Series 90
Axial Piston Motors
### Revision history

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<table>
<thead>
<tr>
<th>Date</th>
<th>Changed</th>
<th>Rev</th>
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<tbody>
<tr>
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<td>edits to graph and table on page 17</td>
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<td>various updates</td>
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<tr>
<td>September 2008</td>
<td>flange to shaft length dimension should be ([5.15 ±0.001])</td>
<td>DB</td>
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<td>Remove allowable shaft loading data - consult factory</td>
<td>DA</td>
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Series 90 Family of Pumps and Motors

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

Series 90 variable displacement pumps are compact, high power density units. All models utilize the parallel axial piston/slipper concept in conjunction with a tiltable swashplate to vary the pump’s displacement. Reversing the angle of the swashplate reverses the flow of oil from the pump and thus reverses the direction of rotation of the motor output.

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

Series 90 motors also use the parallel axial piston/slipper design in conjunction with a fixed 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
- Four sizes of fixed displacement motors
- SAE and cartridge mount configurations
- Efficient axial piston design
- Proven reliability and performance
- Compact, lightweight
- Worldwide sales and service

Fixed Displacement Motor, SAE Mount

Cross section
General Description

**Name plate**

![Name plate diagram]

- **Model Code**: A - 00 - 13 - 67890
- **Serial Number**: 501829
- **Made in Germany**
- **Place of Manufacture**: P101372E

**Fixed Displacement Motor, Cartridge Mount**

**Cross section**

- **Charge relief valve**
- **Loop flushing valve**
- **Valve plate**
- **Cylinder block**
- **Piston**
- **Roller bearing**
- **Output shaft**
- **Swashplate**
General Description

Name plate

![Name plate image]

Model Code 90M100 NC 0 N 7 N 9 C7
Serial No. A - 00 - 13 - 67890
Made in China

Pictorial Circuit Diagram

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

System Schematic
Technical Information
Series 90 Axial Piston Motors

Technical Specifications

Overview

Specifications for the Series 90 motors are listed here for quick reference. For definitions and additional information, see Operating Parameters on page 8.

Features and Options

<table>
<thead>
<tr>
<th>Motor type</th>
<th>In-line, axial piston, closed loop, positive displacement motors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction of rotation</td>
<td>Bi-directional, see outline drawings for rotation vs. flow direction information</td>
</tr>
<tr>
<td>Installation position</td>
<td>Discretionary: Housing must be filled with hydraulic fluid</td>
</tr>
<tr>
<td>Other system requirements</td>
<td>Independent braking system, overpressure protection, suitable reservoir, proper filtration</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>055 MF</th>
<th>075 MF</th>
<th>100 MF</th>
<th>130 MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of mounting (SAE flange size per SAE J744)</td>
<td>SAE C, cartridge</td>
<td>SAE C, cartridge</td>
<td>SAE C</td>
<td>SAE D</td>
</tr>
<tr>
<td>Port connections</td>
<td>Twin, axial</td>
<td>Twin, axial</td>
<td>Twin</td>
<td>Twin</td>
</tr>
<tr>
<td>Output shaft options</td>
<td>Spline, tapered, straight</td>
<td>Spline, tapered, straight</td>
<td>Spline, tapered, straight</td>
<td>Spline</td>
</tr>
<tr>
<td>Control options</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Loop flushing</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Speed sensor</td>
<td>o</td>
<td>o</td>
<td>o</td>
<td>o</td>
</tr>
</tbody>
</table>

- Standard
- Optional
— Not available / not applicable

Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>055 MF</th>
<th>075 MF</th>
<th>100 MF</th>
<th>130 MF</th>
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</thead>
<tbody>
<tr>
<td>Swashplate</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Fixed</td>
</tr>
<tr>
<td>Theoretical torque N-m/bar [lb-in/1000 psi]</td>
<td>0.88 [530]</td>
<td>1.19 [730]</td>
<td>1.59 [970]</td>
<td>2.07 [1260]</td>
</tr>
<tr>
<td>Weight kg [lb]</td>
<td>SAE</td>
<td>22 [49]</td>
<td>26 [57]</td>
<td>34 [74]</td>
</tr>
<tr>
<td>Cartridge</td>
<td>26 [57]</td>
<td>33 [72]</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Mass moment of inertia kg-m² [slug-ft²]</td>
<td>0.0060 [0.0044]</td>
<td>0.0096 [0.0071]</td>
<td>0.0150 [0.0111]</td>
<td>0.0230 [0.0170]</td>
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Operating Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>055 MF</th>
<th>075 MF</th>
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<tr>
<td>Speed limits</td>
<td>min⁻¹ (rpm)</td>
<td>3900</td>
<td>3600</td>
<td>3300</td>
<td>3100</td>
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<tr>
<td>Maximum (max. disp.)</td>
<td></td>
<td>4250</td>
<td>3950</td>
<td>3650</td>
<td>3400</td>
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<tr>
<td>Continuous (min. disp.)</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Maximum (min. disp.)</td>
<td></td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
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</table>
**Technical Specifications**

<table>
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<th>075 MF</th>
<th>100 MF</th>
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<tr>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow ratings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Case pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>bar [psi]</td>
<td>3 [44]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum (cold start)</td>
<td></td>
<td>5 [73]</td>
<td></td>
<td></td>
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</table>

**Fluid Specifications**

<table>
<thead>
<tr>
<th>Viscosity mm²/sec (cSt) [SUS]</th>
<th></th>
<th></th>
<th></th>
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<tr>
<td>Minimum</td>
<td>7 [49]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>12-80 [70-370]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>1600 [7500]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature °C [°F] (measured at the hottest point in the system, usually the case drain)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>-40 [-40]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>104 [220]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>115 [240]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filtration</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanliness</td>
<td>22/18/13 or better per ISO 4406</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency (suction filtration)</td>
<td>β_{35.45} = 75 (β_{10} ≥ 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency (charge filtration)</td>
<td>β_{15.20} = 75 (β_{10} ≥ 10)</td>
<td></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>
<td></td>
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</table>
Operating Parameters

Overview

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

Speed Limits

*Continuous speed* is the highest input speed recommended at full power condition. Operating at or below this speed should yield satisfactory product life. In a machine propel application, maximum motor speed during unloaded, on-road travelling on level ground should not exceed this limit.

*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

**Unintended vehicle or machine movement hazard.**

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

System Pressure

*System pressure* is the differential pressure between high pressure system ports. It is the dominant operating variable affecting hydraulic unit life. High system pressure, which results from high load, reduces expected life. Hydraulic unit life depends on the speed and normal operating, or weighted average, pressure that can only be determined from a duty cycle analysis.

*Application pressure* is the high pressure relief or pressure limiter setting normally defined within the order code of the pump. This is the applied system pressure at which the drive-line generates the maximum calculated pull or torque in the application.

*Maximum working pressure* is the highest recommended Application pressure. Maximum working pressure is not intended to be a continuous pressure. Propel systems with application pressures at, or below, this pressure should yield satisfactory unit life given proper component sizing.

*Maximum pressure* is the highest allowable Application pressure under any circumstance. Application pressures above maximum working Pressure will only be considered with duty cycle analysis and factory approval.

Pressure spikes are normal and must be considered when reviewing maximum working pressure.

Minimum **low loop pressure** must be maintained under all operating conditions to avoid cavitation.

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

Servo Pressure

Servo pressure is the pressure in the Servo-system needed to position and hold the pump on stroke. It depends on system pressure and speed.

At **minimum** servo pressure the pump will run at reduced stroke depending on speed and pressure.

**Minimum** servo pressure at corner power holds the pump on full stroke at max speed and max pressure.

**Maximum** servo pressure is the highest pressure typically given by the charge pressure setting.
Operating Parameters

Case Pressure

Under normal operating conditions, the rated case pressure must not be exceeded. During cold start case pressure must be kept below maximum intermittent case pressure. Size drain plumbing accordingly.

⚠️ Warning

**Possible component damage or leakage**

Operation with case pressure in excess of stated 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 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 on 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.
System Design Parameters

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 ingression 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 ($\beta_x$).

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.

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 $\beta_{30-45} = 75$ ($\beta_{10} \geq 2$) or better has been found to be satisfactory. For some open circuit systems, and closed circuits with cylinders being supplied from the same reservoir, a considerably higher filter efficiency is recommended. This also applies to systems with gears or clutches using a common reservoir. For these systems, a charge pressure or return filtration system with a filter $\beta$-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.

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.

The reservoir outlet to the charge pump inlet should be 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 mm screen over the outlet port is recommended.

The reservoir inlet (fluid return) should be positioned so that flow to the reservoir is discharged below the normal fluid level, and also directed into the interior of the reservoir for maximum dwell and efficient de-aeration. A baffle (or baffles) between the reservoir inlet and outlet ports will promote de-aeration and reduce surging of the fluid.
Overpressure Protection

Series 90 motors (as well as other system components) have pressure limitations. As Series 90 motors are not equipped with overpressure protection, it is necessary that relief valves or pressure limiters are present elsewhere in the high pressure circuit to protect components from excessive pressures.

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 de-stroke the pump in order to limit the system pressure. For unusually rapid load application, the high pressure relief valve function is available to also limit the pressure level. Refer to publication Series 90 Pumps Technical Information Manual 520L0603 for more information.

For systems with relief valves only, high pressure relief valves are intended for transient overpressure protection and are not intended for continuous pressure control. Operation over relief valves for extended periods of time may result in severe heat build up. High flows over relief valves may result in pressure levels exceeding the nominal valve setting and potential damage to system components.

Case Drain

A case drain line must be connected to one of the case outlets (L1 or L2) to return internal leakage and loop flushing flow 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 motors. 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-9985, 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.

Formulas

Based on SI units

\[
\text{Input flow } Q = \frac{V \cdot n}{1000 \cdot \eta_v} \quad \text{(l/min)}
\]

\[
\text{Output torque } M = \frac{V \cdot \Delta p \cdot \eta_m}{20 \cdot \pi} \quad \text{(N\cdotm)}
\]

\[
\text{Output power } P = \frac{Q \cdot \Delta p \cdot \eta_t}{600} \quad \text{(kW)}
\]

\[
\text{Motor speed } n = \frac{Q \cdot 1000 \cdot \eta_m}{V_i} \quad \text{(min}^{-1}\text{rpm})
\]

Based on US units

\[
\text{Input flow } Q = \frac{V \cdot n}{231 \cdot \eta_v} \quad \text{(US gal/min)}
\]

\[
\text{Output torque } M = \frac{V \cdot \Delta p \cdot \eta_m}{2 \cdot \pi} \quad \text{(lbf\cdotin)}
\]

\[
\text{Output power } P = \frac{Q \cdot \Delta p \cdot \eta_t}{1714} \quad \text{(hp)}
\]

\[
\text{Motor speed } n = \frac{Q \cdot 231 \cdot \eta_m}{V_i} \quad \text{(min}^{-1}\text{rpm})
\]

Variables

SI units [US units]

- \(V\) = Displacement per revolution \( \text{cm}^3/\text{rev} \) \([\text{in}^3/\text{rev}]\)
- \(p_o\) = Outlet pressure \( \text{bar} \) \([\text{psi}]\)
- \(p_i\) = Inlet pressure \( \text{bar} \) \([\text{psi}]\)
- \(\Delta p\) = \(p_o - p_i\) (system pressure) \( \text{bar} \) \([\text{psi}]\)
- \(n\) = Speed \( \text{min}^{-1} \) \([\text{rpm}]\)
- \(\eta_v\) = Volumetric efficiency
- \(\eta_m\) = Mechanical efficiency
- \(\eta_t\) = Overall efficiency \((\eta_v \cdot \eta_m)\)
System Design Parameters

External Shaft Loading and Bearing Life

In vehicle propel drives with no external shaft loads where the system pressure is changing direction and magnitude regularly and the operating parameters are within the limits, the normal L20 bearing life (80% survival) will exceed the hydraulic life of the unit.

In non-propel drives such as vibratory drives, conveyor drives or fan drives, the operating pressure is often constant. These drives have unique duty cycles compared to a propel drive. In these types of applications a bearing life review is recommended.

In a bearing life analysis the following parameters are considered: Speed, pressure and external loads. Other factors that affect life include fluid type, viscosity and cleanliness.

Shaft loading parameters

<table>
<thead>
<tr>
<th>Re</th>
<th>Maximum radial side load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Me</td>
<td>Maximum external moment</td>
</tr>
<tr>
<td>L</td>
<td>Distance from mounting flange to point of load</td>
</tr>
</tbody>
</table>

Applications with external shaft loads

Avoid external thrust (axial) loads in either direction whenever possible. Thrust loads could reduce the bearing life in applications with low delta system pressure or when present in combination with radial loading or bending moments.

External loads are found in applications where the motor is driven with a radial load on the shaft (i.e. belt or gear driven) as well as installations with misalignment or improper concentricity between the motor and drive coupling. All external loads will act to reduce the normal bearing life of a motor.

In applications where external radial shaft loads cannot be avoided, minimize the impact on bearing life by orienting the load to the 180° position as shown in the figure below when possible. Use tapered output shafts or clamped-type couplings where radial shaft loads are present.
System Design Parameters

Maximum allowable external shaft loads

<table>
<thead>
<tr>
<th>Displacement</th>
<th>cm³</th>
<th>055</th>
<th>075</th>
<th>100</th>
<th>130</th>
</tr>
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<tbody>
<tr>
<td>External moment Me</td>
<td>N·m</td>
<td>101</td>
<td>118</td>
<td>126</td>
<td>*</td>
</tr>
</tbody>
</table>

* No tapered shaft available

If continuous applied radial loads exceed 25% of the maximum allowable or thrust (axial) loads are present, contact your Danfoss representative for a bearing life evaluation.
Loop Flushing

⚠️ Warning

Unintended vehicle or machine movement hazard. Excessive motor loop flushing flow may result in the inability to build required system pressure in some conditions. Maintain correct charge pressure under all conditions of operation to maintain pump control performance in hydrostatic systems.

An integral non-adjustable loop flushing valve is incorporated into Series 90 motors. Installations that require fluid to be removed from the low pressure side of the system circuit because of cooling requirements or contamination removal will benefit from loop flushing.

The integral loop flushing valve is equipped with an orificed charge pressure relief valve designed with a cracking pressure of 16 bar [232 psi]. Valves are available with several orifice sizes to meet the flushing flow requirements of all system operating conditions.

The total system charge pump flow should be of sufficient volume to accommodate:
- The number of motors in the system
- System efficiency under worst case conditions
- Pump control requirements
- External needs

Although charge pump sizing requires the consideration of many system variables, the following table gives a recommendation of what charge pump displacement may be required to accommodate the flushing flow of each available charge relief valve orifice.

**Equation**

\[ Q_{\text{Flush}} = \frac{Q_{\text{Charge}} - Q_{\text{Leak}}}{2 \cdot k_{Mo}} \]

**Where**

- \( Q_{\text{Flush}} \) = flushing flow per motor
- \( Q_{\text{Charge}} \) = charge flow at operating speed
- \( k_{Mo} \) = number of motors fed by one pump
- \( Q_{\text{Leak}} \) = sum of external leakages including the following:
  - motor leakage
  - pump leakage + internal consumers: 8 l/min [2.11 US gal/min] for displacement control pumps or for non-feedback controlled pumps at 200 bar [2900 psi]
  - external consumers (brakes, cylinders, other pumps)
### Features and Options

#### Loop flushing flow curves

![Loop flushing flow curves](image)

#### Recommended charge pump displacement

<table>
<thead>
<tr>
<th>Orifice option</th>
<th>Charge pump displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>13 bar ± 8.5% cracking pressure</strong></td>
<td><strong>16 bar ± 8.5% cracking pressure</strong></td>
</tr>
<tr>
<td>N4</td>
<td>E4</td>
</tr>
<tr>
<td>N6</td>
<td>E6</td>
</tr>
<tr>
<td>A0</td>
<td>F0</td>
</tr>
<tr>
<td>A3</td>
<td>F3</td>
</tr>
<tr>
<td>B0</td>
<td>G0</td>
</tr>
<tr>
<td>B3</td>
<td>G3</td>
</tr>
<tr>
<td>C0</td>
<td>H0</td>
</tr>
</tbody>
</table>

#### Schematic diagram of loop flushing valve

![Schematic diagram of loop flushing valve](image)

#### Loop flushing valve cross section

![Loop flushing valve cross section](image)

### 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 motor 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).
Features and Options

Speed Sensor

Specifications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></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 Danfoss representative for a special sensor.

Pulse frequency

<table>
<thead>
<tr>
<th></th>
<th>055</th>
<th>075</th>
<th>100</th>
<th>130</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse per revolution</td>
<td>52</td>
<td>58</td>
<td>63</td>
<td>69</td>
</tr>
</tbody>
</table>

Speed sensor with Turck® Eurofast connector

Turck Eurofast Connector

![Turck Eurofast Connector diagram](image)

Speed sensor with Packard® Weather-Pack connector

Packard Weather-Pack

![Packard Weather-Pack diagram](image)

Shaft Options

Series 90 motors are available with a variety of splined, straight keyed, and tapered shaft ends. Nominal shaft sizes and torque ratings are shown in the accompanying table.
Features and Options

Torque ratings assume no external radial loading. Continuous torque ratings for splined shafts are based on spline tooth wear, and assume the mating spline has a minimum hardness of Rc 55 and full spline depth with initial lubrication. Maximum torque ratings are based on fatigue and assume 200,000 load reversals. The permissible continuous torque may approach the maximum rating if the spline is immersed in circulating oil.

Series 90 shaft options

<table>
<thead>
<tr>
<th>Shaft description</th>
<th>Option code</th>
<th>Torque rating</th>
<th>Frame size availability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N-m</td>
<td>in-lbf</td>
</tr>
<tr>
<td>21 tooth, 16/32 pitch spline</td>
<td>C6</td>
<td>Maximum: 1130 384</td>
<td>Continuous: 10 000 3400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum: 1580 509</td>
<td>Continuous: 14 000 4500</td>
</tr>
<tr>
<td>27 tooth, 16/32 pitch spline</td>
<td>C8</td>
<td>Maximum: 2938 814</td>
<td>Continuous: 26 000 7200</td>
</tr>
<tr>
<td>13 tooth, 8/16 pitch spline</td>
<td>F1</td>
<td>Maximum: 1810 746</td>
<td>Continuous: 16 000 6600</td>
</tr>
<tr>
<td>13 tooth, 8/16 pitch spline (long)</td>
<td>F2</td>
<td>Maximum: 1810 746</td>
<td>Continuous: 16 000 6600</td>
</tr>
<tr>
<td>14 tooth, 12/24 pitch spline</td>
<td>S1</td>
<td>Maximum: 735 283</td>
<td>Continuous: 6500 2500</td>
</tr>
<tr>
<td>17 tooth, 12/24 pitch spline</td>
<td>S5</td>
<td>Maximum: 1695 599</td>
<td>Continuous: 15 000 5300</td>
</tr>
<tr>
<td>34.9 mm [1.374 in] dia. straight keyed</td>
<td>K1</td>
<td>Maximum: 768</td>
<td>Continuous: 6800</td>
</tr>
<tr>
<td>38.07 mm [1.499 in] dia. straight keyed</td>
<td>K2</td>
<td>Maximum: 1130</td>
<td>Continuous: 10 000</td>
</tr>
<tr>
<td>44.42 mm [1.749 in] dia. straight keyed</td>
<td>K3</td>
<td>Maximum: 1582</td>
<td>Continuous: 14 000</td>
</tr>
</tbody>
</table>

• Available
— Not available

Recommended mating splines for Series 90 splined output shafts should be in accordance with ANSI B92.1 Class 5. Danfoss external splines are modified class 5 fillet root side fit. The external spline major diameter and circular tooth thickness dimensions are reduced to assure a clearance fit with the mating spline. Contact your Danfoss representative for other splined shaft options.
Installation Drawings

90K55 Fixed Motor Cartridge Mount

Technical Information
Series 90 Axial Piston Motors

All SAE straight thread O-rings ports per SAE J1926 (fittings per SAE 514). Shaft rotation is determined by viewing motor from output shaft end. Contact your Danfoss representative for specific installation drawings.
Splined output shaft options

<table>
<thead>
<tr>
<th>Output shaft option</th>
<th>Shaft diameter T</th>
<th>Full spline length U</th>
<th>Major diameter V</th>
<th>Pitch diameter W</th>
<th>Number of teeth Y</th>
<th>Pitch Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>24.9 [0.98]</td>
<td>27.9 [1.10]</td>
<td>31.13 [1.2258]</td>
<td>29.634 [1.1667]</td>
<td>14</td>
<td>12/24</td>
</tr>
</tbody>
</table>

Flow direction

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>Flow direction</th>
<th>Port “A”</th>
<th>Port “B”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clockwise (CW)</td>
<td></td>
<td>Out</td>
<td>In</td>
</tr>
<tr>
<td>Counterclockwise (CCW)</td>
<td></td>
<td>In</td>
<td>Out</td>
</tr>
</tbody>
</table>

Splined shaft options
(see tables)

View “X” (front view)

Speed sensor connector

Coupling must not protrude beyond this surface "U"
"V" dia maximum
"T" dia maximum
R 2.54 [R 0.10] maximum

Shaft option K1

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Installation Drawings

90M55 Fixed Motor SAE Mount

Endcap ports
1.00 in dia. – 6000 psi
(4) bolt split
flange type per
SAE J518 (code 62)
except 20.8 [0.82]
minimum full depth

0.075 – 18 straight thread
O-ring boss per SAE J514
system pressure gauge port M1

0.5625 – 18 straight thread
O-ring boss per SAE J514
charge pressure gauge port M3
(to be used as gauge port only)

0.875 – 14 straight thread
O-ring boss case
outlet port L1

Approximate center
of gravity

All SAE straight thread O-rings ports per SAE J1926 (fittings per SAE 514). Shaft rotation is determined by viewing motor from output shaft end. Contact your Danfoss representative for specific installation drawings.
### Installation Drawings

#### Splined output shaft options

<table>
<thead>
<tr>
<th>Output shaft option</th>
<th>Shaft diameter T</th>
<th>Full spline length U</th>
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<th>Pitch diameter W</th>
<th>Number of teeth Y</th>
<th>Pitch Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>24.9 [0.98]</td>
<td>27.9 [1.10]</td>
<td>31.13 [1.2258]</td>
<td>29.634 [1.1667]</td>
<td>14</td>
<td>12/24</td>
</tr>
</tbody>
</table>

#### Flow direction

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clockwise (CW)</td>
<td>Out In</td>
</tr>
<tr>
<td>Counterclockwise (CCW)</td>
<td>In Out</td>
</tr>
</tbody>
</table>

#### Splined shaft options

- **View “X”** (front view)
- **Speed sensor connector**
- **Approximate center of gravity**
- **R. 7.4 ± 0.8 [0.29 ± 0.03]** (4 places)
- **R. 2.5 maximum** (0.1 2 places)

#### Technical Information

**Series 90 Axial Piston Motors**
All SAE straight thread O-rings ports per SAE J1926 (fittings per SAE 514). Shaft rotation is determined by viewing motor from output shaft end. Contact your Danfoss representative for specific installation drawings.
Installation Drawings

**Splined output shaft options**

<table>
<thead>
<tr>
<th>Output shaft option</th>
<th>Shaft diameter T</th>
<th>Full spline length U</th>
<th>Major diameter V</th>
<th>Pitch diameter W</th>
<th>Number of teeth Y</th>
<th>Pitch Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>29.9 [0.98]</td>
<td>27.9 [1.10]</td>
<td>31.13 [1.2258]</td>
<td>29.634 [1.1667]</td>
<td>14</td>
<td>12/24</td>
</tr>
<tr>
<td>C7</td>
<td>32.3 [1.27]</td>
<td>34.8 [1.37]</td>
<td>37.59 [1.480]</td>
<td>36.513 [1.4375]</td>
<td>23</td>
<td>16/32</td>
</tr>
</tbody>
</table>

**Flow direction**

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clockwise (CW)</td>
<td>Port &quot;A&quot;</td>
</tr>
<tr>
<td>Counterclockwise (CCW)</td>
<td>In</td>
</tr>
</tbody>
</table>

---

Image descriptions:

- **View "X" (Front view)**: Diagram showing port locations "A" and "B".
- **Coupling must not protrude beyond this surface**: Dimensions and notes indicating maximum size.
- **Splined shaft options (see table)**: Diagram with key dimensions and tolerances.
- **Shaft options K2 (keyed)**: Diagram showing key dimensions and tolerances.
90M75 Fixed Motor SAE Mount

End cap ports: options 3 & 7 axial ported 1.00 – 6000 psi (4) bolt split flange type per SAE J518 (code 62) except 20.8 (0.82) minimum full thread depth

Loop flushing relief valve

View "Y" (top view)

View "Z" (rear view) axial ported

View "Z" (rear view) twin ported

Port "A" Port "B"

1.0625 – 12 straight thread O-ring boss per SAE J514 case outlet port L1

0.5625 – 18 straight thread O-ring boss system pressure gauge port M1

0.5625 – 18 straight thread O-ring boss system pressure gauge port M2

View "Z" (bottom view)

Port "A" Port "B"

0.5625 – 18 straight thread O-ring boss per SAE J514 shaft speed sensor port

All SAE straight thread O-rings ports per SAE J1926 (fittings per SAE 514). Shaft rotation is determined by viewing motor from output shaft end. Contact your Danfoss representative for specific installation drawings.
Splined output shaft options

<table>
<thead>
<tr>
<th>Output shaft option</th>
<th>Shaft diameter T</th>
<th>Full spline length U</th>
<th>Major diameter V</th>
<th>Pitch diameter W</th>
<th>Number of Teeth Y</th>
<th>Pitch Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>24.9 [0.96]</td>
<td>27.9 [1.10]</td>
<td>31.13 [1.2256]</td>
<td>29.634 [1.1667]</td>
<td>14</td>
<td>12/24</td>
</tr>
<tr>
<td>C7</td>
<td>32.3 [1.27]</td>
<td>34.6 [1.37]</td>
<td>37.59 [1.460]</td>
<td>36.513 [1.4375]</td>
<td>23</td>
<td>16/32</td>
</tr>
</tbody>
</table>

Flow direction

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clockwise (CW)</td>
<td>Port “A”</td>
</tr>
<tr>
<td>Counterclockwise (CCW)</td>
<td>Port “B”</td>
</tr>
</tbody>
</table>

Splined shaft options (see table)

Speed sensor connector

View “X” (front view)

Shaft option K2 (keyed)

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All SAE straight thread O-rings ports per SAE J1926 (fittings per SAE 514). Shaft rotation is determined by viewing motor from output shaft end. Contact your Danfoss representative for specific installation drawings.
### Splined output shaft options

<table>
<thead>
<tr>
<th>Output shaft option</th>
<th>Shaft diameter T</th>
<th>Full spline length U</th>
<th>Major diameter V</th>
<th>Pitch diameter W</th>
<th>Number of teeth Y</th>
<th>Pitch Z</th>
<th>Length S</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>24.9 [0.98]</td>
<td>27.9 [1.10]</td>
<td>31.13 [1.2258]</td>
<td>29.634 [1.1667]</td>
<td>14</td>
<td>12/24</td>
<td>47.6 [1.875]</td>
</tr>
<tr>
<td>C7</td>
<td>32.3 [1.27]</td>
<td>34.8 [1.37]</td>
<td>37.59 [1.480]</td>
<td>36.513 [1.4375]</td>
<td>23</td>
<td>16/32</td>
<td>47.6 [1.875]</td>
</tr>
<tr>
<td>F1</td>
<td>34.5 [1.36]</td>
<td>49.5 [1.95]</td>
<td>43.94 [1.730]</td>
<td>41.275 [1.6250]</td>
<td>13</td>
<td>8/16</td>
<td>66.7 [2.625]</td>
</tr>
<tr>
<td>F2</td>
<td>34.5 [1.36]</td>
<td>67.1 [2.64]</td>
<td>43.94 [1.730]</td>
<td>41.275 [1.6250]</td>
<td>13</td>
<td>8/16</td>
<td>84.3 [3.32]</td>
</tr>
</tbody>
</table>

### Flow direction

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>Flow direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clockwise (CW)</td>
<td>Port “A” Out</td>
</tr>
<tr>
<td>Counterclockwise (CCW)</td>
<td>Port “B” In</td>
</tr>
</tbody>
</table>

### Spliced shaft options (see chart)

- **View “X” (front view)**
- **Approximate center of gravity**
- **Speed sensor connector**
- **Port “B”**
- **Port “A”**
- **Coupling must not protrude beyond this surface**
- **“S” ± 0.64 (± 0.025)**
- **“U” ± 0.5 (± 0.02)**
- **“F” maximum**
- **Ø0.10 ± 0.09 (± 0.0035)**
- **“E” thread**
- **R 2.5 [0.10] maximum**
- **Ø 0.76 (± 0.03) (4) places**
- **R 7.37 ± 0.76 (± 0.03) (4) places**
- **57.25 ± 0.025 (2) places**
- **Ø100.6 [3.96] minimum**
- **57.25 (2.254) (2) places**
- **92.2 [3.63] case outlet (alternative position)**
- **95 [3.74] case outlet**

### Shaft option K3 (keyed)

- **Coupling must not protrude beyond 2.33 maximum**
- **44.425 ± 0.025 [1.749 ± 0.001]**
- **9.525 [0.375] square key x 38.1 long [1.5]**
- **61.85 ± 0.64 [2.435 ± 0.025]**
- **7.87 [0.31]**
All SAE straight thread O-rings ports per SAE J1926 (fittings per SAE S14). Shaft rotation is determined by viewing motor from output shaft end. Contact your Danfoss representative for specific installation drawings.
Splined output shaft options

<table>
<thead>
<tr>
<th>Output shaft option</th>
<th>Shaft diameter T</th>
<th>Full spline length U</th>
<th>Major diameter V</th>
<th>Pitch diameter W</th>
<th>Number of teeth Y</th>
<th>Pitch Z</th>
<th>Length S</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>34.5 [1.36]</td>
<td>42.5 [1.67]</td>
<td>43.94 [1.730]</td>
<td>41.275 [1.6250]</td>
<td>13</td>
<td>8/16</td>
<td>66.7 [2.625]</td>
</tr>
<tr>
<td>C8</td>
<td>37.5 [1.48]</td>
<td>42.5 [1.67]</td>
<td>43.94 [13730]</td>
<td>42.862 [1.6875]</td>
<td>27</td>
<td>16/32</td>
<td>66.7 [2.625]</td>
</tr>
</tbody>
</table>

Flow direction

<table>
<thead>
<tr>
<th>Shaft rotation</th>
<th>Flow direction</th>
<th>Port “A”</th>
<th>Port “B”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clockwise (CW)</td>
<td>Out</td>
<td>In</td>
<td></td>
</tr>
<tr>
<td>Counterclockwise (CCW)</td>
<td>In</td>
<td>Out</td>
<td></td>
</tr>
</tbody>
</table>

All SAE straight thread O-rings ports per SAE J1926 (fittings per SAE 514). Shaft rotation is determined by viewing motor from output shaft end. Contact your Danfoss representative for specific installation drawings.
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.

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Please contact the Danfoss Power Solution representative nearest you.