Series 20
Axial Piston Pumps

Technical Information
Sauer-Danfoss a world leader in hydraulic power systems has developed a family of axial piston pumps.

Sauer-Danfoss axial piston variable displacement pumps are of swash plate design with variable flow capability suitable for hydrostatic transmissions with closed loop circuit. Tilting the swash plate to the opposite side of the neutral or zero displacement position reverses flow direction.

Sauer-Danfoss axial piston variable displacement pumps are well engineered and easy to handle. The full-length shaft with a highly efficient tapered roller bearing arrangement offers a high loading capacity for external radical forces. The hydro-mechanical servo displacement control maintains the selected swash plate position and hence pumps displacement. Upon release of the control handle, the swash plate automatically returns to zero position and the flow reduces to zero.

High case pressures can be achieved without leakage even at the lowest temperatures by using suitable shaft seals. The servo valve arrangement offers the facility to incorporate function regulators and remote control systems. Axial piston units are designed for easy servicing. Complete dismantling and reassembly can be carried out with standard hand tools, and all components or sub-assemblies are replaceable. Axial piston variable displacement pumps of the Sauer-Danfoss pattern are made by licensed producers worldwide, providing consistent service and fully interchangeable parts.

TYPICAL MARKETS

- Industrial
- Mining
- Transit Mixer
- Utility Vehicles
Series 20 – Axial Piston Pumps
Technical Information

Contents

GENERAL DESCRIPTION
Introduction ................................................................................................................. 2
Description ..................................................................................................................... 2
Typical markets .............................................................................................................. 2

SECTIONAL VIEW
Axial piston variable displacement pump ................................................................. 4

SYSTEM CIRCUIT DESCRIPTION
Pump and motor circuit description ......................................................................... 5
Pump circuit schematic ................................................................................................. 5

TECHNICAL SPECIFICATION
Technical parameters ................................................................................................. 6
Design ......................................................................................................................... 6
Type of mounting ........................................................................................................ 6
Pipe connections .......................................................................................................... 6
Direction of rotation .................................................................................................... 6
Installation position ..................................................................................................... 6
External drain fluid loss ............................................................................................... 6
Hydraulic parameters................................................................................................... 7
System pressure range, input $p_1$ ............................................................................. 7
System pressure range, output $p_2$ ............................................................................ 7
Case pressure .............................................................................................................. 7
Hydraulic fluid ............................................................................................................ 7
Hydraulic fluid temperature range .......................................................................... 7
Viscosity range ............................................................................................................ 7
Filtration ....................................................................................................................... 7
Shaft load .................................................................................................................... 7
Determination of nominal pump size .......................................................................... 8
Servo displacement control (linear response) ............................................................. 9
Pump flow direction .................................................................................................... 9
Reversing time ............................................................................................................ 10
Reset time .................................................................................................................. 11
Changing reversing and reset time ........................................................................... 11

DIMENSIONS – FRAME SIZE 070 AND 089
Outline drawing, configuration PS, displacement control VML 1 ............................ 12
Tapered shaft end ........................................................................................................ 12
Pump configuration AA 010, displacement control VML 1 .................................... 15

DIMENSIONS – FRAME SIZE 334
Pump configuration PS, displacement control VML 1 ............................................. 17
Pump configuration AA 010, displacement control VML 1 .................................... 19
PUMP AND MOTOR CIRCUIT DESCRIPTION

Above figure shows schematically the function of a hydrostatic transmission using an axial piston variable displacement pump and a fixed displacement motor.

PUMP CIRCUIT SCHEMATIC

Designation:
1 = Variable displacement pump
2 = Charge pump
3 = Servo control valve
4 = Charge check valve
5 = Charge relief valve
6 = Filter
7 = Heat exchanger

Ports:
A, B = Main pressure ports (working loop)
S = Suction port - charge pump
L1, L2 = Drain ports
M = Gauge port - charge pressure
Series 20 – Axial Piston Pumps
Technical Information
Technical Specification

**TECHNICAL PARAMETERS**

**Design**
Axial piston pump of swash plate design, with variable displacement.

**Type of mounting**
SAE four bolt flanges.

**Pipe connections**
Main pressure ports: SAE split flange
Remaining ports: SAE O-ring boss

**Direction of rotation**
Clockwise or counterclockwise (viewing from the input shaft).

**Installation position**
Optional; pump housing must be always filled with hydraulic fluid.

**External drain fluid loss**

![Graph showing external drain fluid loss vs. driveshaft speed]

Typical values for 350 bar [5076 psi] and 18° swashplate angle
Series 20 – Axial Piston Pumps
Technical Information
Technical Specification

HYDRAULIC PARAMETERS

**System pressure range, input p₁**
Variable displacement pump:
Charge pressure nominal: 13 bar [189 psi] above case pressure
Charge pressure minimum: 8 bar [116 psi], intermittent only

Charge pump input pressure:
Min. allowable pressure, continuous = 0.75 bar [10.9 psi] absolute
Min. allowable pressure, intermittent = 0.50 bar [7.3 psi] absolute (for cold start)

Charge pump output pressure:
Max. operating pressure = 35 bar [508 psi] above case pressure

**System pressure range, output p₂**
Pressure on port A or B: Max. operating pressure \( \Delta p = 420 \text{ bar} \) [6092 psi]
Max. high pressure setting \( \Delta p = 460 \text{ bar} \) \(^1\) [6672 psi]

\(^1\) only with POR-valve

**Case pressure**
Max. rated pressure = 2.5 bar [36.3 psi]
Intermittent = 5.0 bar [72.5 psi]

**Hydraulic fluid**
Refer to Sauer-Danfoss publications *Hydraulic Fluids and Lubricants* and *Experience with Bio Fluids for biodegradable hydraulic fluids*.

**Hydraulic fluid temperature range**
\( \theta _{\text{min}} = -40 \degree \text{C} [-40 \degree \text{F}] \)
\( \theta _{\text{max}} = 95 \degree \text{C} [203 \degree \text{F}] \)

**Viscosity range**
\( \nu _{\text{min}} = 7 \text{ mm}^2/\text{s} \) [49 SUS*]
\( \nu _{\text{max}} = 1000 \text{ mm}^2/\text{s} \) [4630 SUS*] (intermittent cold start)
Recommended viscosity range: 12 - 60 mm\(^2\)/s [66 - 280 SUS*]

* SUS (Saybolt Universal Second)

**Filtration**
Required cleanliness level: ISO 4406 - 1999 Code 22/18/13 or better. Refer to Sauer-Danfoss publication *Hydraulic Fluids and Lubricants* and *Design Guideline for Hydraulic Fluid Cleanliness*.

**Shaft load**
The pump will accept radial and axial loads on its shaft, the maximum capacity being determined by direction and point of application of the load.
*Please contact your Sauer-Danfoss representative.*
### Technical data

<table>
<thead>
<tr>
<th></th>
<th>Frame size</th>
<th>070</th>
<th>089</th>
<th>334</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. displacement</td>
<td>cm³ [in³]</td>
<td>69.8</td>
<td>89.0</td>
<td>333.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[4.26]</td>
<td>[5.43]</td>
<td>[20.36]</td>
</tr>
<tr>
<td>Charge pump displacement</td>
<td>cm³ [in³]</td>
<td>18.03</td>
<td>65.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>[1.10]</td>
<td>[4.00]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>options</td>
<td>12.30</td>
<td></td>
<td>[0.75]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0.75]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum speed</td>
<td>min⁻¹ (rpm)</td>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated speed 1</td>
<td>min⁻¹ (rpm)</td>
<td>3200</td>
<td>2900</td>
<td>1900</td>
</tr>
<tr>
<td>Maximum swash plate angle</td>
<td>degree</td>
<td>±18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass moment of inertia of rotating group</td>
<td>kg m² · 10⁻³ [lbf ft² · 10⁻³]</td>
<td>12.34</td>
<td>17.77</td>
<td>161.40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[292.8]</td>
<td>[421.7]</td>
<td>[3830.0]</td>
</tr>
<tr>
<td>Weight</td>
<td>kg [lb]</td>
<td>63</td>
<td>78</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[139]</td>
<td>[172]</td>
<td>[595]</td>
</tr>
</tbody>
</table>

¹ for higher speeds contact your Sauer–Danfoss representative

### Determination of nominal pump size

**Unit:**
- **Metric system:**
  - Pump output flow: \( Q = \frac{V_g \cdot n \cdot \eta_v}{1000} \) l/min
  - Input power: \( P = \frac{V_g \cdot n \cdot \Delta p}{600 000 \cdot \eta_t} \) kW
  - Input torque: \( M = \frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m} \) Nm
- **Inch system:**
  - Pump output flow: \( Q = \frac{V_g \cdot n \cdot \eta_v}{231} \) [gpm]
  - Input power: \( P = \frac{V_g \cdot n \cdot \Delta p}{396 000 \cdot \eta_t} \) [hp]
  - Input torque: \( M = \frac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m} \) [lbf•in]

Efficiency characteristic curves available on request.

\( V_g \) = Pump displacement per revolution  \( \text{cm}^3 \) [in³]
\( n \) = Pump speed  \( \text{min}^{-1} \) (rpm)
\( \Delta p \) = Hydraulic pressure differential  \( \text{bar} \) [psid]
\( \eta_v \) = Pump volumetric efficiency
\( \eta_m \) = Pump mechanical efficiency
\( \eta_t \) = Pump total efficiency
\( p_{\text{HD}} \) = High pressure  \( \text{bar} \) [psid]
\( p_{\text{ND}} \) = Low pressure  \( \text{bar} \) [psid]
Regulated by the control handle on the servo valve, the swash plate can be infinitely varied in both directions with the help of the servo system. The pump displacement resulting from any control handle position can be established using the figures on this page. The angle of the control handle for stroke initiation and for the final position of the stroke can vary from unit to unit within the range of the tolerance band. The inter-relation of flow direction, rotation of the pump and the control handle movement is shown below.

### Pump flow direction

Flow direction changes with the direction of rotation and the control handle movement (see above).

<table>
<thead>
<tr>
<th>Pump rotation</th>
<th>Movement of control handle in direction</th>
<th>Pressure port OUT</th>
<th>Pressure port IN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counterclockwise (L)</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Clockwise (R)</td>
<td>C</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

### Technical Specification

**SERVO DISPLACEMENT CONTROL (LINEAR RESPONSE)**

- **SPV 2/070**
- **SPV 2/089**
- **SPV 2/334**
**SERVO DISPLACEMENT CONTROL (LINEAR RESPONSE)**

(continued)

### Reversing time

Time for the directional change of the flow from $Q_{\text{max}}$, across zero to $Q_{\text{max}}$, depending on the size of the control orifice fitted in the supply port to the servo valve (see below). The values given assume movement of the control handle directly from one end position to the other.

Adjustment time of handle: $< \text{minimum reversing time}$

- **Operating pressure:** $\Delta p_2 = 210 \text{ bar} [3046 \text{ psi}]$
- **Speed:** $n = 1450 \text{ min}^{-1} \text{ (rpm)}$
- **System temperature:** $50 \, ^\circ\text{C} \text{ [122 } ^\circ\text{F]}$
- **Viscosity:** $35 \text{ mm}^2/\text{s} \text{ [164 SUS]}$

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Minimum reversing time (s) without orifice</th>
<th>Maximum reversing time (s) with orifice Ø 0.66 in supply port</th>
</tr>
</thead>
<tbody>
<tr>
<td>070</td>
<td>1.0</td>
<td>9.3</td>
</tr>
<tr>
<td>089</td>
<td>1.1</td>
<td>9.0</td>
</tr>
<tr>
<td>334</td>
<td>5.6</td>
<td>43.8</td>
</tr>
</tbody>
</table>

*Scheme diagram of servo valve with alternative orifice positions*
SERVO DISPLACEMENT CONTROL (LINEAR RESPONSE) (continued)

**Reset time**
Time for reducing the flow from either flow direction from \( Q_{\text{max}} \) to 0 releasing the control handle.
Assuming no mechanical blockage of the control handle’s free return and assuming no orifices in the pilot ports:

- **Operating pressure:** \( \Delta p_2 = 210 \text{ bar [3046 psi]} \)
- **System temperature:** \( 50 \text{ °C [122 ° F]} \)
- **Viscosity:** \( 35 \text{ mm}^2/\text{s [164 SUS]} \)

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Minimum reset time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>070</td>
<td>3.0</td>
</tr>
<tr>
<td>089</td>
<td>3.3</td>
</tr>
<tr>
<td>334</td>
<td>5.4</td>
</tr>
</tbody>
</table>

**Changing reversing and reset time**
Inserting one orifice in each of the pilot ports can extend the reversing time. The reset time will also be extended.
Inserting an orifice in one of the pilot ports only can extend the reversing time in one flow direction. The reset time will be extended only for this flow direction.
**Series 20 – Axial Piston Pumps**

**Technical Information**

**Dimensions – Frame Size 070 and 089 cm³**

- Minimum and maximum angle $\alpha$, (see section *servo displacement control*).
- Shaft spline data: spline shaft with involute spline, according to SAE handbook, 1963, class 1, fillet root side fit.

---

**OUTLINE DRAWING, CONFIGURATION PS, DISPLACEMENT CONTROL VML 1**

- Coupling may not protrude beyond 48 mm maximum length of full spline.
- Charge pressure relief valve.
- Gauge port - servo cylinder pressure (both sides) 7/16-20 UNF-2B SAE straight thread O-ring boss.
- Serrated shaft.
- Control handle.

---

**Shaft spline data:**
- Pitch Ø = P
- Pressure angle = 30°
- Number of teeth = R
- Pitch = S
Max. torque for charge pump inlet port (7/8 -14 UNF - 2B) is 22 - 28 Nm [195 - 248 lbf•in].

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Port A and B</th>
<th>Port L₁ and L₂</th>
<th>Port S</th>
<th>Port M</th>
</tr>
</thead>
</table>
| 070        | SAE flange, size 1  
SAE split flange boss  
5000 psi  
4 threads  
3/8-16 UNC-2B  
18 deep | 7/8-14 UNF-2B  
SAE straight thread  
O-ring boss | 7/16-20 UNF-2B  
SAE straight thread  
O-ring boss |
### OUTLINE DRAWING, CONFIGURATION PS, DISPLACEMENT CONTROL VML 1 (continued)

#### View X (for SPV 2/070 only)

- **Control handle shaft spline data:** 64/128 pitch, 64 diametral pitch acc. to SAE handbook 1963
- **Outside diameter:** 10.13 - 0.14
- **Number of teeth:** 24

#### View X (for SPV 2/089 only)

- **Control handle shaft spline data:** 64/128 pitch, 64 diametral pitch acc. to SAE handbook 1963
- **Outside diameter:** 10.13 - 0.14
- **Number of teeth:** 24

#### Dimensions – Frame Size 070 and 089 cm³

<table>
<thead>
<tr>
<th>Frame size</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>Ø N</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Frame size</th>
<th>T</th>
<th>U</th>
<th>V</th>
<th>W</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>AA</th>
<th>BB</th>
<th>CC</th>
<th>DD</th>
<th>EE</th>
</tr>
</thead>
</table>

### Charge pump

- **cm³ [in³]**

<table>
<thead>
<tr>
<th>Frame size</th>
<th>FF</th>
<th>GG</th>
<th>HH</th>
<th>JJ</th>
</tr>
</thead>
</table>

### Shaft spline

<table>
<thead>
<tr>
<th>Ø O</th>
<th>Ø P</th>
<th>R</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 [0.732]</td>
<td>18 [1.098]</td>
<td>21 [0.827]</td>
<td>16/32</td>
</tr>
<tr>
<td>34.50 [1.358]</td>
<td>33.338 [1.313]</td>
<td>16/32</td>
<td></td>
</tr>
<tr>
<td>34.50 [1.358]</td>
<td>34.50 [1.358]</td>
<td>21 [0.827]</td>
<td></td>
</tr>
</tbody>
</table>

### Bore diameter for shaft coupling

<table>
<thead>
<tr>
<th>S</th>
<th>mm [in]</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/32</td>
<td>31.75 ± 0.002 [1.250 ± 0.002]</td>
</tr>
<tr>
<td>16/32</td>
<td>34.95 ± 0.002 [1.376 ± 0.002]</td>
</tr>
</tbody>
</table>

1 Short version available on request. Please contact your local Sauer-Danfoss representative.
Series 20 – Axial Piston Pumps
Technical Information
Dimensions – Frame Size 070 and 089 cm³

TAPERED SHAFT END

Depth, keygroove: 5,7 + 0,1
Shaft, cone: 1 : 8

Coupling may not protrude beyond
81 mm maximum length of shaft

Designation:
1 = Variable Displacement pump
3 = Servo control valve
4 = Charge check valve
7 = Heat exchanger

Ports:
A, B = Main pressure ports
       (working loop)
L1, L2 = Drain ports
M = Gauge port - charge pressure
PUMP CONFIGURATION AA 010, DISPLACEMENT CONTROL VML 1 (continued)

Dimensions

<table>
<thead>
<tr>
<th>Frame Size</th>
<th>A mm [in]</th>
<th>B mm [in]</th>
<th>Weight kg [lb]</th>
</tr>
</thead>
</table>
Series 20 – Axial Piston Pumps
Technical Information
Dimensions – Frame Size 334 cm³

PUMP CONFIGURATION
PS, DISPLACEMENT
CONTROL VML 1

* Minimum and maximum angle α, (see section servo displacement control).
** Shaft spline data: spline shaft with involute spline, according to SAE handbook, 1963, class 1, fillet root side fit.

View Z

Maximum displacement
Null position
26° 28' min.
26° 28' max.

Maximum displacement
Control handle
R 25.4
R 50.8

Gauge port - servo cylinder pressure (both sides) 7/16-20 UNF-2B SAE straight thread
O-ring boss

Charge pressure relief valve
Port "S": Charge pump suction port

Port "L": Case drain port (use highest port as outlet)

Gauging port - servo cylinder pressure
(both sides) 7/16-20 UNF-2B SAE straight thread
O-ring boss

Null position
Maximum displacement

Port "S": Charge pump suction port

Coupling may not protrude beyond 48 mm maximum length of full spline

Shaft spline data**
Pitch Ø
Pressure angle
Number of teeth
Pitch
Internal opening for grooving

= 63.500
= 30°
= 27
= 16/32
= 61.93 ± 0.062
PUMP CONFIGURATION PS, DISPLACEMENT CONTROL VML 1 (continued)

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Port A and B</th>
<th>Port L₁, and L₂</th>
<th>Port S</th>
<th>Port M</th>
</tr>
</thead>
<tbody>
<tr>
<td>334</td>
<td>SAE flange, size 1 1/2</td>
<td>7/16-12 UNF-2B</td>
<td>SAE flange, size 1 1/4</td>
<td>7/16-20 UNF-2B</td>
</tr>
<tr>
<td></td>
<td>SAE split flange boss</td>
<td>SAE straight thread O-ring boss</td>
<td>SAE split flange boss</td>
<td>SAE straight thread</td>
</tr>
<tr>
<td></td>
<td>6000 psi</td>
<td>3000 psi</td>
<td>3000 psi</td>
<td>O-ring boss</td>
</tr>
<tr>
<td></td>
<td>4 threads</td>
<td>4 threads</td>
<td>4 threads</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5/8-11 UNC-2B</td>
<td>7/16-14 UNC-2B</td>
<td>7/16-14 UNC-2B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35 deep</td>
<td>28 deep</td>
<td>35 deep</td>
<td></td>
</tr>
</tbody>
</table>
Series 20 – Axial Piston Pumps
Technical Information
Dimensions – Frame Size 334 cm³

**PUMP CONFIGURATION**

**AA 010, DISPLACEMENT**

**CONTROL VML 1**

Designation:
1 = Variable Displacement pump
3 = Servo control valve
4 = Charge check valve
7 = Heat exchanger

Ports:
A, B = Main pressure ports (working loop)
S = Suction port - charge pump
L1, L2 = Drain ports
M = Gauge port - charge pressure

**Dimensions**

<table>
<thead>
<tr>
<th>Frame size</th>
<th>A mm [in]</th>
<th>B mm [in]</th>
<th>C mm [in]</th>
<th>Weight kg [lb]</th>
</tr>
</thead>
</table>
Sauer-Danfoss Mobile Power and Control Systems
– Market Leaders Worldwide

Sauer-Danfoss is a comprehensive supplier providing complete systems to the global mobile market.

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

We offer our customers optimum solutions for their needs and develop new products and systems in close cooperation and partnership with them.

Sauer-Danfoss specializes in integrating a full range of system components to provide vehicle designers with the most advanced total system design.

Sauer-Danfoss provides comprehensive worldwide service for its products through an extensive network of Authorized Service Centers strategically located in all parts of the world.

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

Sauer-Danfoss (Neumünster) 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 (Nordborg) A/S
DK-6430 Nordborg, Denmark
Phone: +45 7488 4444, Fax: +45 7488 4400

www.sauer-danfoss.com