ENGINEERING
TOMORROW

Technical Information

Axial Piston Pumps
LPV

Revision history

Table of revisions

Date	Changed	Rev
September 2017	update model code	0102
July 2015	Danfoss Layout	0100
January 2009	neutral assist return mechanism - changes	AF
October 2008	added serial number plate drawing	AE
April 2008	changes to auxilliary mounting dimensions	AD
August 2007	revised endcap and loop flusing options in model code	AC
May 2007	correct displacement errors	AB
July 2006	First edition	A-0

Contents

General description

Overview

LPV is a family of variable displacement, axial piston pumps for closed circuit applications. The LPV family is uniquely designed to optimize performance, size, and cost, matching the work requirements of the demanding turf care and utility vehicle marketplace. This document gives the detailed specifications and features for LPV pumps.

Design

High performance

- Displacements 25 cm^3/rev [1.53 in3/rev], 30 cm^3/rev [1.83 in3/rev], 35 cm^3/rev [2.14 in3/rev]
- Speeds up to 3600 rpm
- Pressures up to 210 bar [3045 psi] continuous, and 345 bar [5000 psi] peak
- Direct displacement control

Latest technology

- Customer-driven using quality function deployment (QFD) and design for manufacturability (DFM) techniques
- Optimized valve plates for quiet operation
- Compact package size minimizing installation space requirements
- Single piece rigid housing to reduce noise and leak paths
- Integrated neutral return mechanism for simplified installation
- Optional loop flushing for circuit flexibility

Reliability

- Designed to rigorous standards
- Proven in both laboratory and field
- Manufactured to rigid quality standards
- Long service life

Typical applications

- Turf care
- Utility vehicles

LPV product specifications

Basic units

The LPV pumps provide an infinitely variable speed range between zero and maximum in both forward and reverse modes of operation.

LPV pumps are compact, high power density units. All models use 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 fluid from the pump, reversing the direction of rotation of the output motor.

General description

LPV pump

Serial number plate

General description

Design

LPV is a family of hydrostatic pumps for low to medium power applications with maximum loads of 345 bar [5000 psi]. You can apply these pumps with other products in a system to transfer and control hydraulic power.

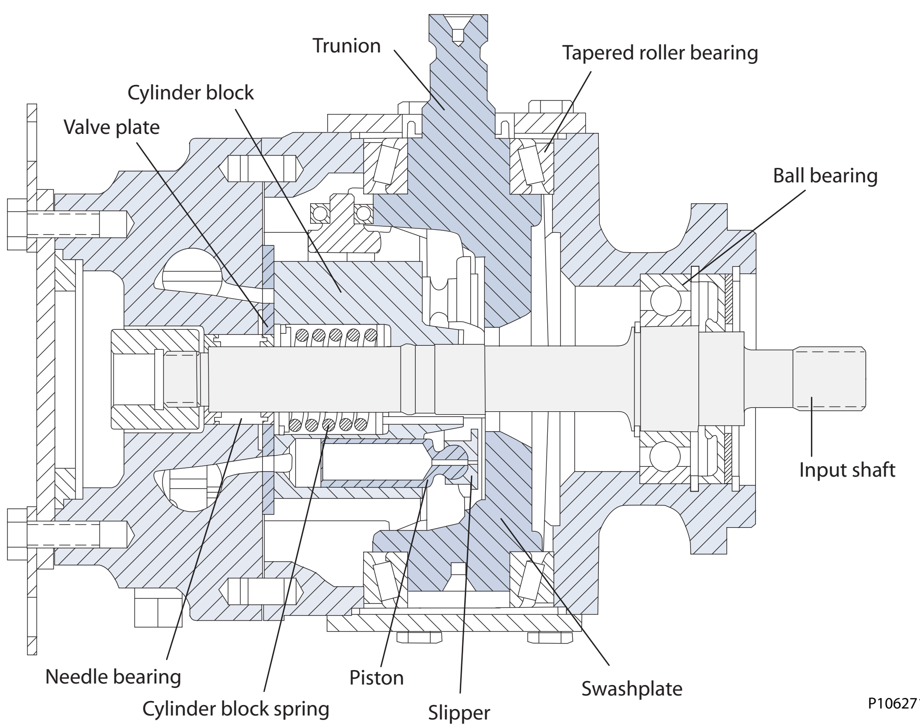
LPV pumps provide an infinitely variable speed range between zero and maximum in both forward and reverse modes of operation. LPV pumps come in three displacements (25 cm3 [1.53 in^3], 30 cm^3 [1.83 in^3], and 35 cm^3 [2.14 in^3]).

LPV pumps are compact, high power density units. All models use 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 fluid from the pump, reversing the direction of rotation of the motor output.

LPV pumps have an internal neutral return mechanism for ease of installation, and are available with optional loop flushing for circuit flexibility. LPV pumps can receive charge flow from an auxiliary circuit or from a gear pump mounted on the auxiliary mounting pad. LPV pumps feature an SAE A auxiliary mounting pad to accept auxiliary hydraulic pumps for use in complementary hydraulic systems.

LPV pumps include a trunnion style direct displacement control.

LPV cross section

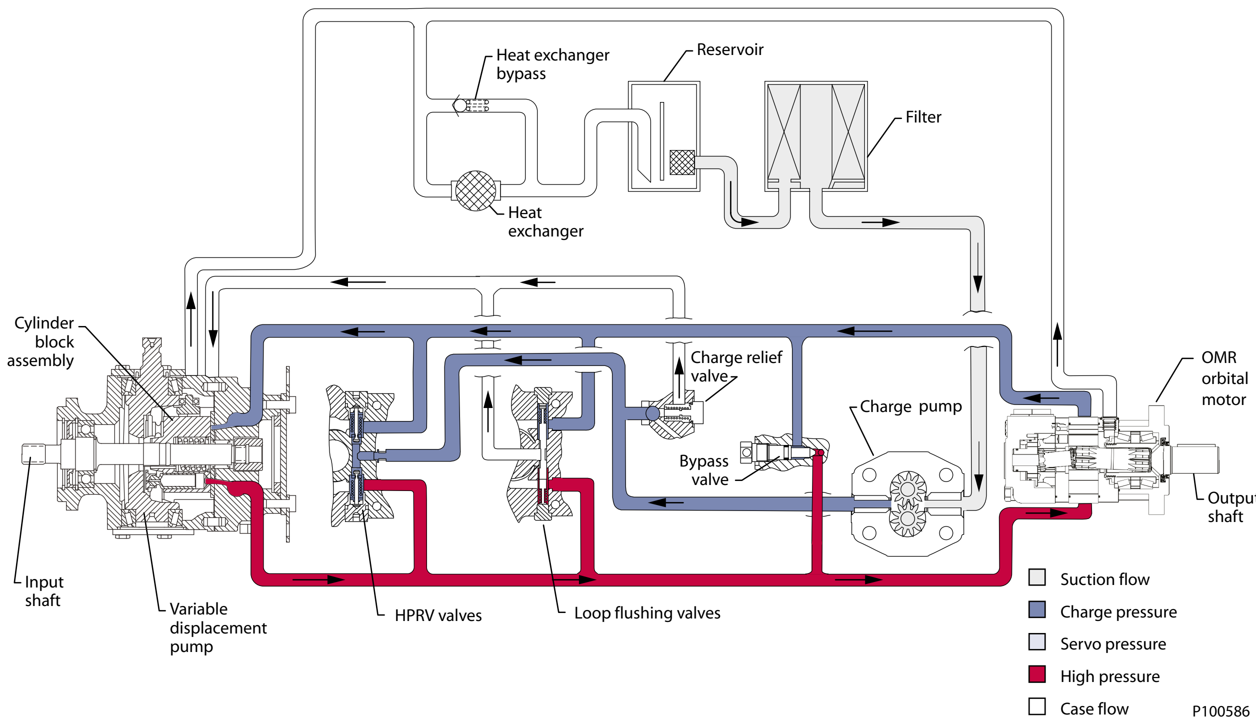


General description

Direct displacement drive system

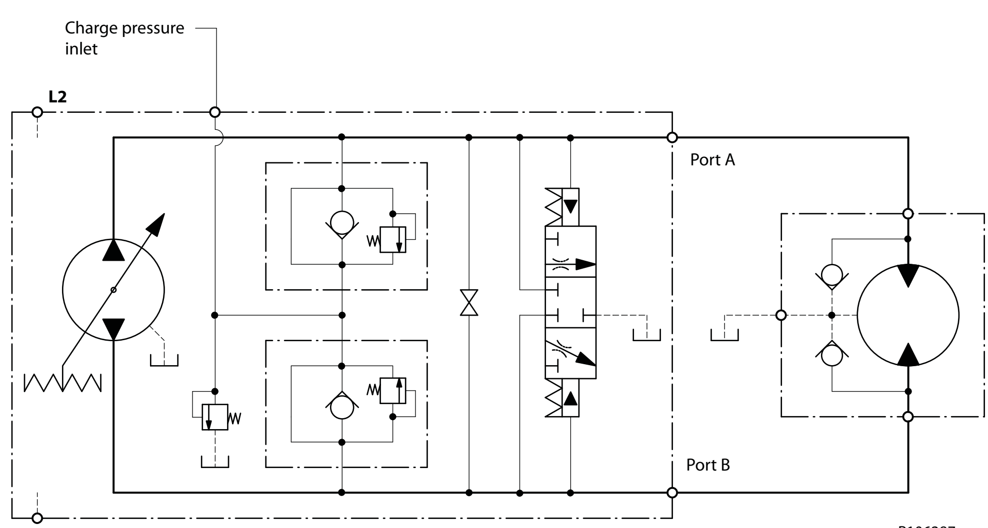
The direct displacement control varies the swashplate angle. Swashplate angle determines pump flow and motor speed.

Pictorial circuit diagram



The diagram shows an LPV pump driving an OMR motor. The system shown uses an external charge pump and external filter. Charge pressure relief valves, high pressure relief valves, and loop flushing valves are shown separated from the pump to provide clarity to the hydraulic system.

LPV Pump schematic diagram



Operating parameters

Overview

This section defines the operating parameters and limitations for LPV pumps with regard to input speeds and pressures. For actual parameters, refer to *Technical specifications* on page 20.

Input speed

The table in *Technical specifications* on page 20, gives rated and maximum speeds for each displacement. Not all displacements operate under the same speed limits. Definitions of these speed limits appear below.

Continuous speed is the maximum recommended operating speed at full power condition. Operating at or below this speed should yield satisfactory product life. Do not exceed maximum pump speed during unloaded, on-road travel over level ground.

Maximum speed is the highest operating speed permitted. Exceeding maximum speed reduces pump life and can cause loss of hydrostatic power and braking capacity. Never exceed the maximum speed limit under any operating conditions.

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.

System pressure

The table in *Technical specifications* on page 20, gives maximum and maximum working pressure ratings for each displacement. Not all displacements operate under the same pressure limits. Definitions of the operating pressure limits appear below.

Pressure Ratings

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 driveline 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.

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.

Viscosity

Maintain fluid viscosity within the recommended range for maximum efficiency and bearing life. **Minimum viscosity** should only occur during brief occasions of maximum ambient temperature and

Operating parameters

severe duty cycle operation. **Maximum viscosity** should only occur at cold start. Limit speeds until the system warms up. Refer to *Specifications* on page 20, for specifications.

Temperature

Maintain fluid temperature within the limits shown in the table. *Technical specifications* on page 20. **Minimum temperature** relates to the physical properties of the component materials. Cold oil will not affect the durability of the pump components, however, it may affect the ability of the pump to provide flow and transmit power. **Maximum temperature** is based on material properties. Don't exceed it. Measure maximum temperature at the hottest point in the system. This is usually the case drain. Refer to *Specifications* on page 20, for specifications.

Ensure fluid temperature and viscosity limits are concurrently satisfied.

Case pressure

Do not allow case pressure to exceed ratings under normal operating conditions. During cold start, keep case pressure below maximum intermittent case pressure. Size drain plumbing accordingly.

Caution

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.

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 provides clean fluid, dissipates heat, and removes trapped air from the hydraulic fluid. It allows for fluid volume changes associated with fluid expansion and cylinder differential volumes. Minimum reservoir capacity depends on the volume needed to perform these functions. Typically, a capacity of 5/8 of the charge pump flow (per minute) is satisfactory for a closed reservoir. Open circuit systems sharing a common reservoir require greater fluid capacity.

Locate the reservoir outlet (suction line) near the bottom, allowing clearance for settling foreign particles. Use a 100 - 125 µm screen covering the outlet port.

Place the reservoir inlet (return lines) below the lowest expected fluid level, as far away from the outlet as possible. Use a baffle (or baffles) between the reservoir inlet and outlet ports to promote de-aeration and reduce fluid surging.

System design parameters

Case drain

Connect the case drain line to one of the case outlets to return internal leakage to the system reservoir. Use the higher of the outlets to promote complete filling of the case. Case drain fluid is typically the hottest fluid in the system. Return case drain flow through the heat exchanger to the reservoir.

Charge flow requirements

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

Maintain charge pressure at the level specified in the table *Technical specifications* on page 20 under all operating conditions to prevent damage to the transmission. Danfoss recommends testing under actual operating conditions to verify this.

Charge pump displacement should be at least 10% of the total displacement of all axial piston components in the system. However, unusual application conditions may require a more detailed review of charge pump sizing. Refer to *Selection of Drive line Components*, **BLN-9985**, for a more detailed selection procedure, or contact your Danfoss representative for assistance.

Loop flushing

Closed circuit systems may require loop flushing to meet temperature and cleanliness requirements. A loop flushing valve removes hot fluid from the low pressure side of the system loop for additional cooling and filtering. Ensure the charge pump provides adequate flow for loop flushing and the loop flushing valve does not cause charge pressure to drop below recommended limits.

LPV utilizes a special loop flushing spool design. On dual path systems, take special care to verify acceptable performance.

Bearing loads and life

Bearing life is a function of speed, system pressure, charge pressure, and swashplate angle, plus any external side or thrust loads. The influence of swashplate angle includes displacement as well as direction. External loads are found in applications where the pump is driven with a side/thrust load (belt or gear) as well as in installations with misalignment and improper concentricity between the pump and drive coupling. All external side loads will act to reduce the normal bearing life of a pump. Other life factors include oil type and viscosity.

In vehicle propel drives with no external shaft loads and where the system pressure and swashplate angle are changing direction and magnitude regularly, the normal L20 bearing life (80 % survival) will exceed the hydraulic load-life of the unit.

In non propel drives such as vibratory drives, conveyor drives, or fan drives, the operating speed and pressure are often nearly constant and the swashplate angle is predominantly at maximum. These drives have a distinctive duty cycle compared to a propulsion drive. In these types of applications a bearing life review is recommended.

Applications with external shaft loads

LPV pumps have bearings that can accept some external radial and thrust loads. When external loads are present, the allowable radial shaft loads are a function of the load position relative to the mounting

System design parameters

flange, the load orientation relative to the internal loads, and the operating pressures of the hydraulic unit. In applications with external shaft loads, you can minimize the impact on bearing life with proper orientation of the load.

Optimum pump orientation is a consideration of the net loading on the shaft from the external load, the pump rotating group and the charge pump load.

- In applications where the pump is operated such that nearly equal amounts of forward vs reverse swashplate operation is experienced; bearing life can be optimized by orientating the external side load at 0° or 180° such that the external side load acts 90° to the rotating group load.
- In applications where the pump is operated such that the swashplate is predominantly (> 75 %) on one side of neutral (ie vibratory, conveyor, typical propel); bearing life can be optimized by orientating the external side load generally opposite (90° or 270°) the internal rotating group load. The direction of internal loading is a function of rotation and which system port has flow out. Contact Danfoss for a bearing life review if external side loads are present.

You can calculate the **maximum allowable radial load** (R_e), using the formula below, the maximum external moment (M_e) from the table on the next page, and the distance (L) from the mounting flange to the load.

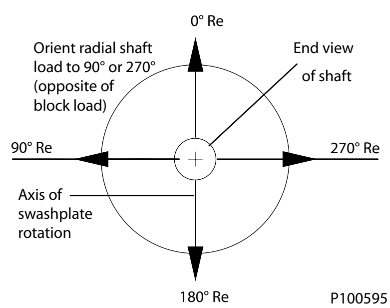
$\mathbf{R_e = M_e / L}$

Avoid thrust loads in either direction.

If continuously applied external radial loads are 25% of the maximum allowable or more, or thrust loads are known to occur, contact your Danfoss representative for an evaluation of unit bearing life.

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

Direction of external shaft load



Shaft loading parameters

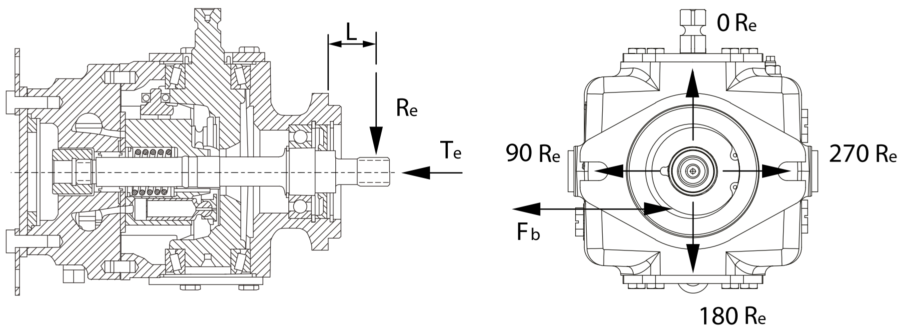
R_e	Maximum radial load
M_e	Maximum external moment
L	Distance from mounting flange to point of load
F_b	Force of block
T_e	Thrust load

Maximum external shaft moments

LPV	
M_e /N•m [in•lbf]	101 [890]

System design parameters

Diagram of external radial shaft loads



Hydraulic unit life

Hydraulic unit life is the life expectancy of the hydraulic components. It is a function of speed and system pressure. System pressure is the dominant operating variable. High pressure, which results from high load, reduces expected life.

Design the hydraulic system to a projected machine duty cycle. Know the expected percentages of time at various loads and speeds. Ask your Danfoss representative to calculate an appropriate pressure based your hydraulic system design. If duty cycle data is not available, input power and pump displacement are used to calculate system pressure.

All pressure limits are differential pressures (referenced to charge pressure) and assume normal charge pressure.

LPV pumps will meet satisfactory life expectancy if applied within the parameters specified in this bulletin. For more detailed information on hydraulic unit life see *Pressure and Speed Limits*, **BLN-9884**.

Mounting flange loads

Estimating overhung load moments

Adding auxiliary pumps and/or subjecting pumps to high shock loads may result in excessive loading of the mounting flange. Applications which experience extreme resonant vibrations or shock may require additional pump support. You can estimate the overhung load moment for multiple pump mounting using the formula below.

$M_S = G_S (W_1L_1 + W_2L_2 + ... + W_nL_n)$

$M_C = G_C (W_1L_1 + W_2L_2 + ... + W_nL_n)$

Where:

M_C = Rated load moment N•m [lbf•in]

M_S = Shock load moment N•m [lbf•in]

G_C = Rated (vibratory) acceleration (G's)* m/s2 [ft/s2]

G_S = Maximum (shock) acceleration (G's)* m/s2 [ft/s2]

W_n = Weight of n^{th} pump

L_n = Distance from mounting flange to CG (center of gravity) of n^{th} pump

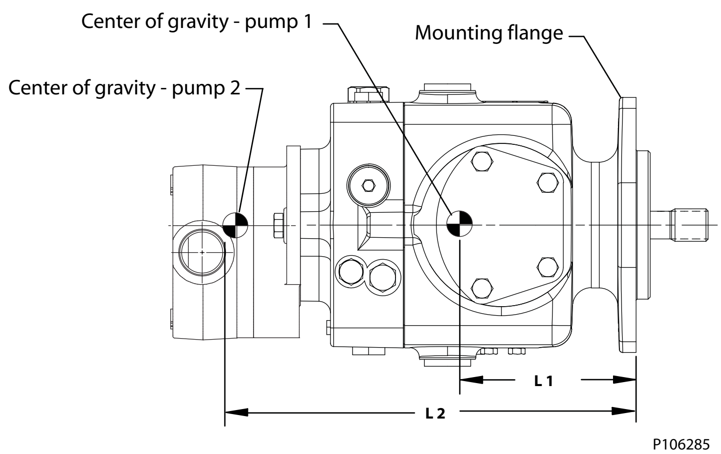
(Refer to *Installation drawings* on page 30 to locate CG of pump.)

** Carry out calculations by multiplying gravity (g = 9.81 m/s^2 [32 ft/s^2]) with a given factor. This factor depends on the application.*

Refer to *Specifications* on page 20, for allowable overhung load moment values.

System design parameters

Shaft loading parameters



Input shaft torque rating and spline lubrication

A spline running in oil-flooded environment provides superior oxygen restriction in addition to contaminant flushing. An **oil-flooded spline** is found in a pump to pump drive (mounted on the auxiliary pad of another pump). An oil-flooded spline connection can withstand a continuously applied torque up to the published maximum rating. **Maximum torque** ratings are based on torsional fatigue strength of the shaft and assume a maximum of 200,000 load reversals.

Coupling arrangements that are not oil-flooded require a reduced torque rating due to spline tooth wear. Contact your Danfoss representative for torque ratings if your application involves non oil-flooded couplings.

Danfoss recommends mating splines adhere to ANSI B92.1-Class 5. Danfoss external splines are modified class 5 fillet root side fit. The external major diameter and circular tooth thickness dimensions are reduced to ensure a good clearance fit with the mating spline. See *Input shafts* on page 27 for full spline dimensions and data.

Maintain a spline engagement at least equal to the pitch diameter to maximize spline life. Spline engagement of less than ¾ pitch diameter is subject to high contact stress and spline fretting.

Alignment between the mating spline's pitch diameters is another critical factor in determining the operating life of a splined drive connection. Plug-in, or rigid spline drive installations can impose severe radial loads on the shaft. The radial load is a function of the transmitted torque and shaft eccentricity. Increased spline clearance will not totally alleviate this condition; but, increased spline clearance will prevent mechanical interference due to misalignment or radial eccentricity between the pitch diameters of the mating splines. Maximize spline life by adding an intermediate coupling between the bearing supported splined shafts.

Torques are additive for multiple pump installations. Ensure total through torque for the main pump and auxiliary pump does not exceed published maximum shaft torque. See *Input shafts* on page 27 for shaft torque ratings.

Understanding and minimizing system noise

A table in the *Specifications* on page 20, gives sound levels for each displacement. Sound level data are collected at various operating speeds and pressures in a semi-anechoic chamber. Many factors contribute to the overall noise level of any application. Here is some information to help understand the nature of noise in fluid power systems, and some suggestions to help minimize it.

Noise is transmitted in fluid power systems in two ways: as fluid borne noise, and structure borne noise.

Fluid-borne noise (pressure ripple or pulsation) is created as pumping elements discharge oil into the pump outlet. It is affected by the compressibility of the oil, and the pump's ability to transition pumping

System design parameters

elements from high to low pressure. Pulsations travel through the hydraulic lines at the speed of sound (about 1400 m/s [4600 ft/sec] in oil) until there is a change (such as an elbow) in the line. Amplitude varies with overall line length and position.

Structure-borne noise is transmitted wherever the pump casing connects to the rest of the system. The way system components respond to excitation depends on their size, form, material, and mounting.

System lines and pump mounting can amplify pump noise. Follow these suggestions to help minimize noise in your application:

- Use flexible hoses.
- Limit system line length.
- If possible, optimize system line position to minimize noise.
- If you must use steel plumbing, clamp the lines.
- If you add additional support, use rubber mounts.
- Test for resonants in the operating range, if possible avoid them.

Sizing equations

Use these equations to help choose the right pump size and displacement for your application. An evaluation of the machine system to determine the required motor speed and torque to perform the necessary work function initiates the design process. Refer to *Selection of drive line components*, **BLN-9985**, for a more complete description of hydrostatic drive line sizing. First select motor size to transmit the maximum required torque. Then select pump as a flow source to achieve the maximum motor speed.

	Based on SI units	Based on US units
Flow	Output flow $Q_e = \dfrac{V_g \cdot n \cdot \eta_v}{1000}$ (l/min)	Output flow $Q_e = \dfrac{V_g \cdot n \cdot \eta_v}{231}$ (US gal/min)
	Input torque $M_e = \dfrac{V_g \cdot \Delta p}{20 \cdot \pi \cdot \eta_m}$ (N•m)	Input torque $M_e = \dfrac{V_g \cdot \Delta p}{2 \cdot \pi \cdot \eta_m}$ (lbf•in)
Power	Input power $P_e = \dfrac{M_e \cdot n}{9550} = \dfrac{Q_e \cdot \Delta p}{600 \cdot \eta_t}$ (kW)	Input power $P_e = \dfrac{V_g \cdot n \cdot \Delta p}{396\,000 \cdot \eta_t}$ (hp)

Variables SI units [US units]

V_g	=	Displacement per revolution	cm^3/rev [in^3/rev]
p_{HD}	=	Outlet pressure	bar [psi]
p_{ND}	=	Inlet pressure	bar [psi]
Δp	=	$p_{HD} - p_{ND}$ (system pressure)	bar [psi]
n	=	Speed	min^{-1} (rpm)
η_v	=	Volumetric efficiency	
η_{mh}	=	Mechanical efficiency	
η_t	=	Overall efficiency ($\eta_v \cdot \eta_m$)	
p	=	Differential hydraulic pressure	bar [psi]

Fluids

Ratings and performance 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.

System design parameters

Fire resistant fluids are also suitable at modified operating conditions. Please see *Hydraulic Fluids and Lubricants Technical Information*, **520L0463**, for more information. Refer to *Experience with Biodegradable Hydraulic Fluids Technical Information*, **520L0465**, for information relating to biodegradable fluids.

The following hydraulic fluids are suitable:

- Hydraulic Oil ISO 11 158 - HM (Seal compatibility and vane pump wear resistance per DIN 51 524-2 must be met)
- Hydraulic Oil ISO 11 158 - HV (Seal compatibility and vane pump wear resistance per DIN 51 524-3 must be met)
- Hydraulic Oil DIN 51 524-2 - HLP• Hydraulic Oil DIN 51 524-3 - HVLP
- Automatic Transmission Fluid (ATF) A Suffix A (GM)
- Automatic transmission fluid Dexron II (GM), which meets Allison C-3 and Caterpillar TO-2 test
- Automatic transmission fluid M2C33F and G (Ford)
- Engine oils API classification SL, SJ (for gasoline engines) and CI-4, CH-4, CG-4, CF-4 and CF (for diesel engines)
- Super Tractor Oil Universal (STOU) special agricultural tractor fluid

Filtration system

To prevent premature wear, ensure only clean fluid enters the hydrostatic transmission circuit. Danfoss reccommends a filter capable of controlling the fluid cleanliness to ISO 4406 class 22/18/13 (SAE J1165) or better, under normal operating conditions.

Filtration strategies include suction or pressure filtration. 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. Select filters to meet the above requirements using rating parameters of efficiency and capacity.

You can express measured filter efficiency with a Beta ratio[1] (βX). For simple suction-filtered closed circuit transmissions and open circuit transmissions with return line filtration, a filter with a β-ratio within the range of $\beta_{35\text{-}45} = 75$ ($\beta_{10} \geq 2$) or better should be satisfactory. For some open circuit systems, and closed circuits with cylinders being supplied from the same reservoir, we recommend a considerably higher filter efficiency. This also applies to systems with gears or clutches using a common reservoir. These systems typically require a charge pressure or return filtration system with a filter β-ratio in the range of $\beta_{15\text{-}20} = 75$ ($\beta_{10} \geq 10$) or better.

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 Technical Information*, **520L0467** for more information.

Ensure fluid entering pump is free of contaminants to prevent damage (including premature wear) to the system. LPV pumps require system filtration capable of maintaining fluid cleanliness at ISO 4406-1999 class 22/18/13 or better.

Consider these factors when selecting a system filter:

- Cleanliness specifications
- Contaminant ingression rates
- Flow capacity
- Desired maintenance interval

Locate filter either on the inlet (suction filtration) or discharge (charge pressure filtration) side of the charge pump. Either strategy is applicable for LPV pumps.

[1] Filter βx-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.

System design parameters

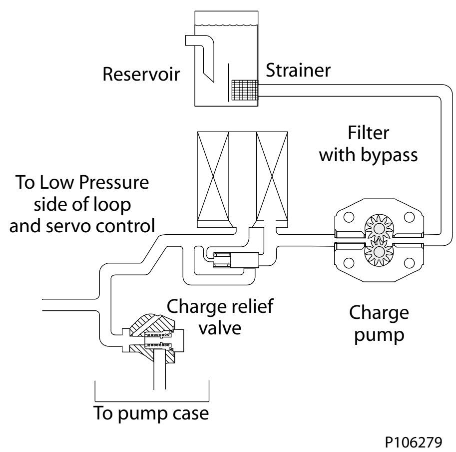
Charge filtration

The pressure filter is remotely mounted in the circuit after the charge pump, as shown in the accompanying illustration.

Filters used in charge pressure filtration circuits must be rated to at least 34.5 bar [500 psi] pressure. Danfoss recommends locating a 100 - 125 µm screen in the reservoir or in the charge inlet line when using charge pressure filtration.

A filter bypass valve is necessary to prevent damage to the system. In the event of high pressure drop associated with a blocked filter or cold start-up conditions, fluid will bypass the filter. Avoid working with an open bypass for an extended period. We recommend a visual or electrical bypass indicator. Proper filter maintenance is mandatory.

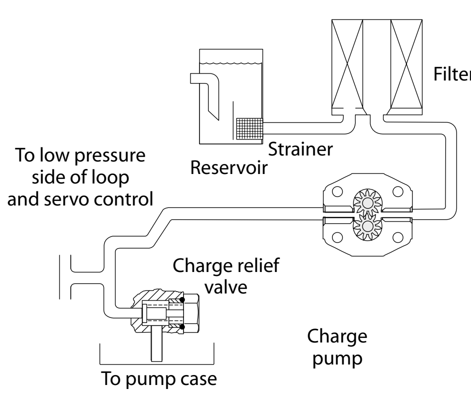
Charge filtration



Suction filtration

The suction filter is placed in the circuit between the reservoir and the inlet to the charge pump as shown in the accompanying illustration.

Suction filtration

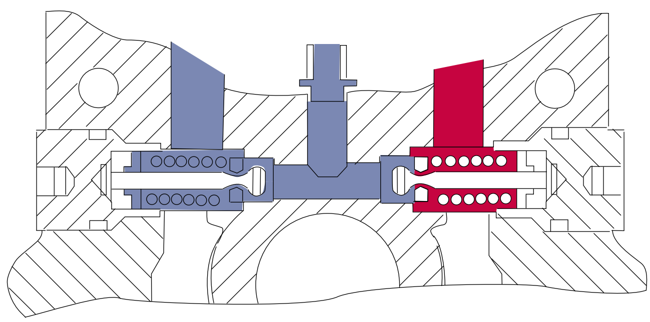


Operation

HPRV (High pressure relief valve)

LPV pumps are equipped with a combination high pressure relief and charge check valve. The high-pressure relief function is a dissipative (with heat generation) pressure control valve for the purpose of limiting excessive system pressures. The charge check function acts to replenish the low-pressure side of the working loop with charge oil. Each side of the transmission loop has a dedicated HPRV valve that is non-adjustable with a factory set pressure. When system pressure exceeds the factory setting of the valve, oil is passed from the high pressure system loop, into the charge gallery, and into the low pressure system loop via the charge check. The high pressure relief valve used on LPV is designed to remove pressure spikes for short periods of time. Operating over the high pressure relief valve for extended periods may damage the pump.

HPRV valve



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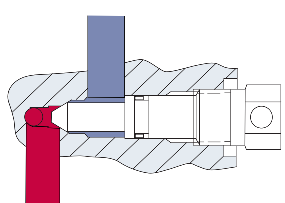
Bypass function

The LPV contains a dedicated bypass valve. the bypass function is activated when the bypass valve is mechanically backed out 3 full turns (maximum). The bypass function allows a machine or load to be moved without rotating the pump shaft or prime mover.

Bypass valve



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Caution

Excessive speed or extended movement will damage the pump and motor(s)

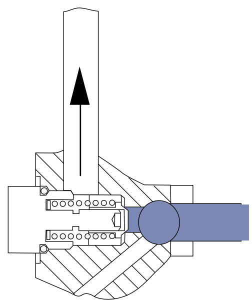
Avoid excessive speeds and extended load/vehicle movement. Do not move the load or vehicle more than 20 % of maximum speed or for longer than 3 minutes. When the bypass function is no longer needed, reseat the bypass valve to the normal operating position.

CPRV (Charge pressure relief valve)

An internal charge relief valve regulates charge pressure. The charge pump supplies pressure to maintain a minimum pressure in the low side of the transmission loop.

Operation

CPRV valve



P106274

Minimum charge pressure is the lowest pressure allowed to maintain a safe working condition in the low side of the loop.

Maximum charge pressure is the highest charge pressure allowed which provides normal component life. Elevated charge pressure can be used as a secondary means to reduce the swashplate response time. The charge pressure setting listed in the order code is the set pressure of the charge relief valve with the pump in neutral, operating with 5 gpm of charge flow. The charge pressure setting is referenced to case pressure. Charge pressure is the differential pressure above case pressure.

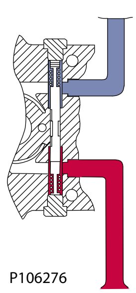
LPV is designed for a maximum charge flow of 57 L/min [15 US gal/min].

Loop flushing valve

LPV pumps incorporate an optional integral loop flushing valve, which removes heat and contaminants from the main loop.

LPV utilizes a special loop flushing spool design. On dual path systems, take special care to verify acceptable performance.

Loop flushing valve



P106276

Neutral return mechanism

The neutral return mechanism mechanically returns the pump to zero displacement. A cam allows precise zero displacement adjustment.

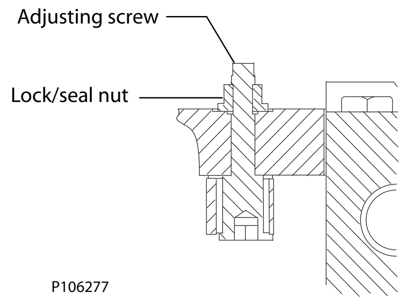
Maximum return force of the neutral return mechanism is 5.65 N•m [50 lbf•in]

Warning

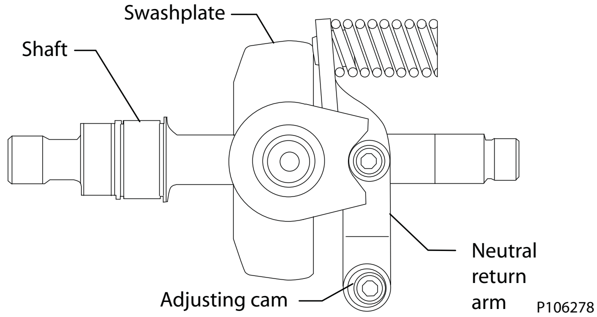
Failure of the pump to return to neutral in the absence of control input will cause unintended vehicle movement. Some control systems may require an additional neutral return mechanism to overcome friction in the control linkage. Verify pump returns to neutral under all operating conditions when the control is released.

Operation

Neutral return adjustment screw



Neutral return mechanism



Technical specifications

Specifications

General specifications

Design	Axial piston pump of trunion swashplate design with variable displacement
Direction of rotation	Clockwise, counter-clockwise
Port connections	Main pressure ports: SAE straight thread O-ring boss
Recommended installation position	Pump installation recommended with control position on the bottom or side. Consult Danfoss for non conformance to these guidelines. The housing must always be filled with hydraulic fluid.

Physical properties

		Displacement		
Feature	**Unit**	**25**	**30**	**35**
Maximum displacement	cm^3 [in^3]	25 [1.53]	30 [1.83]	35 [2.14]
Flow at rated speed (theoretical)	l/min [US gal/min]	85.2 [22.5]	104.9 [27.7]	137.0 [36.2]
Input torque at maximum displacement (theoretical)	N•m/ bar [lbf•in/1000 psi]	0.4 [244]	0.5 [291]	0.6 [340]
Mass moment of inertia of internal rotating components	kg•m^2 [slug•ft^2]	0.001670 [0.0012]	0.001580 [0.00120]	0.001530 [0.0011]
Weight	kg [lb]	23 [51]		
Rotation		Clockwise, counter-clockwise		
Mounting		SAE B 2 bolt		
Auxiliary mounting		SAE J744 A 9T, SPCL 11T		
System ports (type)		1 1/16-12 UNF-2B ORB		
System ports (location)		Twin radial		
Control types		Direct displacement control		
Shafts		Splined SAE 13 tooth, 15 tooth		
Case drain ports		1 1/16-12 SAE ORB		

Operating parameters

			Displacement		
Rating		**Units**	**25**	**30**	**35**
Input speed[2]	minimum	min^{-1} (rpm)	500	500	500
	continuous		3400	3500	3600
	maximum		3950	4150	4300
Pressure	maximum working	bar [psi]	400 [5800]	350 [5075]	300 [4350]
	maximum		415 [6020]	400 [5800]	350 [5075]
External shaft loads	External moment (Me)	N•m [lbf•in]	7.7 [68]		
	Thrust in (Tin), out (Tout)	N [lbf]	750 [169]		
Bearing life (max. swashplate angle and max. continuous speed)	at 210 bar [3045 psi]	B10 hours	120,000	63,000	37,000
Charge pressure	minimum	bar [psi]	6 [87]		
	maximum		30 [435]		

Technical specifications

Operating parameters (continued)

Rating		Units	Displacement 25	30	35
Case pressure	rated	bar [psi]	2 [29]		
	maximum		6 [87]		

Sound levels[1]

dB(A)	100 bar [1450 psi]	200 bar [2900 psi]	300 bar [4350 psi]
Displ. cm^3 [in^3]	1000 min^{-1}(rpm)	1000 min^{-1}(rpm)	1000 min^{-1}(rpm)
25 [1.53]	62	66	68
35 [2.14]	61	66	69
dB(A)	100 bar [1450 psi]	200 bar [2900 psi]	300 bar [4350 psi]
Displ. cm^3 [in^3]	3000 min^{-1}(rpm)	3000 min^{-1}(rpm)	3000 min^{-1}(rpm)
25 [1.53]	70	74	76
35 [2.14]	71	75	80

[1]Sound data was collected per ISO 4412-1 in a semi-anechoic chamber. Values have been adjusted (-3 dB) to reflect anechoic levels.

Fluid specifications

Feature		Unit	Displacement cm^3 [in^3] 25 [1.53], 30 [1.83], 35 [2.14]
Viscosity	Minimum	mm^2/sec [SUS]	7 [47]
	Recommended range		12-60 [66-278]
	Maximum		1600 [7500]
Temperature Range[2]	Minimum	°C [°F]	-40 [-40]
	Rated		82 [180]
	Maximum intermittent		100 [212]
Filtration	Cleanliness per ISO 4406		22/18/13
	Efficiency (charge pressure filtration)	β-ratio	$\beta_{15\text{-}20}$= 75 ($\beta_{10}\geq$ 10)
	Efficiency (suction filtration)		$\beta_{35\text{-}45}$= 75 ($\beta_{10}\geq$ 2)
	Recommended inlet screen mesh size	µm	100 - 125

[2]At the hottest point, normally case drain port.

Mounting flange - allowable overhung parameters

Continuous load moment (M_c)		Shock load moment (M_s)	
N•m	[lbf•in]	N•m	[lbf•in]
361	[3200]	617	[5470]

Technical specifications

Mounting flange - G-factors for sample applications

Application	Continuous (vibratory) acceleration (G_c)	Maximum (shock) acceleration (G_s)
Skid steer loader	6	10
Trencher (rubber tires)	6	8
Asphalt paver	6	6
Windrower	6	5
Aerial lift	6	4
Turf care vehicle	6	4
Vibratory roller	6	10

Applications experiencing extreme resonant vibrations may require additional pump support. Refer to *System design parameters* on page 10 for information concerning mounting flange loads.

Product coding

LPV Model Code

	Swashplate Group	Seal Group	Input Shaft	Rotation, Kit, & Valveplate	Charge Pump	Charge Pressure	Endcap, Loop Flush, & Aux Pad	Neutral Assist	Bypass Valve	System Pressure Protection	Control Orientation & Type	Control Handle	Control Orifice	Auxiliary Mounting Flange	Special Hardware	Special Features (Non Hardware)
Product	C	D	E	F	G	H	J	K	L	M	N	P	R	S	T	Z
L P V	☐	☐	☐	☐	☐	☐	☐☐	☐	☐	☐☐☐	☐☐	☐	☐☐	☐	☐☐☐	☐☐☐

Product

Code	Description
LPV	LPV variable displacement pump

C Swashplate Group

Code	Description
A	Right hand swashplate
C	Left hand swashplate

D Seal Group

Code	Description
A	Standard shaft seal

E Input Shaft Configuration

Code	Description
A	13 Tooth splined 16/32 pitch
B	15 Tooth splined 16/32 pitch
C	20 Tooth splined 24/48 pitch

F Rotating kit, rotation and valveplate

Code	Displacement
A	CW rotation 25 cm^3/rev [1.50 in^3/rev]
B	CW rotation 30 cm^3/rev [1.83 in^3/rev]
C	CW rotation 35 cm^3/rev [2.14 in^3/rev]
D	CCW rotation 25 cm^3/rev [1.50 in^3/rev]
E	CCW rotation 30 cm^3/rev [1.83 in^3/rev]
F	CCW rotation 035 cm^3/rev [2.14 in^3/rev]
J	CW rotation 25 cm^3/rev [1.50 in^3/rev] low leakage
K	CW rotation 30 cm^3/rev [1.83 in^3/rev] low leakage
L	CW rotation 35 cm^3/rev [2.14 in^3/rev] low leakage

G Charge Pump Displacement

Code	Description
A	None

Product coding

H Charge Pressure Relief Valve Setting

Code	Description
E	11.0 bar [160 psi]
G	14.0 bar [200 psi]
I	18.0 bar [260 psi]
K	23.0 bar [335 psi]

J End Cap and Loop Flushing

Code	Description
AA	High loop flushing, 7.6 l/min [2 US gal/min] at 260 psid charge, RH control, SAE A flange 0 Deg.
AB	Low loop flushing, 3.8 l/min [1 US gal/min] at 260 psid charge, RH control, SAE A flange 0 Deg.
AC	No loop flushing, RH control, SAE A flange 0 Deg.
BA	High loop flushing, 7.6 l/min [2 US gal/min] at 260 psid charge, RH control, SAE B flange 0 Deg.
BB	Low loop flushing, 3.8 l/min [1 US gal/min] at 260 psid charge, RH control, SAE B flange 0 Deg.
BC	No loop flushing, RH control, SAE B flange 0 Deg.
DA	High loop flushing, 7.6 l/min [2 US gal/min] at 260 psid charge, RH control, SAE A flange 90 Deg.
DB	Low loop flushing, 3.8 l/min [1 US gal/min] at 260 psid charge, RH control, SAE A flange 90 Deg.
DC	No loop flushing, RH control, SAE A flange 90 Deg.
EA	High loop flushing, 7.6 l/min [2 US gal/min] at 260 psid charge, RH control, SAE B flange 90 Deg.
EB	Low loop flushing, 3.8 l/min [1 US gal/min] at 260 psid charge, RH control, SAE B flange 90 Deg.
EC	No loop flushing, RH control, SAE B flange 0 Deg.
GA	High loop flushing, 7.6 l/min [2 US gal/min] at 260 psid charge, opposite side bypass valve, SAE A flange 0 Deg.
FA	High loop flushing, 7.6 l/min [2 US gal/min] at 260 psid charge, single side only, SAE A flange 90 Deg.

K Neutral Return

Code	Description
C	Neutral assist, standard
D	Neutral assist, high force

L Bypass Valve

Code	Description
A	Bypass valve

M System Pressure Protection

Code	Description
AAA	None/none
BBB	175 bar [2540 psi]/175 bar [2540 psi]
BCC	190 bar [2755 psi]/190 bar [2755 psi]

Product coding

M System Pressure Protection (continued)

Code	Description
BDD	210 bar [3045 psi]/210 bar [3045 psi]
BEE	230 bar [3325 psi]/230 bar [3325 psi]
BFF	250 bar [3625 psi]/250 bar [3625 psi]
BGG	280 bar [4060 psi]/ 280 bar [4060 psi]
BHH	300 bar [4350 psi]/300 bar [4350 psi]
BJJ	345 bar [5000 psi]/345 bar [5000 psi]
BMM	140 bar [2030 psi]/ 140 bar [2030 psi]
BRR	325 bar [4712 psi]/ 325 bar [4712 psi]

N Control Type and Orientation

Code	Description
DR	Direct displacement control, right side
DL	Direct displacement control, left side

P Control

Code	Description
A	DDC

R Control Orifice Diameter

Code	Description
FF	N/A

S Housing and Auxiliary Mounting

Code	Description
A	SAE A, 11T spline, running cover
B	SAE A, 9T spline, running cover
E	SAE B, 13T spline, running cover
N	SAE A, none, running cover

T Special Hardware Features

Code	Description
NNN	None

ZZ Special Features (non hardware)

Code	Description
***	None

Features and options

Controls

Direct displacement control

The LPV pump features Direct Displacement Control (DDC). The swashplate angle is set directly by a control lever or linkage attached directly to the swashplate trunion. Control lever movement changes the displacement and flow direction of the pump by increasing or decreasing the swashplate angle.

The control input shaft is on the right hand side of the pump. Contact your Danfoss representative for availability of left side control input.

Features and benefits

- Simple, low cost design
- Pump output is maintained regardless of load.
- Pump will return to neutral if control input is removed (if equipped with optional neutral return mechanism)

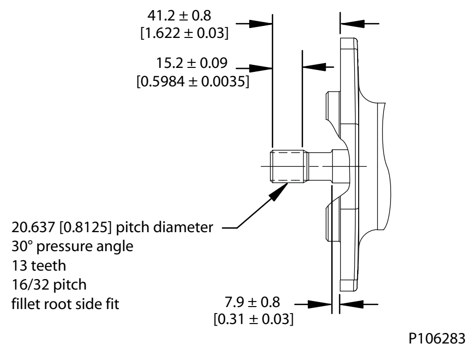
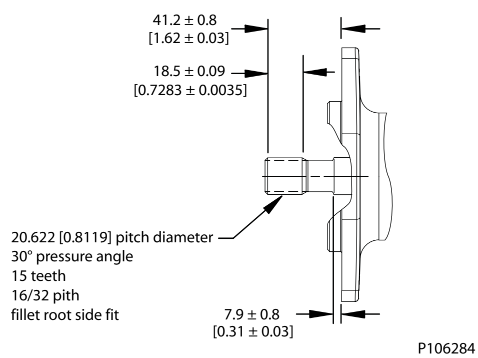
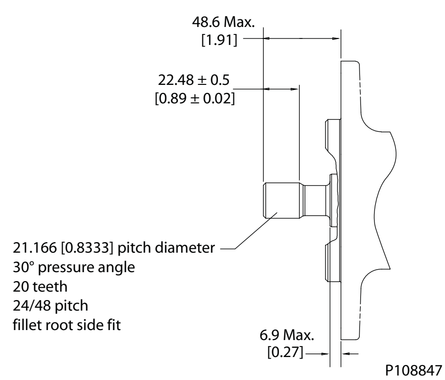
Control handle requirements

Maximum allowable trunnion torque is 79.1 N•m [700 lbf•in]. Minimum available centering moment is 5.7 N•m [50 lbf•in]. The actual value will vary due to the influence of pump operating conditions. Maximum swashplate angle is ±18°. For mating dimensions, see *Installation drawings* on page 30.

Features and options

Input shafts

Shaft data

Code	Description	Maximum torque N•m [lbf•in]	Drawing
A	13 tooth spline 16/32 pitch (ANSI B92.1 1966 - Class 6e)	226 [2000]	
B	15 tooth spline 16/32 pitch (ANSI B92.1 1966 - Class 6e)	362 [3200]	
C	20 tooth spline 24/48 pitch (ANSI B92.1 1966 - Class 6e)	241 [2133]	

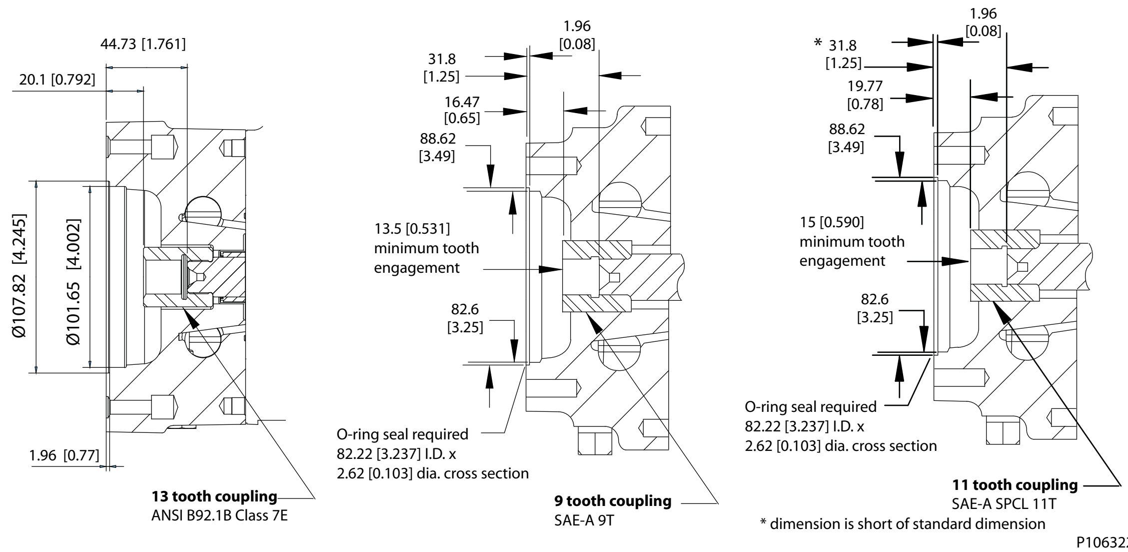
See *Input shaft torque rating and spline lubrication* on page 13 for an explanation of maximum torque.

Features and options

Auxiliary mounting pads

SAE-A Auxiliary mounting

Dimensions

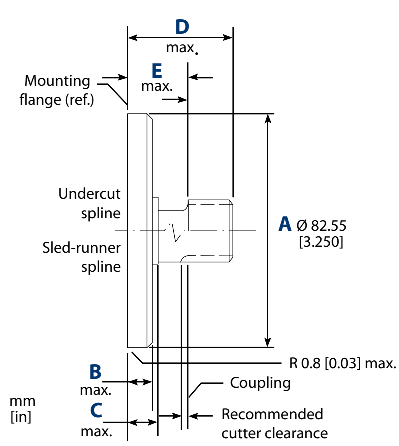


Dimensions in mm [in]

The auxiliary pad operates under case pressure. Use an O-ring to seal the auxiliary pump mounting flange to the pad.

The combination of auxiliary shaft torque and main pump torque must not exceed the maximum pump input shaft rating. The table in *Input shafts* on page 27, gives input shaft torque ratings for each frame size.

Mating pump specifications



Features and options

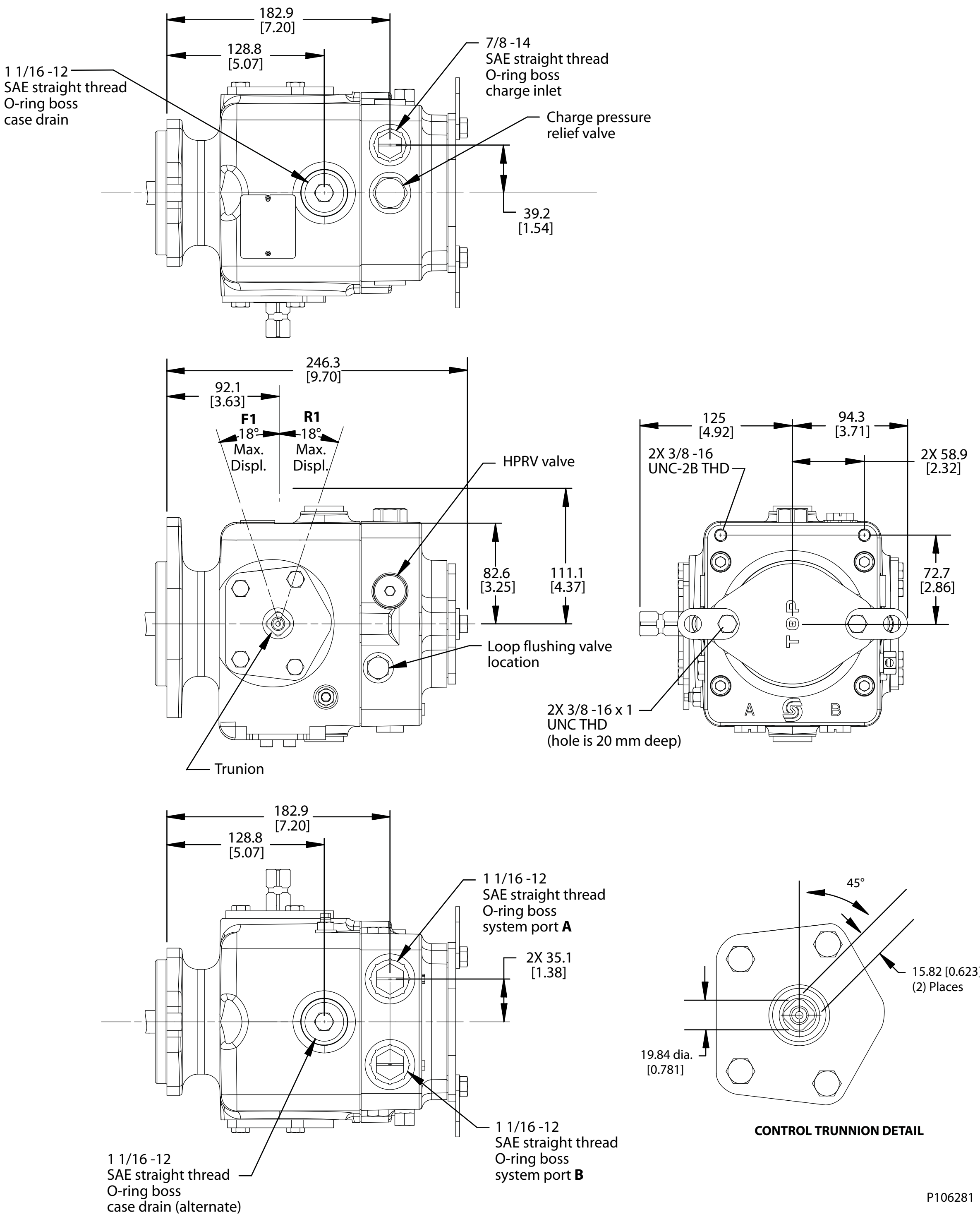
Dimensions

Measurement	SAE A (9T) or (11T) units mm [in]
A	82.55 [3.250]
B	6.35 [0.250]
C	17.78 [0.700]
D*	31.75 [1.250]
E	17.78 [0.700]

* The 11 tooth auxiliary pad option requires a special short shaft on the mating pump due to reduced clearance to the LPV pump shaft.

Installation drawings

LPV Installation drawings



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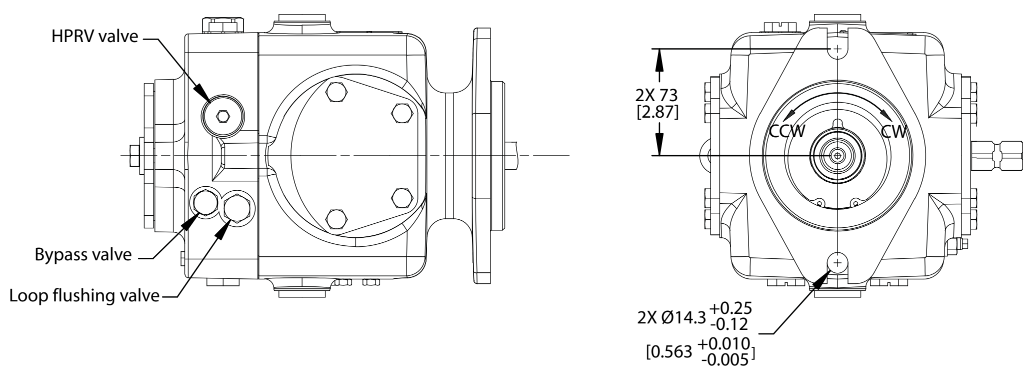
Installation drawings

Shaft rotation

		CW		CCW	
Handle angle		F1	R1	R1	F1
Port flow	A	out	in	in	out
	B	in	out	out	in



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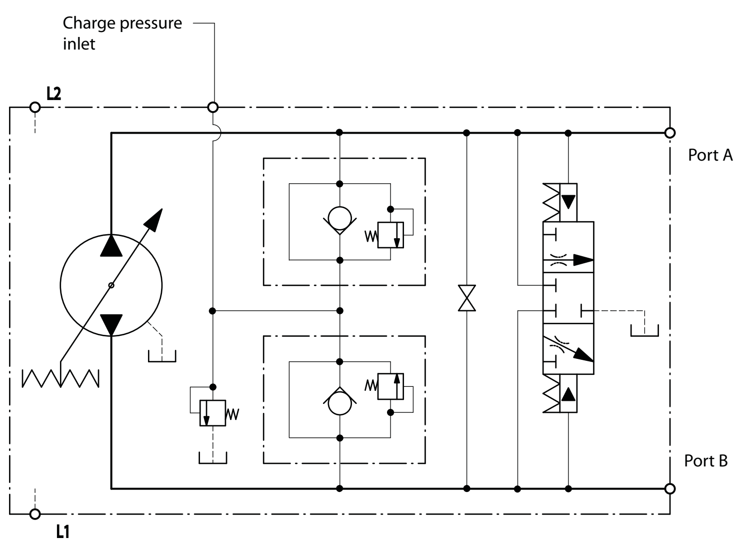
LPV Schematic



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Local address:

Danfoss
Power Solutions (US) Company
2800 East 13th Street
Ames, IA 50010, USA
Phone: +1 515 239 6000

Danfoss
Power Solutions GmbH & Co. OHG
Krokamp 35
D-24539 Neumünster, Germany
Phone: +49 4321 871 0

Danfoss
Power Solutions ApS
Nordborgvej 81
DK-6430 Nordborg, Denmark
Phone: +45 7488 2222

Danfoss
Power Solutions Trading (Shanghai) Co., Ltd.
Building #22, No. 1000 Jin Hai Rd
Jin Qiao, Pudong New District
Shanghai, China 201206
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