid Data

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Power</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 VDC</td>
<td>33 W</td>
<td>Din 46350</td>
</tr>
<tr>
<td>24 VDC</td>
<td>33 W</td>
<td>Din 46350</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Input shaft rotation</th>
<th>CW</th>
<th>CCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal at solenoid</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Port A flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Port B flow</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Servo cylinder active</td>
<td>M5</td>
<td>M5</td>
</tr>
</tbody>
</table>
**Series 90 Axial Piston Pumps**

**Technical Information**

**Control options**

**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 ingestion 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.
- Precise 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.
Series 90 Axial Piston Pumps  
Technical Information  
Control options

**ELECTRIC DISPLACEMENT CONTROL (EDC) (continued)**

### Control signal requirements

<table>
<thead>
<tr>
<th>Coil configuration</th>
<th>a mA</th>
<th>b mA</th>
<th>Pin connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single coil</td>
<td>14 ± 5</td>
<td>85 ± 18</td>
<td>A&amp;B or C&amp;D</td>
</tr>
<tr>
<td>Dual coil in series</td>
<td>7 ± 3</td>
<td>43 ± 9</td>
<td>A&amp;D (C &amp; B common)</td>
</tr>
<tr>
<td>Dual coil parallel</td>
<td>14 ± 5</td>
<td>85 ± 18</td>
<td>AC &amp; BD</td>
</tr>
</tbody>
</table>

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

**MS connector (option KA) MS 3102C-14S-2P**  
Sauer-Danfoss mating parts kit  
Part no. K01588  
Ident No. 615062

**Packard® Weather-Pack (option KP) 4-way shroud connector**  
Sauer-Danfoss mating parts kit  
Part no. K03384  
(female terminals)

### 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)**

<table>
<thead>
<tr>
<th>Input shaft rotation</th>
<th>CW</th>
<th>CCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive current to term</td>
<td>A or C</td>
<td>B or D</td>
</tr>
<tr>
<td>Port A flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Port B flow</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Servo cylinder</td>
<td>M5</td>
<td>M4</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Input shaft rotation</th>
<th>CW</th>
<th>CCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive current to term</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>Port A flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Port B flow</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Servo cylinder</td>
<td>M5</td>
<td>M4</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>Hydraulic signal pressure range</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>3 ± 0.5 bar [43 ± 6 psi]</td>
</tr>
<tr>
<td>b</td>
<td>11 ± 0.5 bar [160 ± 6 psi]</td>
</tr>
</tbody>
</table>

*see diagram page 27
Control options

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 output flow direction vs. control pressure

<table>
<thead>
<tr>
<th>Input shaft rotation</th>
<th>CW</th>
<th>CCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control pressure to port</td>
<td>X2</td>
<td>X1</td>
</tr>
<tr>
<td>Port A flow</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Port B flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Servo cylinder</td>
<td>M4</td>
<td>M5</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Input shaft rotation</th>
<th>CW</th>
<th>CCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handle rotation</td>
<td>A CCW</td>
<td>B CW</td>
</tr>
<tr>
<td></td>
<td>A CCW</td>
<td>B CW</td>
</tr>
<tr>
<td>Port A flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td></td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Port B flow</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td></td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Servo cylinder</td>
<td>MS</td>
<td>M4</td>
</tr>
<tr>
<td></td>
<td>MS</td>
<td>M4</td>
</tr>
</tbody>
</table>

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**

![Non-linear MDC schematic](image1)

**Cross section**

![Cross section](image2)

S1 = servo side 1
S2 = servo side 2
Series 90 Axial Piston Pumps
Technical Information
Control options

**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.

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**

<table>
<thead>
<tr>
<th>Input shaft rotation</th>
<th>CW</th>
<th>CCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handle rotation</td>
<td>“A” CCW</td>
<td>“B” CW</td>
</tr>
<tr>
<td></td>
<td>“A” CCW</td>
<td>“B” CW</td>
</tr>
<tr>
<td>Port A flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Port B flow</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Port B flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Servo cylinder</td>
<td>M5</td>
<td>M4</td>
</tr>
<tr>
<td>Servo cylinder</td>
<td>M5</td>
<td>M4</td>
</tr>
</tbody>
</table>

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

**Resistance Table**

<table>
<thead>
<tr>
<th>Supply Voltage</th>
<th>Coil Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 V</td>
<td>5.4 Ohms</td>
</tr>
<tr>
<td>24 V</td>
<td>21.6 Ohms</td>
</tr>
</tbody>
</table>

**NFPE Schematic**

![NFPE Schematic Diagram]
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.

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>CW</th>
<th>CCW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active solenoid</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Port A flow</td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Port B flow</td>
<td>In</td>
<td>Out</td>
</tr>
<tr>
<td>Servo cylinder</td>
<td>M5</td>
<td>M4</td>
</tr>
</tbody>
</table>

**Solenoid data**

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Control current</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start</td>
</tr>
<tr>
<td>12 V</td>
<td>~ 440 mA</td>
</tr>
<tr>
<td>24 V</td>
<td>~ 220 mA</td>
</tr>
</tbody>
</table>
Manual displacement control (MDC), endcap twin ports, option 80

Series 90 42cc pumps are not available in North America
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

FRAME SIZE 042 (continued)

Auxiliary mounting pad – options AB, BC, BB

SAE A, option AB

SAE B, option BC

SAE B-B, option BB

Coupling spline data:
Pitch diameter = 20.5 [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]

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]
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

FRAMESIZE 055

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

Torque applied to control handle shaft not to exceed 17 Nm [150 lbf-in]

Maximum displacement

R 50.8±0.3
[R 2.0±0.01]

Neutral position

R 25.4±0.3
[R 1.0±0.01]

Maximum displacement

Ø 6.73±0.13
[Ø 0.265±0.005] 2x
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

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

Port S: charge
pump inlet
1-5/16-12UN-2B

Gauge port M2:
system pressure B
9/16-18UNF-2B

Gauge port M1:
system pressure A
9/16-18UNF-2B

Ports A and B
1 - 6000 psi
split flange boss
per SAE J516
(Code 62)
7/16-14UNC-2B
21 [0.83]
minimum full thread

Control MDC, option MA

View "Y"
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

**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]

**For O-ring**
- Ø 82.22 x 2.62
  
  [Ø 3.237 x 0.103]

**View “X”**

**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]

**For O-ring**
- Ø 94.92 x 2.62
  
  [Ø 3.737 x 0.103]

**View “X”**

**SAE B, option BC**

**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]

**For O-ring**
- Ø 82.6 x 2.62
  
  [Ø 3.252]

**View “X”**

**SAE C, option CD**

**Coupling spline data:**
- Pitch diameter = 20.6375 [0.8125]
- Pressure angle = 30°
- Number of teeth = 14
- Pitch = 12/24
- ANSI B92.1-1970, class 6, fillet root side fit
- Length of spline = 22.8 [0.90]

**For O-ring**
- Ø 120.32 x 2.62
  
  [Ø 4.737 x 0.103]

**View “X”**

**SAE D, option BB**

**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]

**For O-ring**
- Ø 127.03 x 2.62
  
  [Ø 5.00]

**View “X”**

**SAE E, option BB**

**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]

**For O-ring**
- Ø 127.03 x 2.62
  
  [Ø 5.00]

**View “X”**

**SAE F, option BB**

**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]

**For O-ring**
- Ø 127.03 x 2.62
  
  [Ø 5.00]
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

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]

For O-ring
- Ø 94.92 x 2.62
  [Ø 3.737 x 0.103]

SAE B-B, option BB

View "X"

4 threads
1/2-13UNC-2B
22 [0.87] deep

For O-ring
Ø 101.65
[Ø 4.002]

"X"

20.75
[0.82]
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

**FRAME SIZE 075**

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

---

**Control MDC, option MA**

*Approximate center of gravity*

- Port S
- Port L1
- Port L2
- Port A
- Port B

**Manual displacement control handle dimensions**

- Torque applied to control handle shaft not to exceed 17 Nm (150 lb•in)
- Maximum displacement
- Neutral position
- Maximum displacement

---

**Shaft spline data:**

- Pitch diameter: 29.633 [1.1667]
- Pressure angle: 30°
- Number of teeth: 14
- Pitch: 12/24
- ANSI B92.1-1970, Class 5, Fillet Root Side Fit

---

**Gauge port M2**

- System pressure
- 9/16-18UNF-2B

---

**Gauge port M1**

- System pressure
- 9/16-18UNF-2B

---

**Gauge port M4**

- System pressure
- 9/16-18UNF-2B

---

**Gauge port M5**

- System pressure
- 9/16-18UNF-2B

---

**Port L1**

- Case drain
- Use highest port as outlet
- 1-1/16-12UN-2B
- 81.3 [3.20]
- 172.2 [6.78]

---

**Port L2**

- Case drain
- 1-1/16-12UN-2B

---

**Port A and B**

- Split flange boss
- SAE J518 (Code 62)
- 9/16-14UNC-2B
- Minimum full thread

---

**Approximate center of gravity**

- Port L1
- Port L2
- Port A
- Port B

---

**Splined Shaft Option S1**

- Ø 37.59 [1.48]
- 47.62 [1.88]

---

**Splined Shaft Option C7**

- Ø 32.3 [1.27]
- 47.62 [1.88]

---

**Splined shaft data:**

- Pitch diameter: 29.633 [1.1667]
- Pressure angle: 30°
- Number of teeth: 14
- Pitch: 12/24
- ANSI B92.1-1970, Class 5, Fillet Root Side Fit

---

**Multifunction valve**

- Charge pressure
- Relief valve

---

**Multifunction valve**

- Port S: charge pump inlet
- Port L2: case drain
- Port 5: charge pump inlet

---

**Shaft spline data:**

- Number of teeth: 23
- Pitch: 16/32
- ANSI B92.1-1970, Class 5, Fillet Root Side Fit

---

**Shaft data:**

- Diameter: 36.513 [1.4375]
- Pressure angle: 30°
- Number of teeth: 23
- Pitch: 16/32
- ANSI B92.1-1970, Class 5, Fillet Root Side Fit

---

**Rotation**

- CCW
- CW

---

**View “Z”**

- Coupling must not protrude beyond 56.4 [2.22] max
- Coupling not to exceed 17 Nm (150 lb•in)

---

**View “X”**

- Coupling may not protrude beyond this surface
- Length of full spline

---

**View “Y”**

- Coupling may not protrude beyond this surface
- Length of full spline

---

**Manual Displacement Control Handle Dimensions**

- Ø 6.33 [0.249]
- 12.70 [0.50]
- 4.78 [0.19]
- 41.67 [1.64]

---

**Configuration:**

- Maximum displacement
- Neutral position
- Maximum displacement

---

**Approximate center of gravity**

- Port L1
- Port L2
- Port A
- Port B

---

**Case drain use highest port as outlet**

1-1/16-12UN-2B

---

**Ports A and B**

- 1 - 6000 psi
- Split flange boss per SAE J518
- 7/16-14UNC-2B
- 20 [0.79]
- Minimum full thread

---

**Shaft Spline Data:**

- Pitch diameter = 36.513 [1.4375]
- Pressure angle = 30°
- Number of teeth = 23
- Pitch = 16/32
- ANSI B92.1-1970, Class 5, Fillet Root Side Fit

---

**Manual Displacement Control Handle Dimensions**

- Ø 6.33 [0.249]
- 12.70 [0.50]
- 4.78 [0.19]
- 41.67 [1.64]

---

**Configuration:**

- Maximum displacement
- Neutral position
- Maximum displacement

---

**Rotation**

- CCW
- CW

---

**Shaft Spline Data:**

- Pitch diameter: 36.513 [1.4375]
- Pressure angle: 30°
- Number of teeth: 23
- Pitch: 16/32
- ANSI B92.1-1970, Class 5, Fillet Root Side Fit

---

**Shaft Spline Data:**

- Pitch diameter: 29.633 [1.1667]
- Pressure angle: 30°
- Number of teeth: 14
- Pitch: 12/24
- ANSI B92.1-1970, Class 5, Fillet Root Side Fit

---

**View “Z”**

- Coupling must not protrude beyond 56.4 [2.22] max
- Coupling not to exceed 17 Nm (150 lb•in)

---

**View “X”**

- Coupling may not protrude beyond this surface
- Length of full spline

---

**View “Y”**

- Coupling may not protrude beyond this surface
- Length of full spline

---

**Manual Displacement Control Handle Dimensions**

- Ø 6.33 [0.249]
- 12.70 [0.50]
- 4.78 [0.19]
- 41.67 [1.64]
Manual Displacement Control (MDC), endcap twin ports, option 80

Gauge port M2, system pressure B
9/16-18UNF-2B

Port S, charge pump inlet
1-5/16-12UN-2B

Gauge port M1, system pressure A
9/16-18UNF-2B

Ports A and B
1 - 6000 psi
split flange boss
per SAE J518
(Code 62)
7/16-14UNC-2B
except 20.8 [0.82]
minimum full thread

Control MDC, option MA

View "Y"

P102 047
Auxiliary mounting pad – Options AB, BC, CD, BB

**SAE A, option AB**
- 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]

- For O-ring
  - Ø 94.92 x 2.62
  - [Ø 3.737 x 0.103]

**SAE B, option BC**
- 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]

- For O-ring
  - Ø 94.92 x 2.62
  - [Ø 3.737 x 0.103]

**SAE C, option CD**
- 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]

- For O-ring
  - Ø 120.32 x 2.62
  - [Ø 4.737 x 0.103]

**SAE A, option AB**
- 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]

- For O-ring
  - Ø 94.92 x 2.62
  - [Ø 3.737 x 0.103]
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]

For O-ring:
- Ø 94.92 x 2.62 [Ø 3.737 x 0.103]

SAE B-B, option BB

View "X"

4 threads 1/2-13UNC-2B
22 [0.87] deep

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]
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

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

- **Control MDC, option MA**
  - Coupling may not protrude beyond this surface.
  - Length of full spline.

- **View "Y"**
  - Shaft spline data:
    - Pitch diameter = 41.275 [1.625]
    - Pressure angle = 30°
    - Number of teeth = 13
    - Pitch = 8/16
    - ANSI B92.1-1970, class 5, fillet root side fit

- **View "Z"**
  - Shaft spline data:
    - Pitch diameter = 36.513 [1.4375]
    - Pressure angle = 30°
    - Number of teeth = 23
    - Pitch = 16/32
    - ANSI B92.1-1970, class 5, fillet root side fit

- **View "X"**
  - Coupling must not protrude beyond 64.0 [2.52] max.
  - Manual displacement control handle dimensions:
    - Torque applied to control handle shaft not to exceed 17 lbf·in [150 lbf·in]
    - Maximum displacement:
      - "B": 90.8±0.3 [3.57±0.01]
      - "A": 25.4±0.3 [0.997±0.01]
    - Neutral position:
      - "A": 0.72±0.12 [0.029±0.005]
      - "B": 0.265±0.008
    - Maximum displacement:
      - "A": 12.70 [0.50]
      - "B": 41.67 [1.64]

- **Installation drawings**
  - **Frame size 100**
  - **Rev FE** • March 2010

- **Technical specifications**
  - **Manual Displacement Control (MDC), endcap side ports, option 60**
    - **Manual displacement control handle dimensions**
      - Torque applied to control handle shaft not to exceed 17 lbf·in [150 lbf·in]
      - Maximum displacement:
        - "B": 90.8±0.3 [3.57±0.01]
        - "A": 25.4±0.3 [0.997±0.01]
      - Neutral position:
        - "A": 0.72±0.12 [0.029±0.005]
        - "B": 0.265±0.008
      - Maximum displacement:
        - "A": 12.70 [0.50]
        - "B": 41.67 [1.64]
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

Frame Size 100
(continued)

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

- Control MDC, option MA
- Gauge port M2: system pressure B
  9/16-18UNF-2B
- Port 5: charge
  pump inlet
  1-5/8-12UN-2B
- Ports A and B
  1 - 6000 psi
  split flange boss
  per SAE J518
  (Code 62)
  7/16-14UNC-2B
  21 (0.83)
  minimum full thread
- Gauge port M1: system pressure A
  9/16-18UNF-2B
- Shaft spline data:
  Pitch diameter = 29.634 (1.1667)
  Pressure Angle = 30
  Number of teeth = 14
  Pitch = 12/24
  ANSI 892.1-1970, Class 5,
  fillet root side fit
- Coupling may not protrude beyond this surface
- Length of full spline
- Splined shaft option S1
- View "Y"
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

FRAME SIZE 100  
_AUXILIARY MOUNTING PADS, SAE AB, SAE BC, SAE CD

SAE A, Option AB  View "X"

SAE B, Option BC  View "X"

SAE C, Option CD  View "X"

**SAE A, Option AB**

COUPLING SPLINE DATA:
- Pitch Dia = 14.288 (5625) mm
- 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 B, Option BC**

COUPLING SPLINE DATA:
- Pitch Dia = 20.6375 (8125) mm
- 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 C, Option CD**

COUPLING SPLINE DATA:
- Pitch Dia = 14.92 (5.9)
- Pressure Angle = 30°
- Number of teeth = 9
- Pitch = 16/32
- ANSI B92.1-1970, Class 6
- Fillet Root Side Fit
- Length of spline = 18.97 (0.747)

---

**SAE A, Option AB**

for O-Ring
- ø8.22 x 2.62
  - (3.237 Dia x 0.103)

**SAE B, Option BC**

for O-Ring
- ø10.02 x 2.62
  - (3.937 Dia x 0.103)

**SAE C, Option CD**

for O-Ring
- ø8.25 x 2.62
  - (3.252 Dia x 0.103)
FRAME SIZE 100
(continued)

COUPLING SPLINE DATA:
- Pitch Dia = 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)

for O-Ring
- ø94.92 x 2.62
  \( (3.737\) Dia x 0.103)\)

SAE B-B, Option BB

View "X"

Auxiliary mounting pad, SAE BB

\[ \text{Pitch Dia} = 23.8125 \ (0.9375) \]
\[ \text{Pressure Angle} = 30° \]
\[ \text{Number of teeth} = 15 \]
\[ \text{Pitch} = 16/32 \]
\[ \text{ANSI B92.1-1970, Class 6, Fillet Root Side Fit} \]
\[ \text{Length of spline} = 24.43 \ (0.96) \]
Manual Displacement Control (MDC), end cap twin ports, option 80

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

Shaf t spline data:
Pitch diameter = 42.862 (1.6875)
Pressure angle = 30°
Number of teeth = 27
Pitch = 8/16
ANSI B92.1-1970, class 5, fillet root side fit

Manual displacement control handle dimensions

View "Y"

Control MDC, option MA

View "Z"

Gauge port M2
System pressure B
9/16-18UNF-2B

Gauge port M4
System pressure A
9/16-18UNF-2B

Port L1
case drain use highest
port as outlet
1-5/16-12UN-2B

Multifunction valve

Charge pressure relief valve

Gauge port M3
charge pressure
9/16-18UNF-2B

Multifunction valve

View "X"

Shaft spline data:
Pitch diameter = 41.275 (1.625)
Pressure angle = 30°
Number of teeth = 13
Pitch = 8/16
ANSI B92.1-1970, class 5, fillet root side fit

Port S charge pump/inlet
1-5/8-12UN-2B

Gauge port M1
System pressure A
9/16-18UNF-2B

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

**SAE A, option AB**
- 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 B, option BC**
- 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 C, option CD**
- 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]
Auxiliary mounting pad - options AB, BC, CD, DE, BB

Series 90 Axial Piston Pumps
Technical Information
Installation drawings

FRAME SIZE 130 (continued)

Coupling spline data:
Pitch diameter = 41.275 [1.625]
Pressure angle = 30°
Number of teeth = 15
ANSI B92.1-1970, class 6, fillet root side fit
Length of spline = 24.59 [0.96]

For O-ring
Ø 153 x 3.0
[Ø 6.02 x 0.118]

SAE D, option DE
View "X"

4 threads
3/4-10UNC-2B
41 [1.6] deep

SAE B-B, option BB
View "X"

4 threads
1/2-13UNC-2B
22 [0.87] deep

Coupling spline data:
Pitch diameter = 23.8125 [0.9375]
Pressure angle = 30°
Number of teeth = 13
ANSI B92.1-1970, class 6, fillet root side fit
Length of spline = 24.59 [0.96]

For O-ring
Ø 94.92 x 2.62
[Ø 3.737 x 0.103]

mm [in]
**Series 90 Axial Piston Pumps**  
**Technical Information**  
**Installation drawings**  

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

**Manual Displacement Control handle dimensions**
- Torque applied to control handle shaft not to exceed 17 Nm (150 lb•in)
- Maximum displacement
  - "B" + 0.5 mm (0.02")
  - "A" + 0.1 mm (0.004")
  - Maximum displacement

**Shaft spline data**
- Pitch diameter = 41.275 (1.625")
- Pressure angle = 30°
- Number of teeth = 13
- ANSI B92.1-1970, class 5, fillet root side fit
- Length of full spline

**Splined shaft option F1**

**Splined shaft option C8**

**Ports A and B**
- 1-1/4" 6000 psi
- split flange boss
- per SAE J518
- (Code 62)
- 1/2-13UNC-2B
- 23 (0.906"
- minimum full thread

**Gauge port M1**
- system pressure A
- 9/16-18UNF-2B

**Gauge port M2**
- system pressure B
- 9/16-18UNF-2B

**Control MDC, option MA**
- Length of full spline
- Coupling may not protrude beyond this surface

**Coupling may not protrude beyond this surface**

**Manual Displacement Control handle shaft**

**Multifunction valve**

**CPRV**

**View "W"**
- Port L2:
  - case drain
  - 1-5/8-12UN-2B
- System pressure A
  - 9/16-18UNF-2B
- System pressure B
  - 9/16-18UNF-2B

**View "Z"**
- Gauges:
  - M1: charge pressure
  - M2: system pressure B
  - M3: charge pressure

**Approximate center of gravity**

**Approximate center of gravity**

**Shaft spline data**
- Pitch diameter = 42.8625 (1.6875")
- Pressure angle = 30°
- Number of teeth = 27
- ANSI B92.1-1970, class 5, fillet root side fit

**Splined shaft option C8**

**Ports and Measurements**
- View "X":
  - Ø 39 (1.54")
  - Approximate center of gravity
  - 224.5 (8.84")
  - 9.4 (0.37")
- View "Y":
  - 326 (12.83")
  - Ø 43.89 (1.73")
  - 156.42 (6.16")
- View "Z":
  - Approximate center of gravity
  - 171.25 (6.75")
  - Ø 100 (3.94")

**Ports and Dimensions**
- Port L1:
  - case drain
  - use highest port as outlet
  - 1-5/8-12UN-2B
- Port L2:
  - case drain
  - 1-5/8-12UN-2B
- Port N (optional)
  - speed pick-up
  - 9/16-18UNF-2B
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

Frame Size 180
(continued)

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

SAE A, option AB

View "X"

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]

View "X"

SAE B, option BC

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]

View "X"

SAE C, option CD

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]

For O-ring
Ø 82.22 x 2.62
Ø 3.237 x 0.103

4 threads
3/8-16UNC-2B
17.8 [0.70] deep

4 threads
1/2-13UNC-2B
22 [0.87] deep

4 threads
1/2-13UNC-2B
22 [0.87] deep

6 threads
1/2-13UNC-2B
22 [0.87] deep

Thread data:
4 threads
3/8-16UNC-2B
17.8 [0.70] deep

6 threads
1/2-13UNC-2B
181 [7.13]

Frame size 180 (continued)
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

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
- ANSI B92.1-1970, class 6,
  fillet root side fit
- Length of spline = 25.9 [1.02]

For O-ring
Ø 153 x 3.0
[Ø 6.02 x 0.118]

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

For O-ring
Ø 164.77 x 2.62
[Ø 6.48 x 0.10]

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

For O-ring
Ø 164.77 x 2.62
[Ø 6.48 x 0.10]
Auxiliary mounting pad - options AB, BC, CD, DE, EF, EG, BB

Frame size 180
(continued)

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)

For O-ring:
- Ø 94.92 x 2.62
  (Ø 3.737 x 0.103)

View "X"

SAE B-B, option BB

4 threads
1/2-13 UNC-2B
22 (0.87) deep

P102 060
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

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

Manual displacement control handle dimensions

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

Frame size 250
**Auxiliary mounting pad - options AB, BC, CD, DE, EF, EG, BB**

**SAE A, option AB**

**SAE B, option BC**

**SAE C, option CD**
Auxiliary mounting pad – options AB, BC, CD, DE, EF, EG, BB

**Coupling spline data:**
- Pitch diameter: 41.275 [1.625] mm
- 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] in

**For O-ring**
- Ø 153 x 3.0 [Ø 6.02 x 0.118] mm

**SAE D, option DE View “X”**

**SAE E, option EF View “X”**

**SAE H, option EG View “X”**

**Coupling spline data:**
- Pitch diameter: 42.862 [1.687] mm
- 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] in

**For O-ring**
- Ø 164.77 x 2.62 [Ø 6.48 x 0.10] mm

4 threads
3/4-10UNC-2B
41 [1.61] deep

4 threads
3/4-10UNC-2B
41 [1.61] deep

4 threads
3/4-10UNC-2B
41 [1.61] deep

**P102 063**
**FRAME SIZE 250**
(continued)

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

**Coupling spline data:**
- Pitch diameter = 23.8125 [0.9375] mm
- 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]

For O-ring
Ø 94.92 x 2.62
[Ø 3.737 x 0.103]

View "X"

4 threads
1/2-13 UNC-2B
22 [0.87] deep

475.1
[18.70]

22.6
[0.89]

457.4
[18.01]

SAE B-B, option BB

Frame size 250
**Series 90 Axial Piston Pumps**

**Technical Information**

**Installation drawings**

---

**COVER PLATE**

Dimensions

<table>
<thead>
<tr>
<th>Frame size</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4 maximum (option 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>055</td>
<td>69.2 [2.72]</td>
<td>179.4 [7.06]</td>
<td>103.6 [4.08]</td>
<td>114 [4.48]</td>
</tr>
<tr>
<td>075</td>
<td>74.2 [2.92]</td>
<td>185.7 [7.31]</td>
<td>109.4 [4.31]</td>
<td>118 [4.65]</td>
</tr>
<tr>
<td>100</td>
<td>83.3 [3.28]</td>
<td>183.3 [7.22]</td>
<td>118.3 [4.66]</td>
<td>136 [5.35]</td>
</tr>
<tr>
<td>130</td>
<td>86.6 [3.41]</td>
<td>209.3 [8.24]</td>
<td>137.2 [5.40]</td>
<td>141 [5.55]</td>
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<tr>
<td>180</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>184 [7.24]</td>
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<tr>
<td>250</td>
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<td>-</td>
<td>184 [7.24]</td>
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---

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

Dimensions

<table>
<thead>
<tr>
<th>Frame size</th>
<th>C5 maximum</th>
<th>C5.1</th>
<th>C5.2</th>
</tr>
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<tbody>
<tr>
<td>042</td>
<td>196.5 [7.74]</td>
<td>108.8 [4.28]</td>
<td>106.2 [4.18]</td>
</tr>
<tr>
<td>055</td>
<td>200.6 [7.90]</td>
<td>108.8 [4.28]</td>
<td>106.2 [4.18]</td>
</tr>
<tr>
<td>075</td>
<td>207.9 [8.19]</td>
<td>108.8 [4.28]</td>
<td>106.2 [4.18]</td>
</tr>
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<td>100</td>
<td>216.8 [8.54]</td>
<td>117.4 [4.62]</td>
<td>97.6 [3.84]</td>
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<tr>
<td>130</td>
<td>235.7 [9.28]</td>
<td>102.4 [4.03]</td>
<td>112.6 [4.43]</td>
</tr>
<tr>
<td>180</td>
<td>252.4 [9.94]</td>
<td>94.6 [3.72]</td>
<td>120.4 [4.74]</td>
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<tr>
<td>250</td>
<td>210.4 [8.28]</td>
<td>94.6 [3.72]</td>
<td>120.4 [4.74]</td>
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</table>

[option DD only]
**ELECTRIC DISPLACEMENT CONTROL (EDC) WITH MS-CONNECTOR OR PACKARD® CONNECTOR**

**Dimensions**

<table>
<thead>
<tr>
<th>Frame size</th>
<th>C6</th>
<th>C7</th>
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</thead>
<tbody>
<tr>
<td>042</td>
<td>95.3 [3.75]</td>
<td>168.6 [6.64]</td>
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<tr>
<td>055</td>
<td>95.3 [3.75]</td>
<td>141.2 [5.56]</td>
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<td>075</td>
<td>105.2 [4.14]</td>
<td>144.8 [5.70]</td>
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<td>100</td>
<td>114.0 [4.49]</td>
<td>153.7 [6.05]</td>
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<tr>
<td>130</td>
<td>99.1 [3.90]</td>
<td>172.7 [6.80]</td>
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<td>180</td>
<td>93.4 [3.68]</td>
<td>190.0 [7.48]</td>
</tr>
<tr>
<td>250</td>
<td>93.4 [3.68]</td>
<td>226.2 [8.91]</td>
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**HYDRAULIC DISPLACEMENT CONTROL (HDC)**

**Dimensions**

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<th>C8.1</th>
<th>C8.2</th>
<th>C9</th>
<th>C10</th>
<th>C11</th>
<th>C12</th>
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<tbody>
<tr>
<td>042</td>
<td>143.5 [5.65]</td>
<td>135.0 [5.31]</td>
<td>71.0 [2.79]</td>
<td>75.7 [2.98]</td>
<td>89.6 [3.52]</td>
<td>99.2 [3.90]</td>
</tr>
<tr>
<td>055</td>
<td>150.8 [5.94]</td>
<td>139.0 [5.47]</td>
<td>71.0 [2.79]</td>
<td>75.7 [2.98]</td>
<td>105.6 [4.15]</td>
<td>115.2 [4.53]</td>
</tr>
<tr>
<td>075</td>
<td>148.9 [5.86]</td>
<td>139.0 [5.47]</td>
<td>68.3 [2.68]</td>
<td>67.0 [2.63]</td>
<td>121.8 [4.79]</td>
<td>125.3 [4.93]</td>
</tr>
<tr>
<td>100</td>
<td>158.0 [6.22]</td>
<td>149.0 [5.86]</td>
<td>76.8 [3.02]</td>
<td>67.0 [2.63]</td>
<td>127.9 [5.03]</td>
<td>131.4 [5.17]</td>
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</table>
MANUAL DISPLACEMENT CONTROL (MDC) WITH NEUTRAL START SWITCH

Dimensions

<table>
<thead>
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<th>Frame size</th>
<th>C13</th>
<th>C14</th>
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<tbody>
<tr>
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<td>0.35 [0.014]</td>
<td>96.0 [3.78]</td>
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<tr>
<td>055</td>
<td>18.0 [0.71]</td>
<td>100.0 [3.94]</td>
</tr>
<tr>
<td>075</td>
<td>25.0 [0.98]</td>
<td>106.9 [4.21]</td>
</tr>
<tr>
<td>100</td>
<td>31.3 [1.23]</td>
<td>115.8 [4.56]</td>
</tr>
<tr>
<td>130</td>
<td>46.0 [1.81]</td>
<td>134.5 [5.29]</td>
</tr>
<tr>
<td>180</td>
<td>52.0 [2.04]</td>
<td>151.8 [5.97]</td>
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<tr>
<td>250</td>
<td>52.0 [2.04]</td>
<td>151.8 [5.97]</td>
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NON-LINEAR MANUAL DISPLACEMENT CONTROL (MDC)

Dimensions

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<td>187.8 [7.39]</td>
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<tr>
<td>130</td>
<td>209.4 [8.24]</td>
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</tbody>
</table>

Torque applied to control handle shaft not to exceed 17 Nm (150 lbf•in)
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

**Electrohydraulic Displacement Control (NFPE)**
(Except 075 NFPE)

**Dimensions**

<table>
<thead>
<tr>
<th>Frame Size</th>
<th>Option</th>
<th>“X”</th>
<th>“Y”</th>
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<tbody>
<tr>
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<td>169.30 [6.67]</td>
<td>140.00 [5.51]</td>
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<td>FA, FB, FC, FD</td>
<td>207.00 [8.15]</td>
<td>145.00 [5.71]</td>
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<td>075</td>
<td>Special version see page 63</td>
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<tr>
<td>100</td>
<td>FA, FB, FC, FD</td>
<td>235.00 [9.25]</td>
<td>161.10 [6.34]</td>
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<td>FG, FH</td>
<td>235.00 [9.25]</td>
<td>176.60 [6.95]</td>
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<td>FG, FH</td>
<td>244.10 [9.61]</td>
<td>195.50 [7.70]</td>
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<td>180</td>
<td>FG, FH</td>
<td>290.00 [11.42]</td>
<td>213.00 [8.39]</td>
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<tr>
<td>250</td>
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</tbody>
</table>
**Series 90 Axial Piston Pumps**

**Technical Information**

**Installation drawings**

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**INTEGRAL PRESSURE FILTER**

- Gauge port M6 charge pressure before filter 9/16-18UNF
- Gauge port M3 charge pressure after filter 9/16-18UNF

**REMOTE PRESSURE - WITHOUT FILTER**

- Port E from filter 7/8-14UNF (option R)
- Port D to filter 7/8-14UNF (option R)
- Port E from filter 1 1/16 -12UN (option T)

---

**Dimensions**

<table>
<thead>
<tr>
<th>Frame size</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4 maximum</th>
<th>F5 maximum</th>
<th>F6 maximum</th>
<th>F7 maximum</th>
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<td>201.4</td>
<td>207.7</td>
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<td>209.6</td>
<td>209.6</td>
<td>114.3</td>
<td>154.3</td>
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<td>253.2</td>
<td>214.4</td>
<td>119.1</td>
<td>159.1</td>
<td>174.4</td>
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<td>075 NFPE</td>
<td>174.5</td>
<td>262.6</td>
<td>253.7</td>
<td>214</td>
<td>119</td>
<td>159 [6.264]</td>
<td>174 [6.866]</td>
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<td>259.2</td>
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</table>
Series 90 Axial Piston Pumps
Technical Information
Installation drawings

FRAME SIZE 075 NFPE

Integrated NFPE control, endcap side ports

System pressure B
Gage port M2
9/16-18UNF-2B

Case drain L1
1-1/16-12UN-2B

Connector
AMP Junior Typ A

System pressure A
Gage port M1
9/16-18UNF-2B

Charge pump inlet M10
9/16-18UNF-2B

Approx center
of gravity

Case drain L2
1-1/16-12UN-2B

View "B"

Connector
Deutsch DTM 06-3 S

Split flange boss (2x)
DN 25 Typ II 400bar series
per ISO 6162
Thread
0.4375-14UNC-2B
0.83 min.
full thread depth

Gage port M5
Serve pressure
9/16-18UNF-2B

Multifunction valve

View "C"

Gage port M4
Serve pressure
9/16-18UNF-2B

Multifunction valve

View "A"

Charge pressure
relief valve

Charge pump inlet S
1-5/16-12UN-2B

P104 324E

P104325E

P104325E
Integrated NFPE control, endcap side ports (continued)

View "D"

Charge pressure Gage port M1 9/16-18UNF-2B

Optional Part for speed pick up 3 9/16-18UNF-2B

View "E"

Integrated NFPE control, endcap side ports (continued)
Integrated NFPE control, endcap twin ports

**System pressure B**
Gage port M2
9/16-18UNF-2B

**System pressure A**
Gage port M1
9/16-18UNF-2B

**Charge pump inlet**
1-5/16-12UN-2B

**Case drain L1**
1-1/16-12UN-2B

**Split flange boss (2x)**
DN 25 Typ II 40MPa series per ISO 6162
Thread: 0.4375-14UNC-2B
[7/16-14UNC-2B]
0.83 min. full thread depth

**Connector**
AMP Junior Typ A

**Connector**
AMP Junior Typ A

**Connector**
Deutsch: DTM 06-3 S

**Spline data**
Pitch dia: 33.3375 [1.3125]
Pressure angle: 30°
Number of teeth: 21
Pitch: 16/32
ANSI B92.1 -1970, class 5
Fillet root side fit

**Charge pump inlet**
1-5/16-12UN-2B

**Approx center of gravity**

**P104 328E**

**P104 329E**
### FRAME SIZE 075 NFPE (continued)

#### Auxiliary mounting pad SAE-A

<table>
<thead>
<tr>
<th>Metric</th>
<th>Inch</th>
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<tbody>
<tr>
<td>106.376</td>
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<td>14.288</td>
<td>0.562</td>
</tr>
<tr>
<td>37.13</td>
<td>1.46</td>
</tr>
</tbody>
</table>

**Thread:** 3/8-16UNC-2B, 0.89 deep

**Spline data:**
- **Pitch dia:** 14.288 [0.562]
- **Pressure angle:** 30°
- **Number of teeth:** 9
- **Pitch:** 16/32
- **ANSI B92.1 -1970, class 6**
- **Fillet root side fit effective length of spline:** 37.13 [1.46]

**Note:** For O-ring Ø82.27 x 1.78 [3.24 x 0.07]
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Local address:

Sauer-Danfoss (US) Company
2800 East 13th Street
Ames, IA 50010, USA
Phone: +1 515 239-6000
Fax: +1 515 239-6618

Sauer-Danfoss GmbH & Co. OHG
Postfach 2460, D-24531 Neumünster
Krokamp 35, D-24539 Neumünster, Germany
Phone: +49 4321 871-0
Fax: +49 4321 871 122

Sauer-Danfoss ApS
DK-6430 Nordborg, Denmark
Phone: +45 7488 4444
Fax: +45 7488 4400

Sauer-Danfoss-Daikin LTD
Shin-Osaka TERASAKI 3rd Bldg.6F
1-5-28 Nishinomiya-ku, Yodogawa-ku, Osaka 532-0004, Japan
Phone: +81 6 6359 6066
Fax: +81 6 6395 8585

www.sauer-danfoss.com