

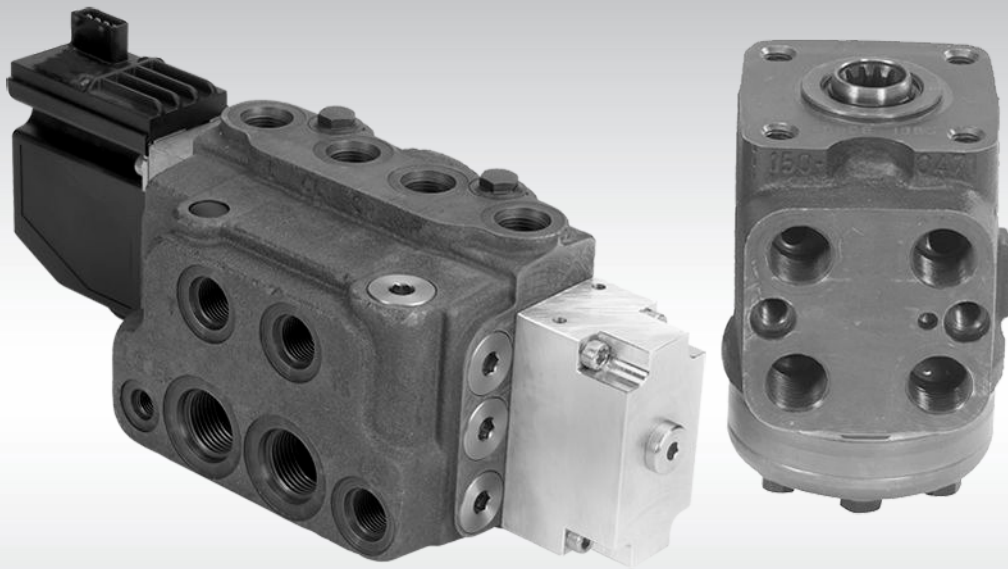


Technical Information

EHPS Steering Valve

PVE Actuation Module

OSPCX CN Steering Unit



Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Revision history*Table of revisions*

Date	Changed	Rev
May 2015	Minor update	EB
August 2014	EHPS type 2 section updated	EA
July 2014	Converted to Danfoss layout	DA
October 2009	Steering column deleted	CA
May 2009	Note added	BC

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A wide range of Steering Components



F500 026

Danfoss is one of the largest producers in the world of steering components for hydrostatic steering systems on off-road vehicles. Danfoss offers steering solutions both at component and system levels. Our product range makes it possible to cover applications of all types - ranging from ordinary 2-wheel steering (also known as Ackermann steering) to articulated steering, automatic steering (e.g. by sensor) and remote controlled steering via satellite. We can offer more than 1,800 different steering units and 250 different priority valves categorized in types, variants and sizes.

For hydrostatic steering systems Danfoss offers:

- Mini steering units with displacements from 32 to 100 cm³/rev [1.95 to 6.10 in³/rev], flow up to 20 l/min [5.28 US gal/min], steering pressure up to 140 bar [2030 psi].
- Steering units with displacements from 40 to 1200 cm³/rev [2.44 to 73.2 in³/rev], flow up to 100 l/min [26.4 US gal/min], steering pressure up to 240 bar [3481 psi].
- Priority valves for rated flows at 40, 80, 120, 160 and 320 l/min [10.6, 21.1, 31.7, 42.3 and 84.5 US gal/min], pressure up to 350 bar [5076 psi].
- Pilot operated flow-amplifiers with amplification factors of 4, 5, 8, 10 or 20 for rated oil flows of 240 and 400 l/min [63.4 and 105.7 US gal/min], steering pressure up to 210 bar [3045 psi].
- Pilot operated steering valve with steering flow up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi] and with integrated priority valve for pump flow up to 120 l/min [31.7 US gal/min].

A wide range of Steering Components

For electrohydraulic steering systems Danfoss offers:

- Pilot operated steering valves (pilot operated by hydrostatic steering unit or by electrical signal) with steering flows up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi].
- Steering units with integrated electrical operated steering valve with steering flow up to 50 l/min [13.2 US gal/min], steering pressure up to 210 bar [3045 psi].

Characteristic features for steering units:

- Low steering torque: From 0.5 N·m to 3 N·m in normal steering situations
- Low noise level
- Low pressure drop
- Many types available: Open center Non-reaction, Open center Reaction, Power Beyond, Closed center Non-reaction, Load Sensing, Load Sensing Reaction
- One or more built-in valve functions: relief valve, shock valves, suction valves, non-return valve in P-line and in LS-line
- Optional port connections (according to ISO, SAE or DIN standards)

Characteristic features for electrohydraulic steering systems with OSPE and EHPS:

- Possibility of GPS, row sensor, variable steering ratio and joystick steering
- The possibility of manual steering even on very heavy vehicles
- EHPS: High steering pressure requiring smaller cylinders and flow
- EHPS: Low pilot pressure and flow giving extremely low noise in the cabin
- EHPS: Can be combined with Danfoss PVG 32 proportional valve

Conversion factors

$$1 \text{ N}\cdot\text{m} = [8.851 \text{ lbf}\cdot\text{in}]$$

$$1 \text{ N} = [0.2248 \text{ lbf}]$$

$$1 \text{ mm} = [0.0394 \text{ in}]$$

$$1 \text{ cm}^3 = [0.061 \text{ in}^3]$$

$$1 \text{ l} = [0.264 \text{ US gal}]$$

$$1 \text{ bar} = [14.5 \text{ psi}]$$

$$^{\circ}\text{F} = [1.8^{\circ}\text{C} + 32]$$

Survey of literature with technical data on Danfoss Steering Components

Detailed data on all Danfoss steering components and accessories can be found in our steering component catalogues, which is divided in to the following individual sub catalogues:

General information	Steering components
Technical data on mini steering units	OSPM
Technical data on open center, and closed center steering units	OSPB, OSPC, and OSPD
Technical data on load sensing steering units, priority valves and flow amplifiers	OSPB, OSPC, OSPF, OSPD, OSPL, OSPBX, OSPLX, OVPL, OLS and OSQ
Technical data on hydraulic and electrohydraulic pilot operated steering valves, electrical actuation modules and appropriate steering units.	EHPS, EHPS w. OLS 320, PVE for EHPS and OSPCX
Technical data on combined steering unit/electrohydraulic steering valves and steering wheel sensors	OSPE and SASA
Technical data on load sensing steering unit with amplification	OSPU

For technical information on individual variants, please contact the Danfoss Sales Organization.

General

Electrohydraulic steering

On loaders, large forklift trucks, dumpers, heavy tractors, combine harvesters, maize harvesters and other similar machines there is often need for electrically actuated steering either in the form of a joystick, or fully automatic.

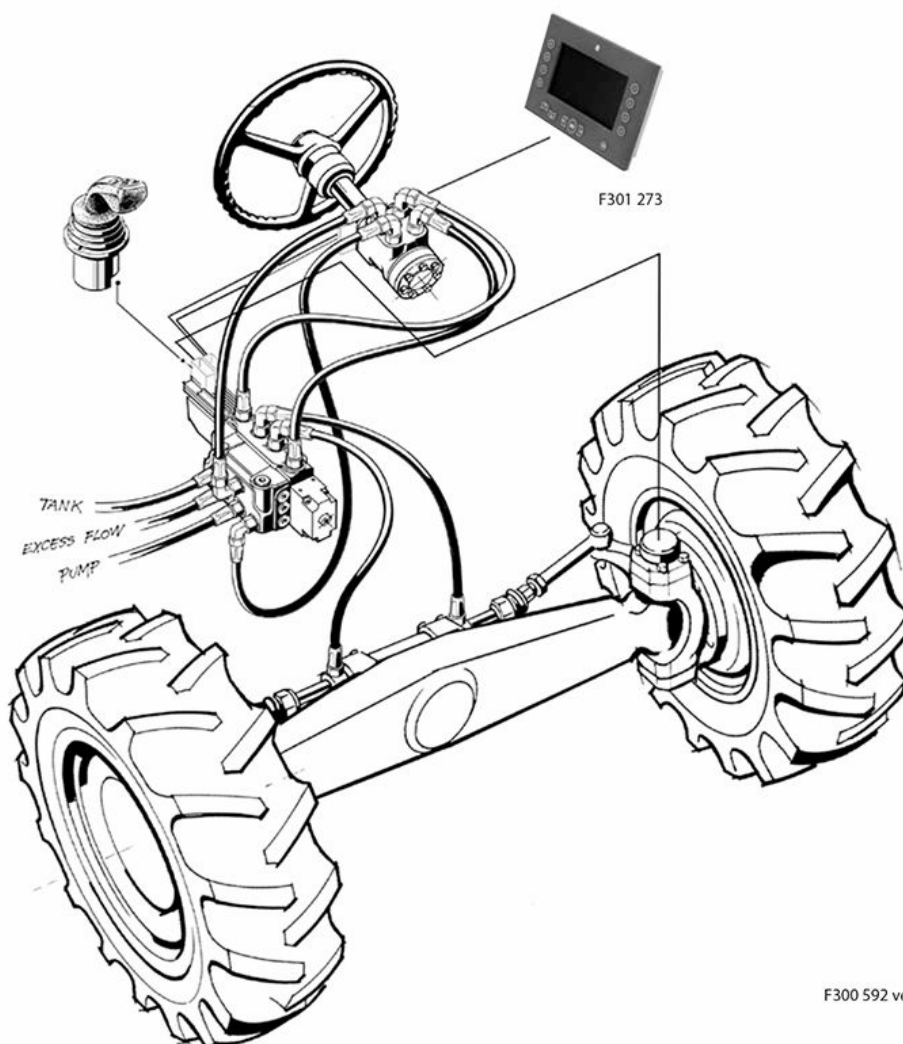
For this purpose Danfoss has developed a pilot operated steering valve type EHPS (Electro Hydraulic Power Steering).

A basic system (type 0) consists of a pilot steering unit as the signal source and an EHPS valve block which controls oil flow to the steering cylinders proportional to the pilot flow.

The system can be extended to include an electrical actuator so that, as an alternative, it becomes possible to steer with a joystick (EHPS type 1).

Alternatively the actuator can be an electrical programmable module (PVED-CLS) to give much more different steering features such like, variable steering ratio, speed dependent steering ratio, steering wheel drift compensation, active jerk force compensation and soft end stop. This system is called EHPS type 2.

Electrohydraulic steering system

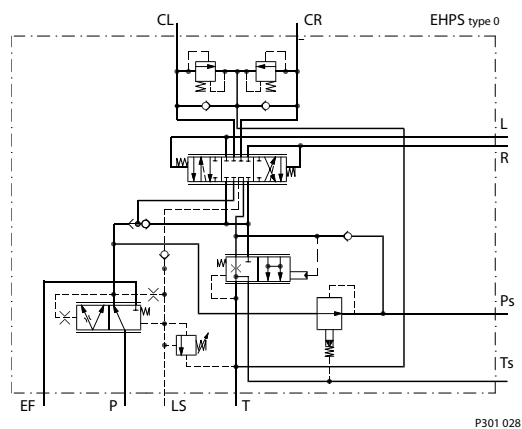
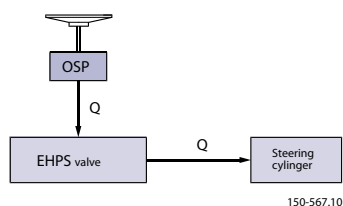


Steering valve EHPS and electrical actuation module PVE for EHPS

Versions

EHPS type 0, hydrostatic steering system:

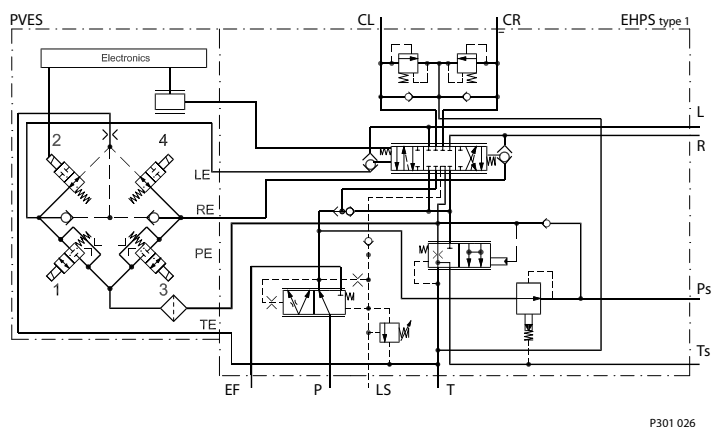
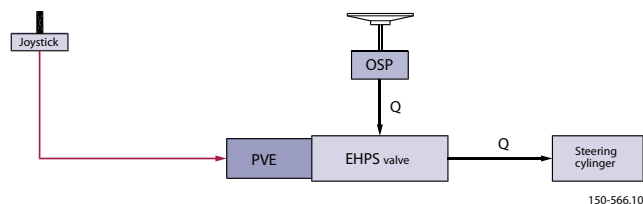
EHPS Type 0 is a hydraulic steering system only with the EHPS valve acting as a pilot operated directional valve. The steering unit type OSPCX CN acts as a pilot unit delivering oil at a low pressure and low flow. The steering unit needs less displacement compared with an ordinary hydrostatic steering system. The displacement can be optimized for emergency steering.



Steering valve EHPS and electrical actuation module PVE for EHPS

EHPS type 1, Hydrostatic and Electrohydraulic Steering System:

This system consists of an EHPS valve (type 0) equipped with an electrical module (PVE) for activating the EHPS valve. There are 2 possibilities of steering: either hydraulic with the steering wheel (OSPCX CN) or electrically using a signal from, for example, a joystick or a mini steering wheel. Input from the steering wheel (OSPCX CN) will always have highest priority.



Steering valve EHPS and electrical actuation module PVE for EHPS

EHPS type 2, hydrostatic and electrohydraulic steering system:

PVED-CL must not be promoted any longer. PVED-CL will be replaced by PVED-CLS by the end of 2014. Please contact Danfoss Sales Organization for further details.

This system consists of an EHPS valve (type 0) equipped with an electrical programmable module (PVED-CLS) for activating the EHPS valve. There are many possibilities of steering:

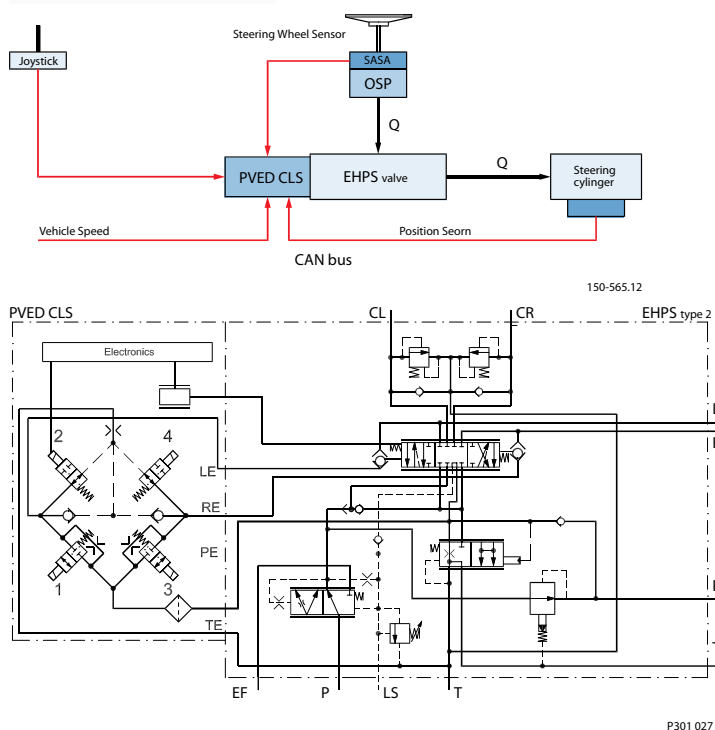
With the steering wheel either pure hydraulic by help of the OSPCX CN steering unit or electrohydraulic by help of the SASA steering wheel sensor placed between column and steering unit.

The EHPS can be controlled electrically also by using signals from, for example, GPS controller, row sensor, joystick or mini steering wheel.

Input from the steering wheel will always have highest priority.

With PVED-CLS the following steering features in electro hydraulic steer mode are possible:

- Variable steering ratio
- Speed dependent steering ratio
- Steering wheel drift compensation
- Active jerk force compensation
- Soft end stop



Steering valve EHPS and electrical actuation module PVE for EHPS

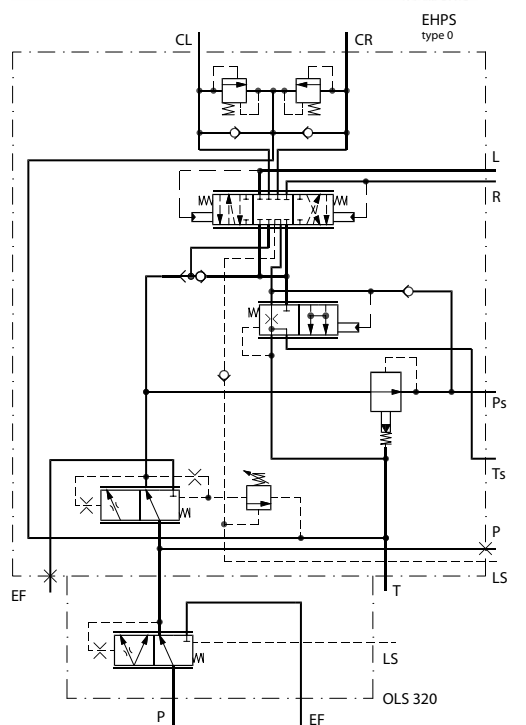
Functional options overview

[Section will be updated with PVED-CLS.](#)

Steering valve EHPS and electrical actuation module PVE for EHPS

EHPS type 0, 1 or 2 with flanged on priority valve OLS 320:

EHPS steering valve has built in priority valve, but for max. pump flow 120 l/min [31.7 US gal/min]. In systems with EHPS and pump flow between 120 l/min [31.7 US gal/min] and 320 l/min [84.5 US gal/min] a combination of EHPS and OLS 320 gives a good compact solution to reduce hosing and installation cost compared with stand alone components.



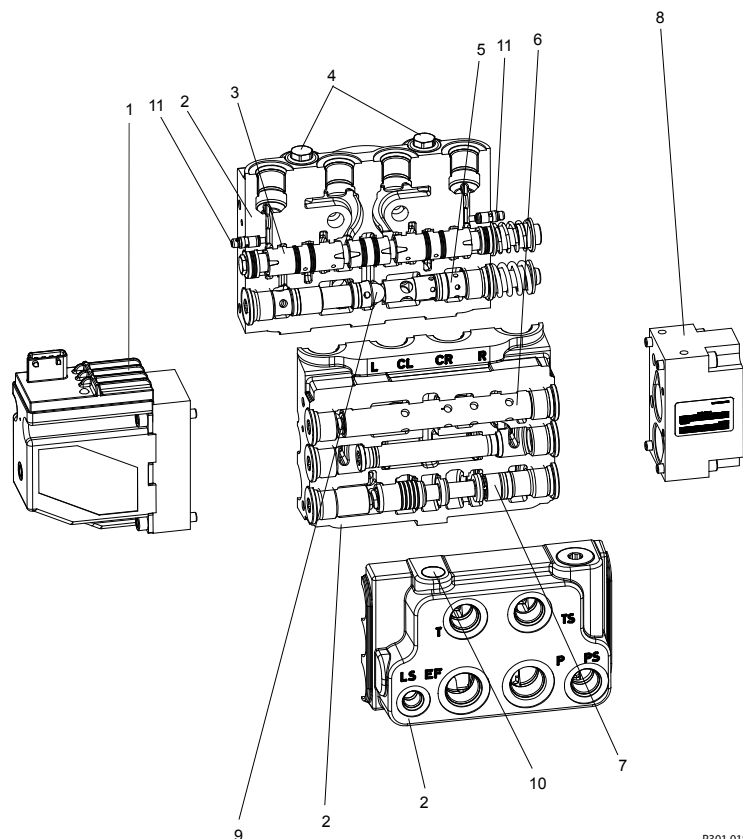
P301 025

Steering valve EHPS and electrical actuation module PVE for EHPS

Function

EHPS valve

The EHPS includes the following main components:

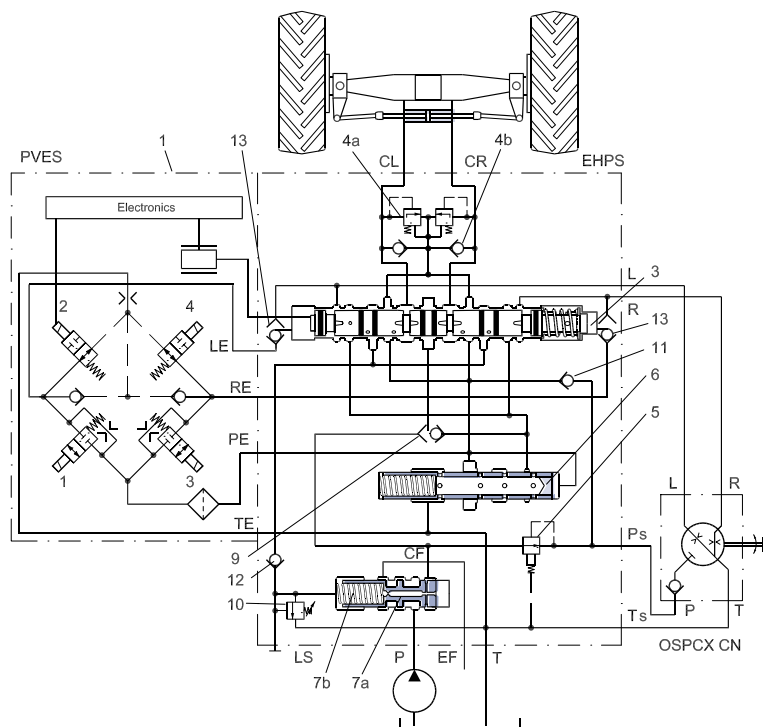


P301 018

1. Electrical actuation module
2. Housing
3. Directional spool
4. Shock and suction valve
5. Pilot pressure reduction valve for steering unit
6. Pilot pressure valve for electrical actuating module also called metering valve
7. Priority valve
8. Cover
9. Emergency steering valve
10. Pilot pressure relief valve
11. Shuttle valves

Steering valve EHPS and electrical actuation module PVE for EHPS

Neutral position



P301 020

1. Electrical actuation module
3. Directional spool
- 4a. Shock valve
- 4b. Suction valves
5. Pilot pressure reduction valve for steering unit
6. Metering valve
- 7a. Priority valve spool
- 7b. Priority valve spring
9. Emergency steering valve
10. Pilot pressure relief valve
11. Check valve for emergency steering
12. Check valve in LS line
13. Shuttle valves

When the engine is turned off, the priority valve spool (7a) is pushed to the right by the spring (7b).

The passage to the EF port is blocked and the passage to CF to the directional spool (3) is open.

When the engine is on and the steering unit OSPCX CN is in neutral position, the CF pressure will rise to match the spring force in the integrated priority valve, and the spool (7a) will move to the left and the oil will pass from the pump across the priority valve (7a + 7b) and out through the EF port.

Steering valve EHPS and electrical actuation module PVE for EHPS

The priority valve is a "dynamic" type, meaning that a flow passes from CF through the Dynamic orifice (integrated in spool 7a) and into the LS line through the check valve (12) to the directional spool (3). In neutral position this dynamic oil flow passes on to the tank.

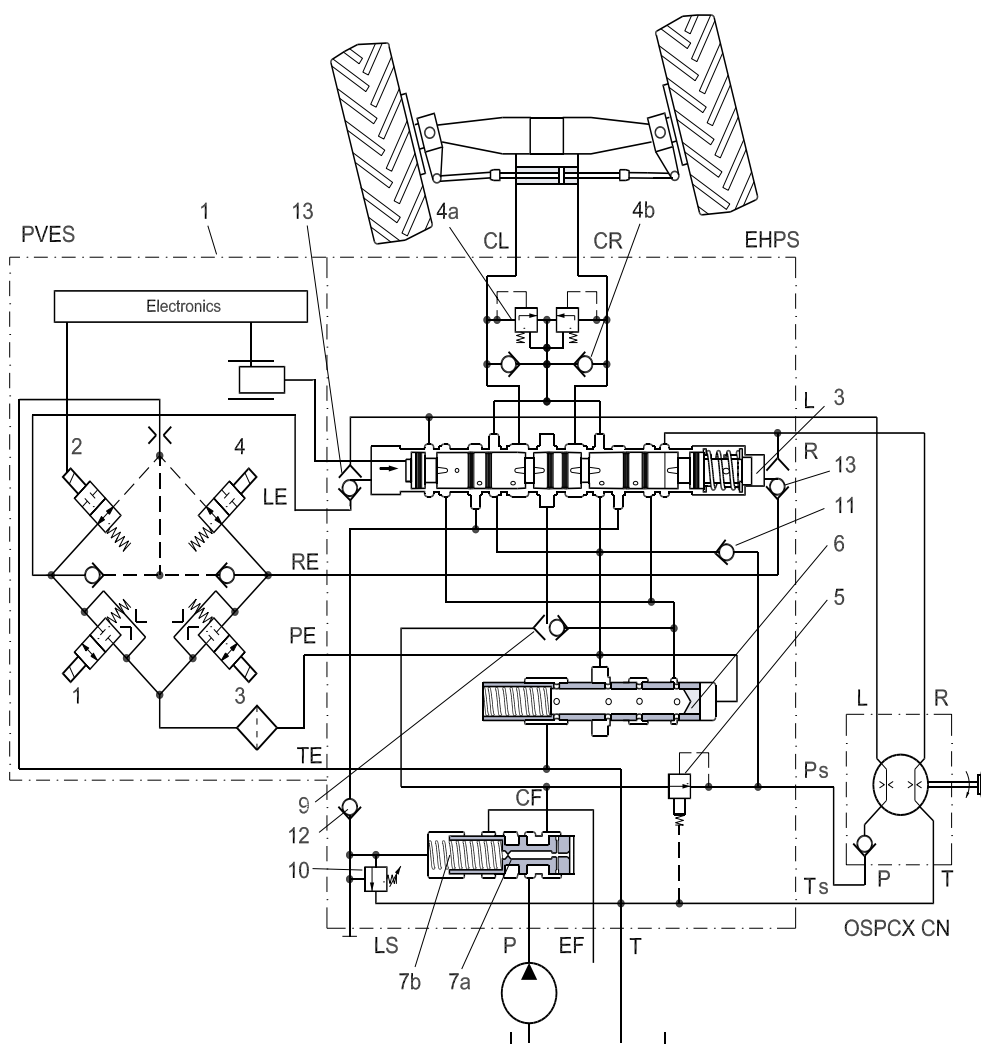
When the steering unit is in neutral position and no signal is generated to PVES, the directional spool will be in its center position. This means that knocks and impacts from the cylinder are not transmitted to the steering unit.

Steering left

When steering, the steering unit will get oil supplied from the pilot pressure reduction valve (5).

The pressure for the steering unit is reduced to approximate 30 bar.

When steering left, oil will be passing on to the L-port of the EHPS and it will fill the left side chamber of the directional spool (3), which makes the spool move to the right.



P301 021

- 1. Electrical actuation module
- 3. Directional spool
- 4a. Shock valve
- 4b. Suction valves

Steering valve EHPS and electrical actuation module PVE for EHPS

5. Pilot pressure reduction valve for steering unit
6. Metering valve
- 7a. Priority valve spool
- 7b. Priority valve spring
9. Emergency steering valve
10. Pilot pressure relief valve
11. Check valve for emergency steering
12. Check valve in LS line
13. Shuttle valves

When moving the directional spool (3), the LS signal will be connected to the steering pressure CL. The pressure will then increase in the spring chamber of the priority valve and the priority valve spool (7a) will be pushed towards the right side. Consequently, oil will flow through CF from the priority valve to the directional spool (3).

Oil will now push the steering cylinder rod out and it will cause steering to the left side.

Return oil from the opposite cylinder side will stream into the CR port through the directional spool (3) and into the right end of the metering valve (6). The metering valve spool is moved to the left and the main stream from CR can pass through the metering valve into the tank.

The metering valve needs 12 bar to move. This return pressure is used for feeding an electrical actuation module PVES in a EHPS type 1 system.

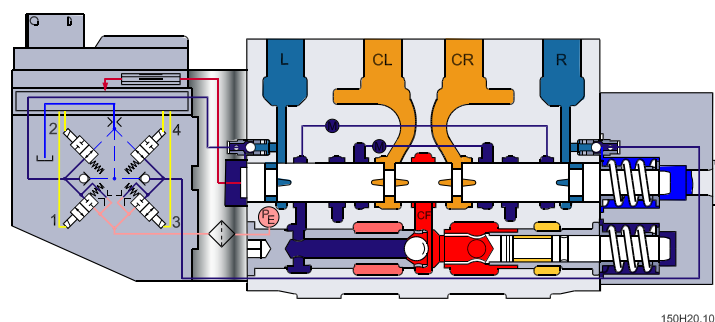
When the metering valve is open, it also leads pilot oil from the steering unit to the tank.

When the steering cylinder has reached end stop, no oil will pass through the CR port, and the control pressure for the metering valve (6) will be reduced. The metering valve will now move to the right, and the valve is closing the tank connection and the pilot oil flow will be blocked. This way you will feel the end stop in the steering wheel.

When turning right, the movement of the directional spool (3) will be opposite. All other functions are equal as when steering left. When steering with an electrical signal the directional spool (3) will be controlled by hydraulic signal from the PVES which is converting electrical signal to hydraulic signal to the directional spool (3), so that the movement of the directional spool (3) will be proportional to the electrical signal to the PVES. The shuttle valves (13) will lead oil from PVES (1) to directional spool (3).

PVES and PVED-CLS, electrical actuation

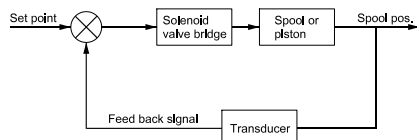
The philosophy of Danfoss electrohydraulic actuation, type PVE, is integration of electronics, sensors and actuators into a single unit that interfaces directly to the EHPS steering valve body.



Steering valve EHPS and electrical actuation module PVE for EHPS

Closed loop control

All the proportional actuators feature an integrated feedback transducer that measures spool movement in relation to the input signal, and by means of a solenoid valve bridge, controls the direction, velocity and position of the directional spool of the valve. The integrated electronics compensate for flow forces on the spool, internal leakage, changes in oil viscosity, pilot pressure, etc. This results in lower hysteresis and better resolution. Furthermore the electronics enable built in safety like fault monitoring, directional indication and LED light indication.



157-503.10

Principle

In principle the input signal (set-point signal) determines the level of pilot pressure which moves the main spool. The position of the directional spool is sensed in the LVDT transducer which generates an electric feed-back signal registered by the electronics. The variation between the set-point signal and feed-back signal actuates the solenoid valves. The solenoid valves are actuated so that hydraulic pilot pressure drives the directional spool into the correct position.

Inductive transducer, LVDT

(Linear Variable Differential Transformer). When the directional spool is moved, a voltage is induced proportional to the spool position. The use of LVDT gives contact-free monitoring of the directional spool position. This means an extra-long working life and no limitation as regards the type of hydraulic fluid used. In addition, LVDT gives a precise position signal of high resolution.

Integrated pulse width modulation

Positioning of the directional spool in PVES is based on the pulse width modulation principle. As soon as the directional spool reaches the required position, modulation stops and the spool is locked in position.

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Technical data

EHPS

The technical data for EHPS are typical measured results. For the hydraulic system a mineral based hydraulic oil with a viscosity of 21 mm²/s [102 SUS] and a temperature of 50°C [122°F] was used.

EHPS "stand alone"

Maximum pressure	Port P, EF, LS	250 bar	[3625 psi]
	Port CL/CR	320 bar	[4641 psi]
	Port L/R	125 bar	[1812 psi]
	Port Ps	55 bar	[798 psi]
	Port T, Ts	25 bar	[363 psi]
Oil flow rated	Port P, EF	120 l/min	[31.7 US gal/min]
	Port CL/CR/T	80/96 l/min ¹⁾²⁾	[21/25 US gal/min]
	Port L/R/Ps	10/12.5 l/min ¹⁾²⁾	[2.6/3.3 US gal/min]
Spool travel, directional spool		± 7 mm	[± 0.27 in]
Dead band, directional spool		± 1.5 mm	[± 0.06 in]
Priority valve	Spring force	10 bar	[145 psi]
	Nominal flow	120 l/min	[31.7 US gal/min]
Oil temperature	Recommended temperature	+30°C → +60°C	[+86°F → +140°F]
	Minimum temperature	-30°C	[-22°F]
	Maximum temperature	+90°C	[+194°F]
Ambient temperature		-30°C → + 60°C	[-22°F → +140°F]
Oil viscosity	Operating range	12 - 80 mm ² /s	[65 - 370 SUS]
	Minimum viscosity	10 mm ² /s	[59 SUS]
	Maximum viscosity	460 mm ² /s	[2129 SUS]
Filtration	Maximum contamination (ISO 4406, 1999 version)	21/19/16	

¹⁾ At 6 mm [0.24 in] spool travel with directional spool for maximum cylinder and pilot flow (80/10)

²⁾ At 7 mm [0.28 in] spool travel (max travel) with directional spool for maximum cylinder and pilot flow (80/10)

Additional Data's for EHPS with OLS 320

Priority valve, OLS 320	Spring force	10 bar	[145 psi]
	Nominal flow	320 l/min	[84.5 US gal/min]

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Technical data

PVES

		PVES	
Supply voltage U_{DC}	rated	11 V to 32 V	
	range	11 V to 32 V	
	max. ripple	5%	
Current consumption at rated voltage PVES		0.57 A @ 12 V	0.3 A @ 24 V
Signal voltage	neutral	$0.5 \times U_{DC}$	
	CR-port ↔ CL-port	$0.25 \cdot U_{DC}$ to $0.75 \cdot U_{DC}$	
Signal current at rated voltage		0.25 mA to 0.70 mA	
Input impedance in relation to $0.5 \cdot U_{DC}$		12 KΩ	
Input capacitor		100 nF	
Power consumption PVES		7 W	

Reaction time

Supply voltage	Function		PVES Prop. supers
Disconnected by means of neutral switch	Reaction time from neutral position to max. spool travel	max.	0.230
		rated	0.150
		min.	0.120
Disconnected by means of neutral switch	Reaction time from max. spool travel to neutral position	max.	0.175
		rated	0.090
		min.	0.065
Constant voltage	Reaction time from neutral position to max. spool travel	max.	0.200
		rated	0.120
		min.	0.050
Constant voltage	Reaction time from max. spool travel to neutral position	max.	0.100
		rated	0.090
		min.	0.065

PVED-CLS

[Information is under preparation.](#)

Hysteresis, PVES and PVED-CLS

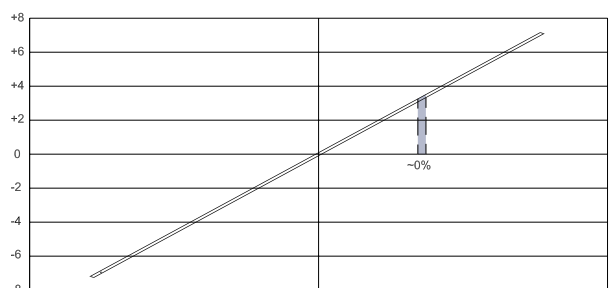
Hysteresis, PVES and PVED-CLS ¹⁾	rated	~ 0%
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¹⁾ Hysteresis is indicated at rated voltage and $f = 0.02$ Hz for one cycle (one cycle = neutral → full CL → full CR → neutral).

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Technical data

Spool travel



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PVES and PVED-CLS

Oil consumption

Supply voltage	Function		PVES and PVED-CLS	
Without voltage	Pilot oil flow	neutral	0.3 l/min	[0.078 US gal/min]
With voltage	Pilot oil flow	locked	0.1 l/min	[0.026 US gal/min]
		continuous actuations	0.8 l/min	[0.211 US gal/min]

Oil viscosity

Oil viscosity	range	12 - 75 mm ² /s	[65 - 347 SUS]
	min.	4 mm ² /s	[39 SUS]
	max.	460 mm ² /s	[2128 SUS]

Note: Max. start up viscosity 2500 mm²/s

Oil temperature

Oil-temperature	Rec. range	30 - 60°C	[86 - 140°F]
	min.	-30°C	[-22°F]
	max.	90°C	[194°F]

Filtering

Filtering in the hydraulic system	Max. allowed degree of contamination (ISO 4406, 1999 version): 23/19/16
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Ambient temperature

Ambiant temperatur range Rec.	-30° → +60°C	[-22° → +140°F]
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Pilot pressure

Pilot pressure (relative to T pressure)	nom.	13.5 bar	[196 psi]
	min.	10 bar	[145 psi]
	max.	15 bar]	[217 psi]

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Technical data*Enclosure and connector version*

Version of connector	AMP JPT connector	Deutsch® connector
Grade of enclosure ¹⁾	IP 66	IP 67

¹⁾ According to the international standard IEC 529

[In particularly exposed applications, protection in the form of screening is recommended.](#)

Installation PVED-CLS

[Information is under preparation.](#)

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Variants

Variants of EHPS

In the table below is shown the available variants of the different modules in the EHPS valve.

EHPS valve module variants

Part	Variants																	
Actuation module	Type 0 (none)									Type 1 (PVES)			Type 2 (PVED-CLS)					
										Connection			Connection					
										AMP		DEUTSCH	DEUTSCH 12 pin					
Directional spool ¹⁾										Cylinder flow (CQ) l/min [US gal/min]								
	Pilot flow (PQ) (l/min) [US gal/min]									20 [5.28]		40 [10.57]		60 [15.85]		80 [21.13]		
	5 [1.32]									CQ/PQ = 20/5		40/5		not available		not available		
	8 [2.11]									not available		not available		60/8		80/8		
	10 [2.64]									not available		40/10		60/10		CQ/PQ=80/10		
Housing ²⁾										Thread								
	Basic									G			Metric			UNF		
	Stand alone									available			available			available		
	For PVG									available			available			available		
	For OLS 320 ³⁾									not available			available			available		
Relieve valve, bar [psi]	100 [1450]	110 [1595]	120 [1740]	130 [1885]	140 [2030]	150 [2175]	160 [2320]	170 [2465]	180 [2610]	190 [2755]	200 [2900]	210 [3045]	220 [3190]	230 [3335]	240 [3480]	250 [3626]		
Shock valves, bar [psi]	160 [2320]	175 [2538]	190 [2755]		210 [3045]		230 [3335]		240 [3480]	250 [3626]	265 [3843]	280 [4061]		300 [4351]		320 [4641]		

1) Directional spool:

Cylinder flow:

CQ = 20 l/min [5.28 US gal/min] is valid for 6 mm [0.24 in] spool travel.

CQ = 40 l/min [10.57 US gal/min] is valid for 6 mm [0.24 in] spool travel etc.

Pilot flow

PQ = 5 l/min [1.32 US gal/min] is based on steering unit with 50 cm³/rev and 100 min⁻¹ [rpm] and causes 6 mm [0.24 in] spool travel at 100 min⁻¹ [rpm] steering wheel speed

PQ = 8 l/min [2.11 US gal/min] is based on steering unit with 80 cm³/rev [4.88 in³/rev] and 100 min⁻¹ [rpm] etc.

For example if you need 60 l/min [15.85 US gal/min] cylinder flow at 100 min⁻¹ [rpm] steering wheel speed and you need 80 cm³/rev [4.88 in³/rev] steering unit, you must choose directional spool 60/8.

2) Housing, threads:

	P, EF	Ps, Ts, T, CL, CR, L & R	LS
G, DIN 3852-2	G 3/4 - S ²⁾	G 1/2 - S ²⁾	G 1/4 - S ²⁾
Metric, ISO 6149-1	M 27 • 2 - O ¹⁾ + S ²⁾	M 18 • 1.5 - O ¹⁾ + S ²⁾	M 12 • 1.5 - O ¹⁾ + S ²⁾
UNF, ISO 11926-1	1 1/16 - 12 UN - O ¹⁾ + S ²⁾	3/4 - 16 UNF - O ¹⁾ + S ²⁾	7/16 - 20 UNF - O ¹⁾ + S ²⁾

¹⁾ O-ring chamfer on port connection

²⁾ Spot face around port connection

3) OLS320 for EHPS, Housing, threads:

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Variants

	P, EF	LS
SAE-ports	1 in SAE flange/M10 threads	None ³⁾ or M 12 • 1.5 - O ¹⁾ + S ²⁾ or 7/16 - 20 UNF - O ¹⁾ + S ²⁾
Metric, ISO 6149-1	M 33 • 2 - O ¹⁾ + S ²⁾	M 12 • 1.5 - O ¹⁾ + S ²⁾
UNF, ISO 11926-1	1 5/16 - 12 UN - O ¹⁾ + S ²⁾	7/16 - 20 UNF - O ¹⁾ + S ²⁾

³⁾ If LS connection is going from OLS320 to LS connection of EHPS

¹⁾ O-ring chamfer on port connection

²⁾ Spot face around port connection

Dimensioning

Dimensioning steering system with EHPS steering valve

The cylinder flow is determined from:

- Steering cylinder volume.
- Steering speed.

Dimension of steering cylinder(s) can be based on formulas in "General, steering components" page 29-31.

Symbols

V (l)	steering cylinder volume
i (rev)	number of steering wheel revolutions from lock to lock
Vvc (cm ³ /rev.)	steering system displacement for steering cylinder
CQ (l/min)	nominal cylinder flow
Pems (bar)	emergency steering pressure
Tems (Nm)	emergency steering torque
Fe (N)	emergency steering wheel rim force
Swd (m)	steering wheel diameter
Vvs (cm ³ /rev)	displacement, steering unit
PQ (l/min)	pilot flow
Qpm (l/min)	pump flow, minimum

Example:

Cylinder volume: $V = 1.85 \text{ l}$ [0.49 US gal/min]

Required number of steering wheel revolutions from lock to lock:

$i = 4 - 5 \text{ revolutions}$

The required steering system displacement for steering cylinder is calculated from

$$Vvc = V/i = (1.85 \cdot 1000)/5 = 370 \text{ cm}^3/\text{rev} [22.6 \text{ in}^3]$$

$$(1.85 \cdot 1000)/4 = 463 \text{ cm}^3/\text{rev} [28.3 \text{ in}^3]$$

In this example we chose $Vvc = 400 \text{ cm}^3/\text{rev}$

The directional spool is designated by nominal cylinder flow at 100 rpm speed on steering wheel.

$$CQ = 400 \cdot 100/1000 \text{ (cm}^3/\text{l)} = 40 \text{ l/min} [10.6 \text{ US gal/min}]$$

The pilot flow is mainly determined by the demand for emergency steering pressure, look in "General , steering components" page 28-29.

Emergency steering pressure, Pems, is calculated to be maximum

$$Pems = 40 \text{ bar} [580 \text{ psi}]$$

Maximum allowable steering torque Tems based on steering wheel rim force $Fe = 350 \text{ N}$ and steering wheel diameter $Swd = 0.381 \text{ m}$ [15 in]

$$Tems = Fe \cdot Swd/2 = 350 \cdot 0.381/2 = 66.7 \text{ Nm} [590 \text{ lbf}\cdot\text{in}]$$

Pilot steering unit displacement can be chosen/calculated from the table lowest on page 28 in "General , steering components".

The nearest displacement Vvs generating minimum 40 bar [580 psi] at $Tws = 66.7 \text{ N}\cdot\text{m}$ [590 lbf·in]

$$Vvs \text{ maximum} = 80 \text{ cm}^3/\text{rev.} [4.88 \text{ in}^3]$$

As in an EHPS steering system pilot oil is dumped to the tank the steering unit displacement should be as small as possible.

In a given example you may be able to use a steering unit with smaller displacement as maximum size acceptable for emergency steering pressure.

This is determined by the required speed for steering the vehicle in a situation without pump oil supply.

Dimensioning

In this example a 50 cm³ [3.01 in³] (Vvs chosen) steering unit could be big enough to obtain the required steering speed in emergency steering mode.

Pilot flow PQ is chosen by:

$$PQ = V_{vs \text{ chosen}} * 100 \text{ rpm} = 50 \text{ cm}^3 [3.01 \text{ in}^3] / \text{rev} * 100 \text{ rpm} = 5 \text{ l/min. [1.3 US gal/min]}$$

Designation CQ/PQ for directional spool is: 40/5.

Calculating pump flow:

If cylinder movement must correspond to steering wheel speed up to 100 rpm, the minimum pump flow Qpm for steering will be:

$$Q_{pm} = CQ + PQ = 40 + 5 = 45 \text{ l/min [11.9 US gal/min]}$$

If pump flow is insufficient, the steering cylinder speed will not match the steering wheel speed: the faster you steer, the higher pilot flow will be, and less flow will be left for cylinder movement.

If you want to have sufficient supply at higher steering wheel speed (higher than 100 rpm) you must choose enough pump capacity for such a case.

See [Directional spool - cylinder flow characteristic for all directional spools](#) on page 27 for the different directional spools. The "40 l/min [10,57 US gal/min]" spool gives maximum cylinder flow 50 l/min [13.21 US gal/min] at end stroke.

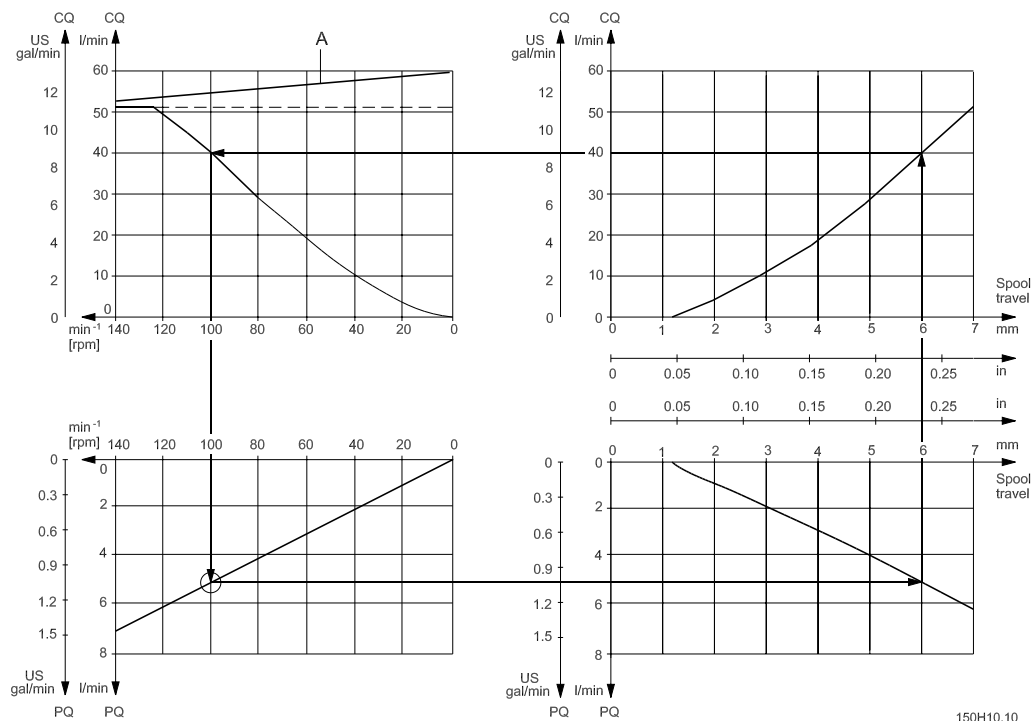
If you in the example above calculate with maximum steering wheel speed 150 rpm, the minimum pump flow capacity must be:

$$Q_{pm} = CQ_{max} + PQ_{max} = 50 + 7.5 = 57.5 \text{ l/min [15.32 US gal/min]}$$

(Qmax comes from 50 cc/rev* 150 rpm = 7.5 l/min [1.98 US gal/min])

Technical characteristics

Directional spool - oil flow characteristic for spool 40/5



A: Flow available for steering, $CQ_a = QP - PQ$

QP = Pump flow

PQ = Pilot flow

The lower left diagram shows pilot flow as function of steering wheel speed. The values are valid for OSPCX 50 CN steering unit: 100 rpm steering wheel speed corresponds to 5 l/min. [1.3 US gal/min] pilot flow.

The lower right diagram shows spool travel as function of pilot flow: 5 l/min. [1.3 US gal/min] pilot flow gives 6 mm spool travel.

The upper right diagram shows cylinder flow as function of spool travel: 6 mm spool travel gives 40 l/min [10.6 US gal/min] cylinder flow.

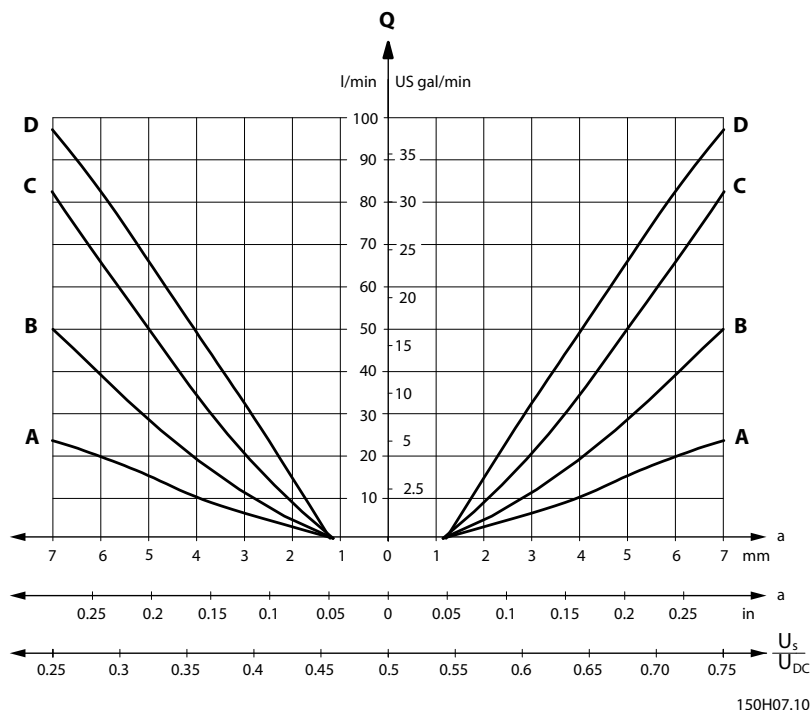
The upper left diagram shows cylinder flow as function of steering wheel speed: 100 rpm steering wheel speed gives 40 l/min [10.6 US gal/min] cylinder flow.

Line A shows flow limit available for cylinder flow, when pump flow is 60 l/min. [15.9 US gal/min]. At 100 rpm 5 l/min. [1.3 US gal/min] is used for pilot flow.

Please contact the Danfoss Organization regarding characteristics for other directional spools.

Technical characteristics

Directional spool - cylinder flow characteristic for all directional spools

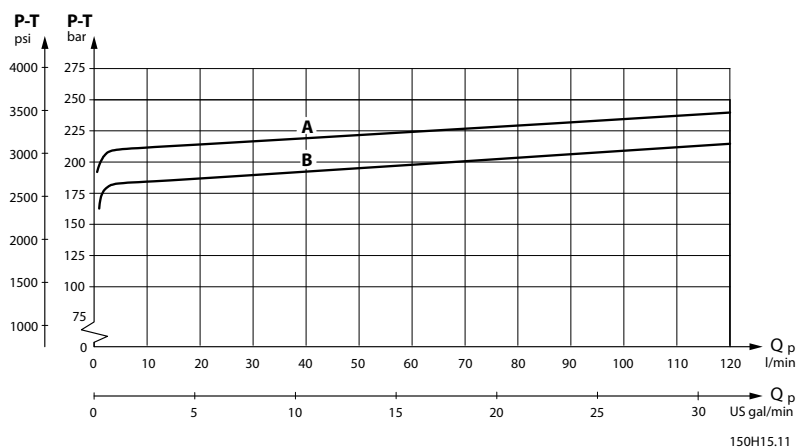


- A** = valid for spools for nominal cylinder flow $CQ = 20$ l/min [5.3 US gal/min]
- B** = valid for spools for nominal cylinder flow $CQ = 40$ l/min [10.6 US gal/min]
- C** = valid for spools for nominal cylinder flow $CQ = 60$ l/min [15.9 US gal/min]
- D** = valid for spools for nominal cylinder flow $CQ = 80$ l/min [21.1 US gal/min]

Pilot pressure relief valve: (P - T, Q_p) characteristic

The pilot pressure relief valve protects the steering system against excessive pressure. The pilot pressure relief valve works together with the priority valve in the EHPS to limit the maximum steering pressure P-T. The pilot pressure relief valve is set at an oil flow to the priority valve of 40 l/min [10.6 US gal/min].

Setting tolerance: rated value +5 bar [72.5 psi]



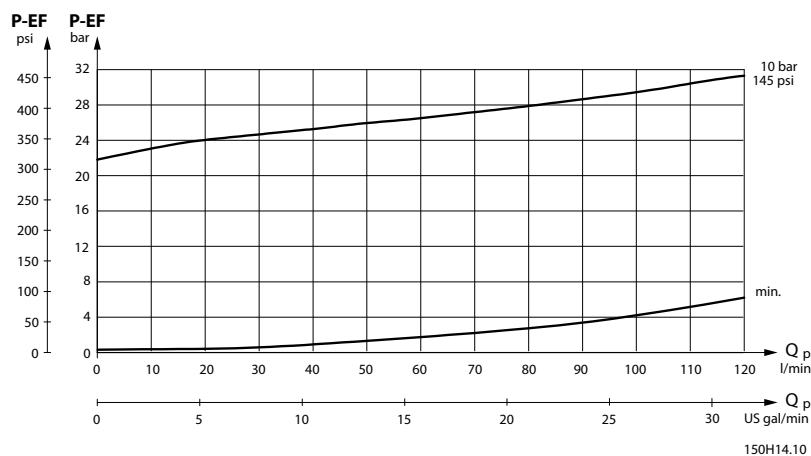
Technical characteristics

- A:** 220 bar +5 / -0 bar [3190 + 72.5 / -0 psi]
B: 190 bar +5 / -0 bar [2756 + 72.5 / -0 psi]

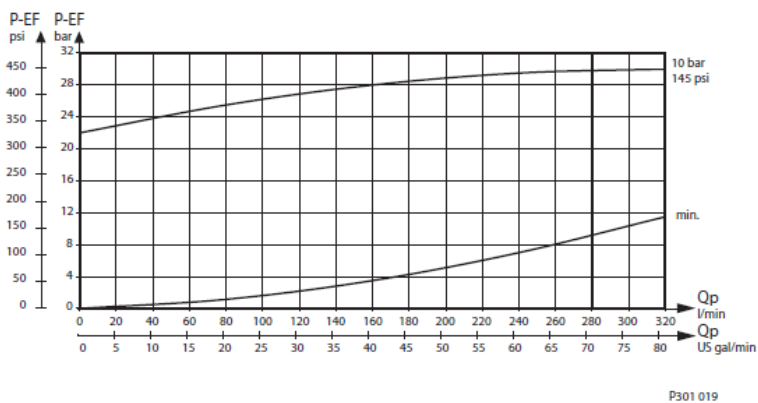
Pressure drop P-EF for Danfoss EHPS valve

This data comes from measurements on a representative sample of EHPS valves from production. Oil with viscosity of 21 mm²/s [102 SUS] at 50 °C [122 °F] was used during measuring. Measurement made when pressure on the LS connection is zero. The minimum curve applies when the pressure on the EF connection is higher than the actual control spring pressure. The curve for control spring pressure of 10 bar [145 psi] applies when pressure on the EF port is zero.

Pressure drop P-EF for OLS integrated in EHPS

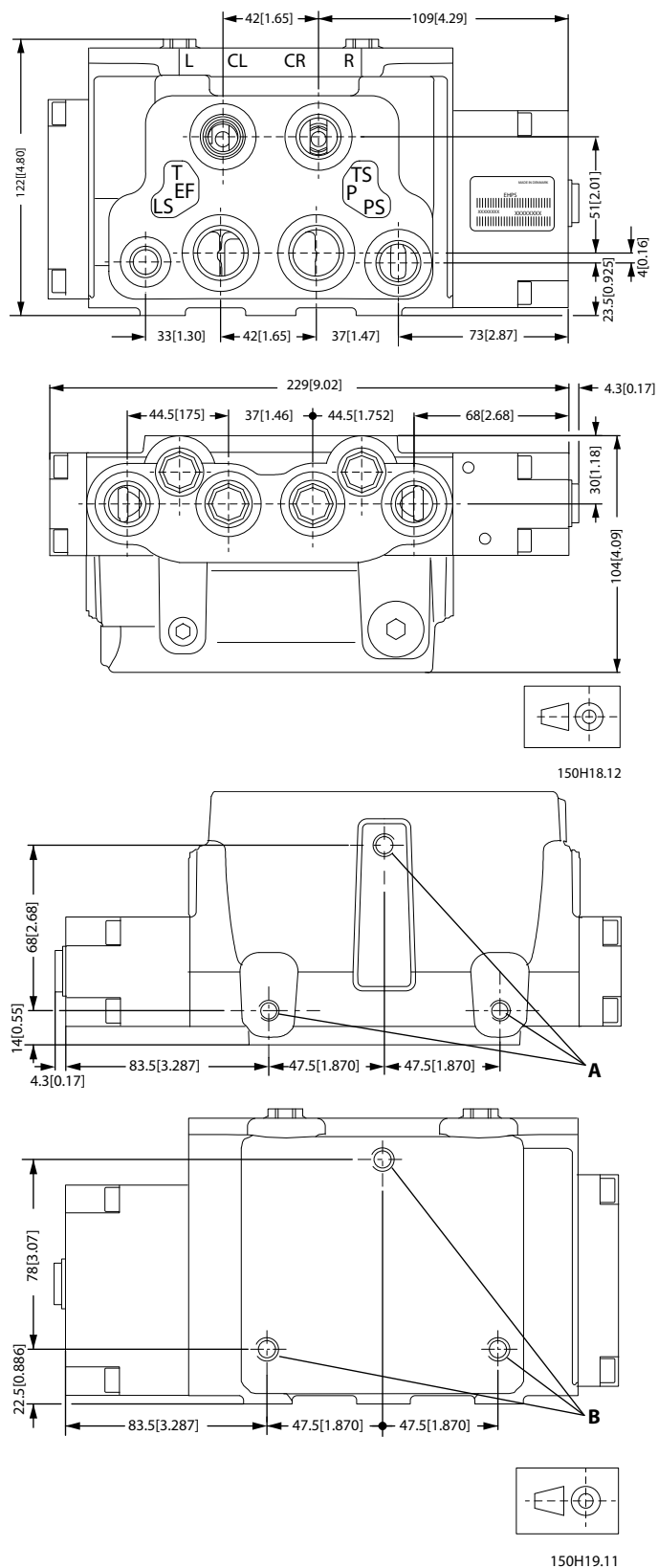


Pressure drop P-EF for OLS 320 static priority valve flanged on EHPS



Dimensions

EHPS type 0, stand alone



Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Dimensions

	P, EF	Ps, Ts, T, CL, CR, L, R	LS
G-port version (G, DIN 3852-2)	G 3/4, 16 mm [0.63 in] deep	G 1/2, 14 mm [0.55 in] deep	G 1/4, 12 mm [0.48 in] deep
Metric-port version (ISO 6149-1)	M27 • 2, 19 mm [0.75 in] deep	M18 • 1.5, 14.5 mm [0.57 in] deep	M12 • 1.5, 11.5 mm [0.45460 mm ² /s in] deep
UNF-port version (ISO 11926-1)	1 1/16 -12 UN, 19 mm [0.75 in] deep	3/4 -16 UNF 14 mm [0.55 in] deep	7/16 -20 UNF, 11.5 mm [0.45 in] deep

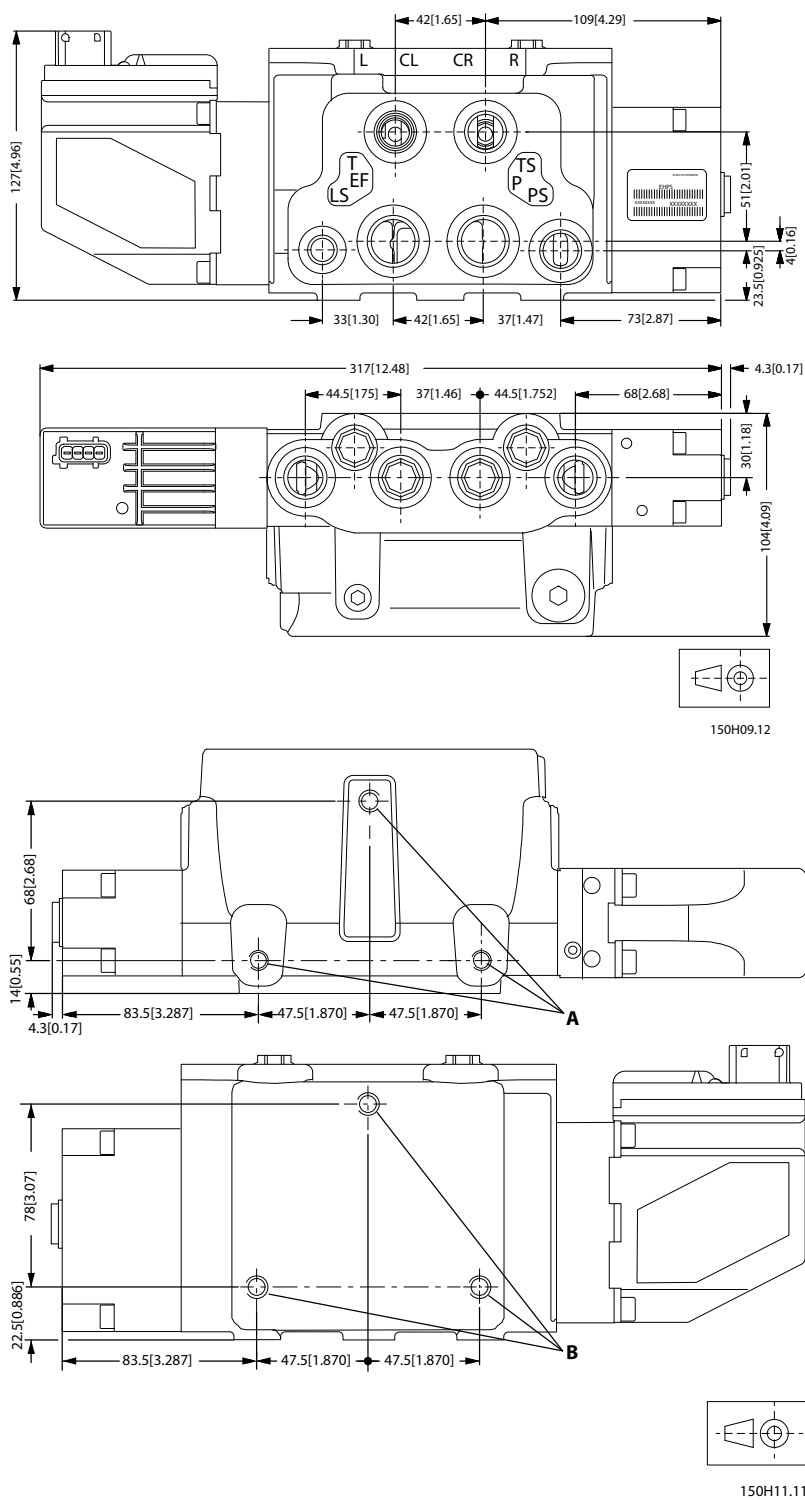
	A	B
All versions:	M8 • 1.25, 10 mm [0.39 in] deep	M8 • 1.25, 10 mm [0.39 in] deep

The mounting surface for the EHPS must be plane. No spots exceeding the height of the area round the three M8 bolt holes allowed.

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Dimensions

EHPS type 1, stand alone



Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Dimensions

	P, EF	Ps, Ts, T, CL, CR, L, R	LS
G-port version (G, DIN 3852-2):	G 3/4, 16 mm [0.63 in] deep	G 1/2, 14 mm [0.55 in] deep	G 1/4, 12 mm [0.48 in] deep
Metric-port version (ISO 6149-1)	M27 • 2, 19 mm [0.75 in] deep	M18 • 1.5, 14.5 mm [0.57 in] deep	M12 • 1.5, 11.5 mm [0.45 in] deep
UNF-port version (ISO 11926-1)	1 1/16 -12 UN, 19 mm [0.75 in] deep	3/4 -16 UNF 14 mm [0.55 in] deep	7/16 -20 UNF, 11.5 mm [0.45 in] deep

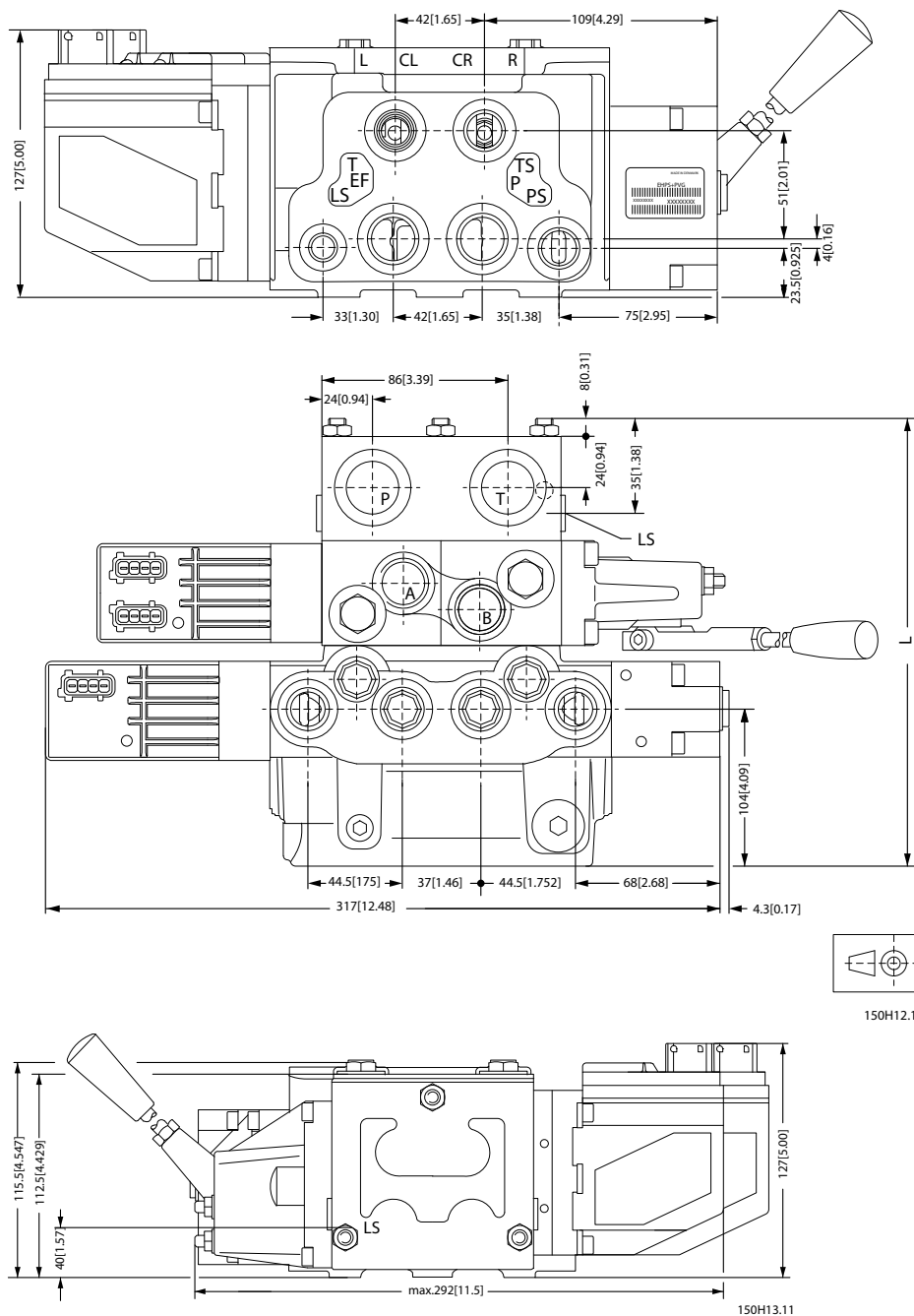
	A	B
All versions:	M8 • 1.25, 10 mm [0.39 in] deep	M8 • 1.25, 10 mm [0.39 in] deep

The mounting surface for the EHPS must be plane. No spots exceeding the height of the area round the three M8 bolt holes allowed.

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Dimensions

EHPS type 1, with PVG



Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Dimensions

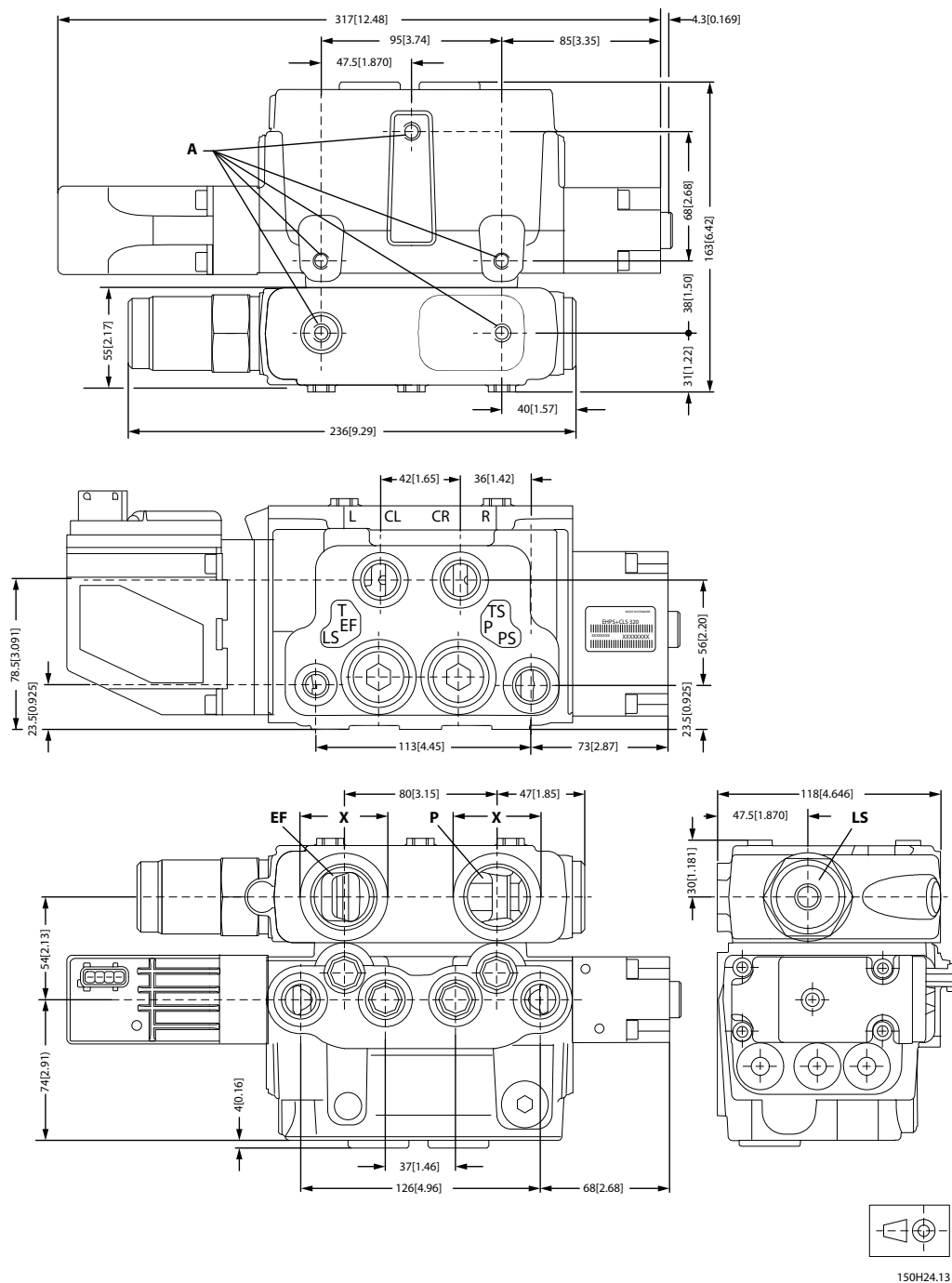
	P, EF	Ps, Ts, T, CL, CR, L, R	LS
G-port version (G, DIN 3852-2)	G 3/4, 16 mm [0.63 in] deep	G 1/2, 14 mm [0.55 in] deep	G 1/4, 12 mm [0.48 in] deep
Metric-port version (ISO 6149-1)	M27 • 2, 19 mm [0.75 in] deep	M18 • 1.5, 14.5 mm [0.57 in] deep	M12 • 1.5, 11.5 mm [0.45 in] deep
UNF-port version (ISO 11926-1)	1 1/16 -12 UN, 19 mm [0.75 in] deep	3/4 -16 UNF 14 mm [0.55 in] deep	7/16 -20 UNF, 11.5 mm [0.45 in] deep

	A
All versions	Bottom side fixing holes (A) in EHPS block, see page 29; M8 x 1.25, 10 mm [0.39 in] deep

PVB	1	2	3	4	5	6	7	8
L1 mm [in]	208 [8.19]	256 [10.08]	304 [12.00]	352 [13.86]	400 [15.75]	448 [17.64]	496 [19.53]	544 [21.42]

Dimensions

EHPS type 1, with OLS 320



Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Dimensions

EHPS

	P, EF	Ps, Ts, T, CL, CR, L, R	LS
G-port version (G, DIN 3852-2):	G 3/4, 16 mm [0.63 in] deep	G 1/2, 14 mm [0.55 in] deep	G 1/4, 12 mm [0.48 in] deep
Metric-port version (ISO 6149-1)	M27 • 2, 19 mm [0.75 in] deep	M18 • 1.5, 14.5 mm [0.57 in] deep	M12 • 1.5, 11.5 mm [0.45 in] deep
UNF-port version (ISO 11926-1)	1 1/16 -12 UN, 19 mm [0.75 in] deep	3/4 -16 UNF 14 mm [0.55 in] deep	7/16 -20 UNF, 11.5 mm [0.45 in] deep

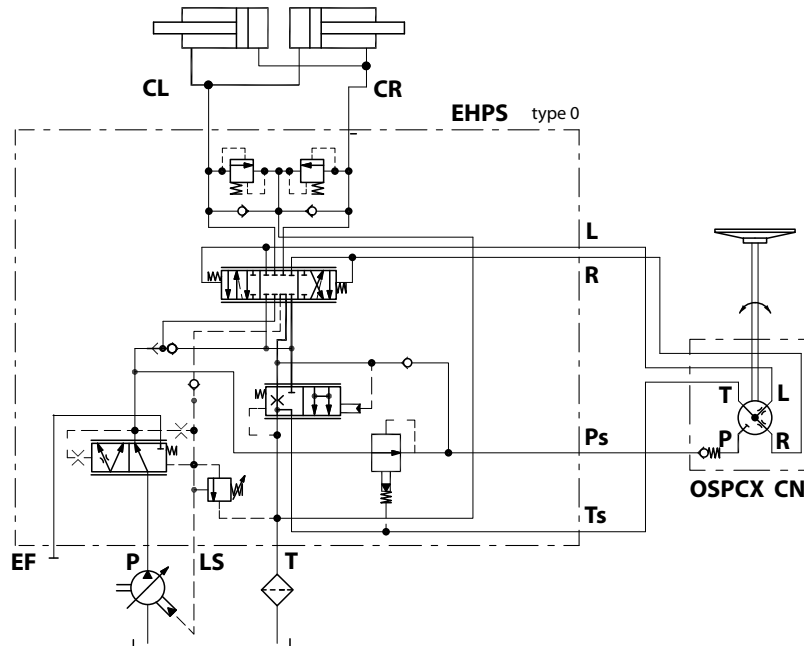
OLS 320

	P, EF	LS
SAE-port version	1 in SAE flange/M10 threads	G 1/4, 12 mm deep
		LS: M12 • 1.5, 11.5 mm deep
		LS: 7/16 - 20 UNF, 11.5 mm deep
Metric-port version (ISO 6149-1)	M33 • 2, x = ø43 mm (in)	M12 • 1.5, 11.5 mm deep
UNF-port version: (ISO 11926-1)	1 5/16 -12 UN, x = ø49mm (in)	7/16 -20 UNF, 11.5 mm deep

	A:
All versions	Bottom side fixing holes: M8 x 1.25, 10 mm deep, see page 29.

Hydraulic systems

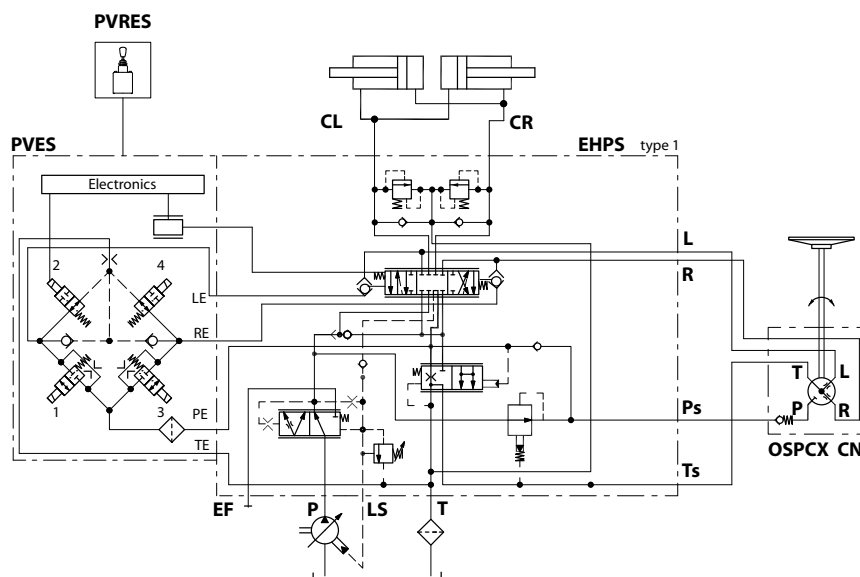
EHPS type 0, stand alone and OSPCX CN steering unit



150H06.11

EHPS type 1, stand alone, OSPCX CN steering unit and PVRES joystick

The vehicle can be steered with either the PVRES joystick or the OSPCX CN steering unit. The signal from the steering unit has priority on simultaneous activation of steering wheel and joystick.

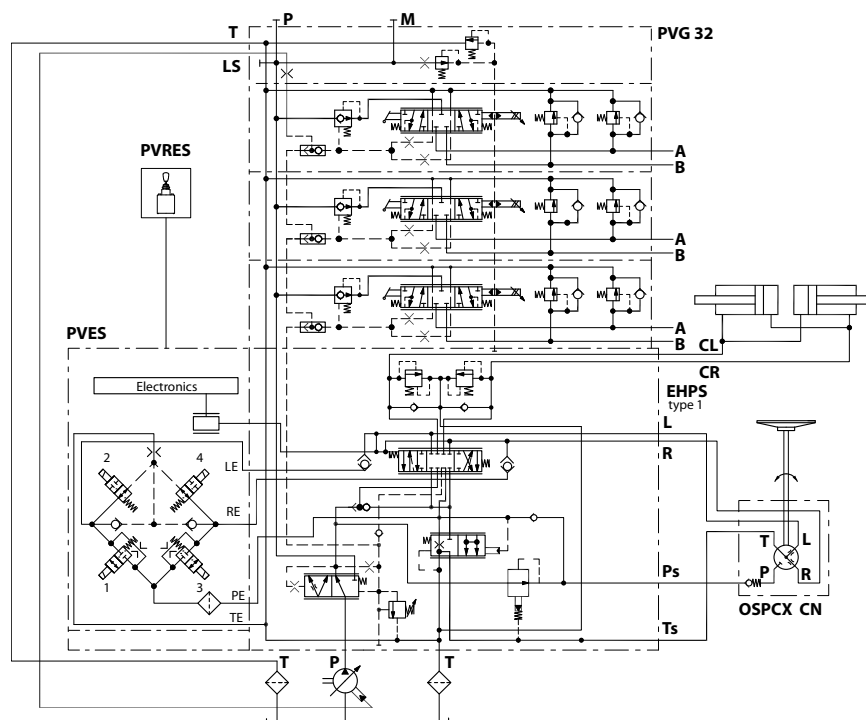


150H05.11

Hydraulic systems

EHPS type 1 with PVG 32, OSPCX CN pilot steering unit and PVRES joystick

The vehicle can be steered with either the PVRES joystick or the OSPCX CN steering unit. The signal from the steering unit has priority on simultaneous activation of steering wheel and joystick.



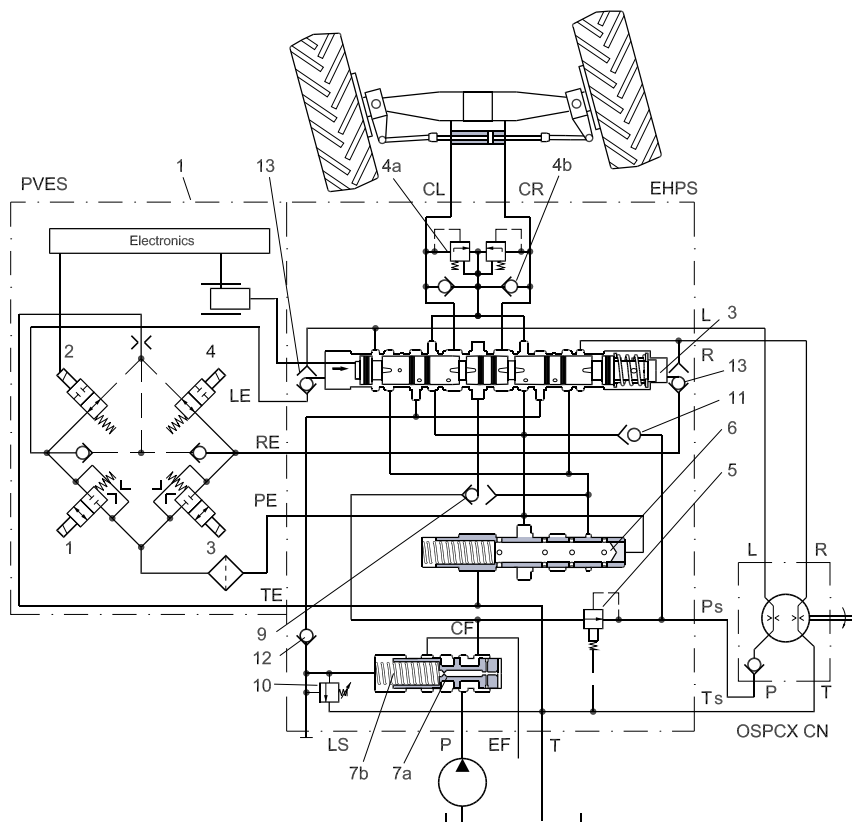
150-575.14

The joystick must be equipped with a neutral position contact to ensure that the PVES is not under tension in neutral position. PVRES joystick has a neutral position contact.

See Technical information for joysticks 520L0554

System safety

Emergency steering



P301 023

1. Electrical actuation module
3. Directional spool
- 4a. Shock valves
- 4b. Suction valves
5. Pilot pressure reduction valve for steering unit
6. Metering valve
- 7a. Priority valve spool
- 7b. Priority valve spring
9. Emergency steering valve
10. Pilot pressure relief valve
11. Check valve for emergency steering
12. Check valve in LS line
13. Shuttle valves

When the pump oil supply fails*, the steering unit can be used as a hand pump depending on the weight of vehicle.

System safety

When steering the steering unit still gets oil from Ps on EHPS. When steering left the oil from the steering unit passes on to the L-port of the EHPS and it will fill the left side chamber of the directional spool (3), and so the spool moves to the right.

As there is no pump supply, there is no pressure in CF consequently there is no pressure on the left side of the emergency steering valve (9). Pilot oil from the steering unit is pushing on the right side of emergency steering valve, and causing it to move towards the left. Now pilot flow is led to the directional spool (3) and into the CL port and the cylinder moves. Return oil from the cylinder enters CR, and will pass over the directional spool (3) and the check valve (11) and it feeds the steering unit.

In this way the cylinder is directly moved by the oil flow from the steering unit, and the ratio is increased in comparison to normal steering situation with active pump supply.

When turning right, the movement of the directional spool (3) will be opposite. All other functions are equal as when steering left.

** Herby is meant when pressure in P-line to EHPS has dropped to less than 12 bar [174 psi]!! When pump pressure is larger than 12 bar [174 psi], emergency steering will not be possible due to metering valve (6) will stay open during steering.*

EHPS type 1 and type 2, prioritizing input signal

In case of active electrical steering (EHPS type 1 and type 2), the steering signal from pilot steering unit has highest priority:

- The oil supply to the steering unit is reduced to 30 bar [435 psi], controlled by pressure reduction valve (5)
- The oil supply to the PVES actuation module is adjusted to 12 bar [174 psi] by the metering valve (6)

If a driver coincidence activates a joystick steering left, and he grabs the steering wheel to steer counter (steer to the right), the signal from the steering wheel has priority as the pilot steering unit can generate 30 bar [435 psi] on the right side of the directional spool and the PVES can only generate 12 bar [174 psi] on the left side of the directional spool.

The joystick must be equipped with a neutral contact to ensure that the PVES is not under tension in neutral position. Without a neutral position contact the joystick will release an electrical signal of $0.5 \cdot U_{DC}$.

If the EHPS is hydraulically activated the main spool is moved, thus changing the LVDT signal. There will be a difference between feedback and input signal and when this reaches more than 15% the PVEA will go into failure mode.

Note concerning type 1 and type 2 systems.

Such systems can be set up without any OSPCX steering unit in case the customer wants pure Steer By Wire (SBW) steering.

In such case it is important to connect L and R of EHPS to tank.

These tank connections are needed to ensure that directional spool of EHPS moves properly into neutral after ending steering input signal to PVE!

Fault monitoring

A fault monitoring system is provided in all PVES and PVED-CL modules. The system is available as passive fault monitoring type, which provides a warning signal only.

- Passive fault monitoring systems are triggered by three main events:

System safety

1. Input signal monitoring

The PVES input signal voltage is continuously monitored. The permissible range is between 15% and 85% of the supply voltage. Outside this range the section will switch into an active error state.

2. Transducer supervision

If one of the wires to the LVDT sensor is broken or short-circuited, the section will switch into an active error state.

3. Supervision of the closed loop

The actual position must always correspond to the demanded position (input signal). If the actual spool position is further than the demanded spool position ($>12\%$), the system detects an error and will switch into an active error state. On the other hand, a situation where the actual position is closer to neutral than that demanded will not cause an error state. This situation is considered "in control".

When an active error state occurs, the fault monitoring logic will be triggered:

Passive fault monitoring

- A delay of 250 ms before anything happens.
- The solenoid valve bridge will not be disabled but still control the main spool position.
- An alarm signal is sent out through the appropriate pin connection, no. 3.
- This state is not memorized. When the erroneous state disappears, the alarm signal will turn to passive again. However, the signal will always be active for a minimum of 100 ms when triggered.

To prevent the electronics from going into an undefined state, a general supervision of the power supply and the internal clock frequency is made. This function applies to PVES and will not activate fault monitoring:

1. High supply voltage:

The solenoid valves are disabled when the supply voltage exceeds 36 V, and the main spool will return/stay in neutral.

2. Low supply voltage:

The solenoid valves are disabled when the supply voltage falls below 8.5 V, and the main spool will return/stay in neutral.

3. Internal clock.

The solenoid valves are disabled when the internal clock frequency fails, and the main spool will return/stay in neutral.

Safety considerations

Warning

The Danfoss range of PVE actuators are single string designs with limited on board fault monitoring. Danfoss strongly recommends application of vehicle specific safety monitoring systems that will detect non-conforming steering and effectively disable electro-hydraulic actuators or issue appropriate warnings as the case may be. A minimum safety system should include a manual power switch to electrical power off electrohydraulic actuators while driving on public roads.

System safety

Safety considerations

On-road operation

Warning

The PVES or PVED-CLS shall be de-energized while driving on-road. It is the OEMs responsibility to establish the necessary means to inform and de-energize the PVE from the cabin when driving on public roads.

The Danfoss range of PVE actuators are single string designs with limited on board fault monitoring. Danfoss strongly recommends application of vehicle specific safety monitoring systems that will detect non-conforming steering and effectively disable electro-hydraulic actuators or issue appropriate warnings as the case may be. A minimum safety system should include a manual power switch to electrical power off electro-hydraulic actuators while driving on public roads.

For details, see:

- Technical information, PVE Series 4
- User Manual PVED-CL controller for Electro-Hydraulics Steering

or contact Danfoss Technical Support Team

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Order specification

Order specification for EHPS and PVE

Specification table for Danfoss EHPS steering valve. Fill in your company data and place x's in the table where appropriate and then send to your Danfoss Power Solutions, sales organization. For further explanation of specification: see page 22

Your company	Name	Vehicle	Potential pcs/year	Completed by	Date											
Actuation module	Type 0 (none)		Type 1 (PVES)		Type 2 ¹⁾ (PVED-CLS)											
			Connector		Connector											
			AMP (A)	DEUTSCH	DEUTSCH											
Directional spool	20/5	40/5	40/10	60/8	60/10	80/8	80/10									
Housing, basic	Stand alone (SA)			For PVG (PVG)		For OLS 320(OLS)										
Housing EHPS, threads	G			Metric (M)		UNF										
Housing OLS 320, threads (if any OLS 320)	SAE			Metric (M)		UNF										
Relief valves setting bar	100	110	120	130	140	150	160	170	180	190	200	210	220	240	250	
Shock valves setting bar	160	175	190	210		230		240	250	265	280	300		320		
Unit painted black	Yes (PB)								No							

¹⁾ Contact Danfoss Sales Organization for software version and vehicle specific parameters to be downloaded in PVED-CLS

	EHPS	Type 1A	80/8	OLS	M	M	240	320	PB
Actuation module									
Directional spool									
Housing, basic									
Housing EHPS, threads									
Housing OLS 320 (if any OLS), threads									
Relief valve setting, EHPS									
Shock valves setting									
Unit painted black									

Please fill in specification for your EHPS:

EHPS								

Only values stated in the table above are available for the EHPS specification.

When choosing housing for PVG, please fill in order specification for the PVG group.

In this PVG group the EHPS will replace the end cover for PVG.

Remember also to specify and order the OSPCX CN steering unit, [Specification table for non catalogue numbers of Danfoss OSPCX CN steering units on page 46.](#)

Steering unit OSPCX CN

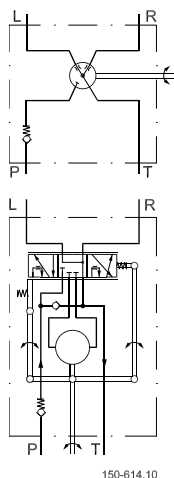
Version

Closed center

Closed center steering units are blocked on their P port in the neutral position.

OSPCX CN: Steering units for steering valve EHPS.

OSPCX CN is a closed center steering unit with the L and the R connections open to the tank when in neutral position. OSPCX CN can only be used with Danfoss steering valve EHPS. OSPCX CN steering unit must not be connected directly to the steering cylinder.



OSPBCX CN Closed center Non-reaction



Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Code numbers and weights

OSPCX closed center non-reaction steering units

OSPCX CN in the table below have all the following valve function incorporated:

- Check valve in P-port

OSPCX CN in the table below have all soft neutral setting springs, see page 42

Steering unit	Code numbers			Weight	
	Connections			kg	[lb]
	European versions		Us Versions		
	G 1/2 S**	M18 • 1.5 - O* + S**	3/4 - 16 UNF O*		
OSPCX 50 CN	-	-	11031535	5.2	[11.5]
OSPCX 70 CN	150G4110	-	-	5.3	[11.7]
OSPCX 80 CN	-	-	150G4112	5.3	[11.7]
OSPCX 100 CN	150G4107	150G4108	150G4109	5.4	[11.9]

** countersinking around port connections (cannot be used in connection with OVR angular block)

* O-ring chamfer on port connections

If you wish other specifications for your OSPCX CN steering unit, please fill in the order form on page 39 and contact the Danfoss sales organization.

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Order specification

Specification table for non catalogue numbers of Danfoss OSPCX CN steering units

Specification table for Danfoss closed center steering units type OSPCX CN which are not available in the code number table.

Fill in with company data and x's in the table and send to your Danfoss Sales Organization

Your company	Name	Vehicle	Potential, pcs/year	Completed	Date
Steering unit type	OSPCX CN				
Displacement cm ³ /rev OSPCX CN	50	60	70	80	100
Port threads	G 1/2 S**		M 18 • 1.5 O* + S**		3/4-16 UNF O*
Neutral setting springs	Soft: 0.15-1.8 N•m [1.33-15.9 lbf•in] in normal steering situation		Standard: 0.8-3 N•m [7.10-26.55 lbf•in] in normal steering situation		Strong: 1.5-4 N•m [13.27-35.40 lbf•in] in normal steering situation
Unit painted black	Yes			No	

** Spot face around port connections (can not be used in connection with OVR angular block)

* O-ring chamfer on port connections

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Technical data

Common data

Look in sub catalogue: "General, steering components"

Manual steering pressure

Look in sub catalogue: "General, steering components "

Displacement, flow and pressure

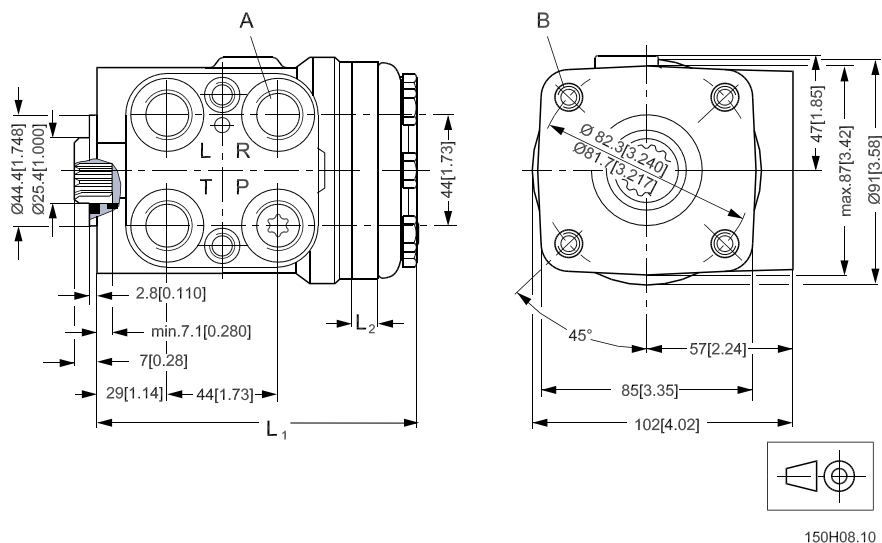
OSPCX

Steering unit	Displacement		Ratet oil flow		Max. pressure on connections					
	cm ³ /rev	[in ³ /rev]	l/min	[US gal/min]	P		T		L, R	
					bar	[psi]	bar	[psi]	bar	[psi]
OSPCX 50 CN	50	[3.05]	5	[1.32]	125	[1813]	25	[363]	100	[1450]
OSPCX 60 CN	60	[3.70]	6	[1.58]						
OSPCX 70 CN	70	[4.30]	7	[1.85]						
OSPCX 80 CN	80	[4.90]	8	[2.11]						
OSPCX 100 CN	100	[6.10]	10	[2.64]						

Technical Information EHPS Steering Valve PVE Actuation Module OSPCX CN Steering Unit

Dimensions

Dimensions OSPCX CN



	A:	B:
European version:	G 1/2 with spot face or M18 • 1.5 ISO 6149 15 mm [0.59 in] deep	M10 • 1.5, 16 mm [0.63 in] deep
US version:	3/4 - 16 UNF O-ring boss; 15 mm [0.59 in] deep	3/8 - 16 UNC, 16 mm [0.63 in] deep

Steering unit	L ₁		L ₂	
	mm	[in]	mm	[in]
OSPCX 50 CN	126	[4.96]	6.5	[0.26]
OSPCX 60 CN	128	[5.04]	9.1	[0.36]
OSPCX 70 CN	128	[5.04]	9.1	[0.36]
OSPCX 80 CN	129	[5.08]	10.4	[0.41]
OSPCX 100 CN	132	[5.20]	13.0	[0.51]



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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
Phone: +86 21 3418 5200

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