Technical Information
Axial Piston Pumps
Series 20
Danfoss a world leader in hydraulic power systems has developed a family of axial piston pumps.

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.

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 Danfoss pattern are made by licensed producers worldwide, providing consistent service and fully interchangeable parts.

Typical markets

- Industrial
- Mining
- Transit Mixer
- Utility Vehicles
## General Description

- Axial Piston Variable Displacement Pump................................................................. 4
- Pump and Motor Circuit Description........................................................................... 5
- Pump circuit schematic ............................................................................................... 5

## Technical Specification

### Technical Parameters
- Design .......................................................................................................................... 6
- Type of mounting .......................................................................................................... 6
- Pipe connections .......................................................................................................... 6
- Direction of rotation .................................................................................................... 6
- Installation position ..................................................................................................... 6
- External drain fluid loss ............................................................................................... 6

### Hydraulic Parameters
- System pressure range, input $p_1$ ................................................................................ 7
- System pressure range, output $p_2$ ............................................................................. 7
- Case pressure ............................................................................................................ 7
- Hydraulic fluids ......................................................................................................... 7
- Temperature range .................................................................................................... 7
- Viscosity range .......................................................................................................... 7
- Filtration ..................................................................................................................... 7
- Shaft load .................................................................................................................. 7

### Determination of Nominal Pump Sizes
- Based on SI units/Based on US units ......................................................................... 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
- Configuration PS, displacement control VML 1 ........................................................ 12
- Configuration AA 010, displacement control VML 1 ................................................. 14

### Frame Size 334
- Configuration PS, displacement control VML 1 ........................................................ 15
- Configuration AA 010, displacement control VML 1 ................................................. 17
General Description

Axial Piston Variable Displacement Pump

Sectional View

- Swash plate
- Control handle
- Servo valve (control valve)
- Charge pump
- Charge check valve
- Servo cylinder
- Cylinder block assembly
- Shaft seal
- Input shaft

Design 1

Design 2
General Description

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
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.](image-url)
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 $\Delta p = 420$ bar [6092 psi]
Max. high pressure setting $\Delta p = 460$ 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 fluids
Refer to Danfoss publications *Hydraulic Fluids and Lubricants, 520L0463* and *Experience with Biodegradable Hydraulic Fluids, 520L0465*.

Temperature range
$\theta_{\text{min}} = -40 \, ^\circ C \, [-40 \, ^\circ F]$  
$\theta_{\text{max}} = 95 \, ^\circ C \, [203 \, ^\circ F]$  

Viscosity range
$\nu_{\text{min}} = 7 \, \text{mm}^2/\text{s} \, [49 \, \text{SUS}]$  
$\nu_{\text{max}} = 1000 \, \text{mm}^2/\text{s} \, [4630 \, \text{SUS}]$ (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 Danfoss publication *Hydraulic Fluids and Lubricants, 520L0463* and *Design Guideline for Hydraulic Fluid Cleanliness, 520L0467*.

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 Danfoss representative.
### Technical Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Frame size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. displacement</td>
<td>cm³ [in³]</td>
<td>69.8 [4.26]</td>
</tr>
<tr>
<td>Charge pump displacement options</td>
<td>cm³ [in³]</td>
<td>18.03 [1.10]</td>
</tr>
<tr>
<td>Minimum speed</td>
<td>min⁻¹ (rpm)</td>
<td>500</td>
</tr>
<tr>
<td>Rated speed 1</td>
<td>min⁻¹ (rpm)</td>
<td>3200</td>
</tr>
<tr>
<td>Maximum swash plate angle</td>
<td>degree</td>
<td>±18</td>
</tr>
<tr>
<td>Mass moment of inertia of rotating group (without charge pump)</td>
<td>kg m² · 10⁻³ [lbf ft² · 10⁻³]</td>
<td>12.34 [292.8]</td>
</tr>
<tr>
<td>Weight</td>
<td>kg [lb]</td>
<td>63 [139]</td>
</tr>
</tbody>
</table>

¹ for higher speeds contact your Sauer–Danfoss representative.

### Determination of Nominal Pump Sizes

Use these formulae to determine the nominal pump size for a specific application:

**Based on SI units**

- **Output flow:**
  \[ Q = \frac{V_g \cdot n \cdot \eta_v}{1000} \text{ l/min} \]

- **Input torque:**
  \[ M = \frac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m} \text{ N\cdot m} \]

- **Input power:**
  \[ P = \frac{M \cdot n}{9550} = \frac{Q \cdot \Delta p}{600 \cdot \eta_t} \text{ kW} \]

**Based on US units**

- **Output flow:**
  \[ Q = \frac{V_g \cdot n \cdot \eta_v}{231} \text{ [US gal/min]} \]

- **Input torque:**
  \[ M = \frac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m} \text{ [lbf\cdot in]} \]

- **Input power:**
  \[ P = \frac{M \cdot n}{63.025} = \frac{Q \cdot \Delta p}{1714 \cdot \eta_t} \text{ [hp]} \]

**Variables:**

- **SI units**
  - \( V_g \): Displacement per rev. \text{ cm³/rev [in³/rev]}
  - \( p_o \): Outlet pressure \text{ bar [psi]}
  - \( p_i \): Inlet pressure \text{ bar [psi]}
  - \( \Delta p \): \( p_o - p_i \) \text{ bar [psi]}
  - \( n \): Speed \text{ min⁻¹ (rpm)}
  - \( \eta_v \): Volumetric efficiency
  - \( \eta_m \): Mechanical (torque) efficiency
  - \( \eta_t \): Overall efficiency \( (\eta_v \cdot \eta_m) \)

- **US units**
  - \( Q \): \text{ [US gal/min]}
  - \( M \): \text{ [lbf\cdot in]}
Technical Specification

Servo Displacement Control (linear response)

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 besides).

<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>CCW (Left)</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>CW (Right)</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>

SPV2/070

SPV2/089

SPV2/334
**Technical Specification**

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

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Minimum reversing time (s) without orifice</th>
<th>Maximum reversing time (s) with orifice $\Theta 0.66$ 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>

*Schematic diagram of servo valve with alternative orifice positions*
Technical Specification

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

**Changing reversing and reset time**

_Servo valve counter bored recesses for orifice insert_

<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></td>
</tr>
<tr>
<td>334</td>
<td>5.4</td>
</tr>
</tbody>
</table>

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.
### Dimensions

#### Frame Size 070 and 089 cm³

**Configuration PS, displacement control VML 1**

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

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

<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>

**Frame size A1**

- Charge pump
  - 12 cm³: 372 [14.646]
  - 18 cm³: 381 [15.000]

- Shaft spline
  - Ø Ø: 34.50 [1.358] – 0.17 [0.800] – 0.0067 [0.0026]
  - Ø Ø: 33.338 [1.313]
  - Ø Ø: 37.68 [1.483] – 0.17 [0.800] – 0.0067 [0.0026]
  - Ø Ø: 36.513 [1.438]

- Bore Ø for shaft coupling
  - 070: 31.75 [1.250] + 0.0024 [0.0009]
  - 089: 34.95 [1.376] + 0.0024 [0.0009]

* Short version available on request. Please contact your local Danfoss representative.

**Dimensions - mm [in]**

<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>
</tr>
</thead>
</table>
### Dimensions

- **Frame Size 070 and 089 cm³**

### 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 \( \pm 0.14 \) mm
- 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 \( \pm 0.14 \) mm
- Number of teeth = 24

#### Table: Dimensions

<table>
<thead>
<tr>
<th>Frame size</th>
<th>AA</th>
<th>BB</th>
<th>CC</th>
<th>DD</th>
<th>EE</th>
<th>FF</th>
<th>GG</th>
<th>HH</th>
<th>JJ</th>
</tr>
</thead>
</table>

#### Figures

- View Y: Gauge port - servo cylinder pressure
- Port "L": Suction port (charge pump)
- Port "S": Suction port (charge pump)
- Position of charge pump for clockwise (R) rotation
- Port "A"
- Position of charge pump for counterclockwise (L) rotation
- Port "L": Case drain port
- Port "B"
Dimensions
- Frame Size 070 and 089 cm³

Configuration AA 010, displacement control VML 1

Dimensions - mm [in]

<table>
<thead>
<tr>
<th>Frame Size</th>
<th>A</th>
<th>B</th>
<th>Weight kg [lb]</th>
</tr>
</thead>
<tbody>
<tr>
<td>070</td>
<td>339</td>
<td>316</td>
<td>63.5 [140]</td>
</tr>
<tr>
<td>089</td>
<td>352</td>
<td>329</td>
<td>78.5 [173]</td>
</tr>
</tbody>
</table>

Circuit schematic

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
Dimensions
– Frame Size 334 cm³

Configuration PS,
displacement control VML 1

Shaft spline data,**
Pitch Ø = 63.500
Pressure angle = 30°
Number of teeth = 27
Pitch = 16/32
Internal opening for grooving = 61.93 ± 0.24

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

* 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.
Technical Information Series 20 Axial Piston Pumps

Dimensions
- Frame Size 334 cm³

Configuration PS,
displacement control VML 1
(continued)

Port A and B: SAE flange, size 1 1/2 SAE split flange boss, 6000 psi, 4 threads, 5/8-11 UNC-2B, 35 deep
Port L1, L2: 1 7/8-12 UNF-2B, SAE straight thread, O-ring boss
Port S: SAE flange, 1 1/4 SAE split flange boss, 3000 psi, 4 threads, 7/16-14 UNC-2B, 28 deep
Port M: 7/16-20 UNF-2B, SAE straight thread, O-ring boss
Dimensions
- Frame Size 334 cm³

Configuration AA 010, displacement control VML 1

Dimensions - mm [in]

<table>
<thead>
<tr>
<th>Frame size</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Weight kg [lb]</th>
</tr>
</thead>
</table>

Circuit schematic

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
Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electronic components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market. Building on our extensive applications expertise, we work closely with our customers to ensure exceptional performance for a broad range of off-highway vehicles.

We help OEMs around the world speed up system development, reduce costs and bring vehicles to market faster.

Danfoss – Your Strongest Partner in Mobile Hydraulics.

Go to www.powersolutions.danfoss.com for further product information.

Wherever off-highway vehicles are at work, so is Danfoss.

We offer expert worldwide support for our customers, ensuring the best possible solutions for outstanding performance. And with an extensive network of Global Service Partners, we also provide comprehensive global service for all of our components.

Please contact the Danfoss Power Solution representative nearest you.

Products we offer:

- Bent Axis Motors
- Closed Circuit Axial Piston Pumps and Motors
- Displays
- Electrohydraulic Power Steering
- Electrohydraulics
- Hydraulic Power Steering
- Integrated Systems
- Joysticks and Control Handles
- Microcontrollers and Software
- Open Circuit Axial Piston Pumps
- Orbital Motors
- PLUS+1® GUIDE
- Proportional Valves
- Sensors
- Steering
- Transit Mixer Drives