Supersedes VBI Release 20 from 9.14.
Changes are marked with a bar (|) in the margin.

Hydraulic system and Power take-off
Hydraulic system and Power take-off
FM (4), FH (4)

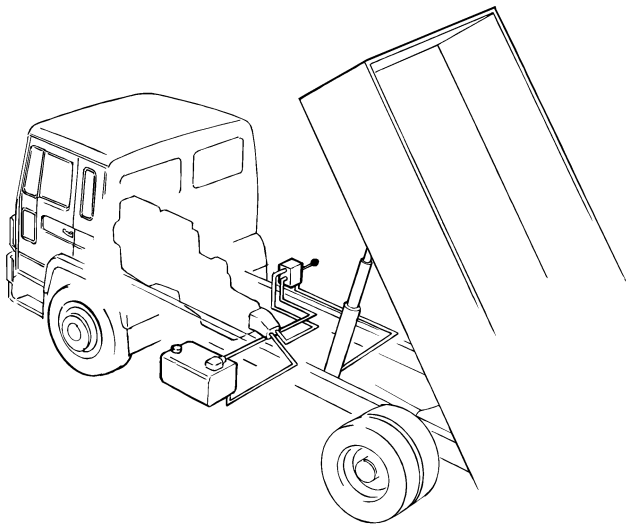
Contents

General

Auxiliary equipment require power take-offs, either when the truck is stationary or when it is in motion. Various power take-off alternatives can be chosen, depending on the bodywork.

The work is generally carried out by equipment which is powered by a hydraulic motor. The hydraulic motor, together with a pump and associated equipment, form the basis of the hydraulic system. The pump, which provides the hydraulic pressure and flow to the motor, is the heart of the hydraulic system.

All power take-offs covered by this chapter are available factory installed. Some variants can also be ordered from Volvo Parts AB.



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For further information about:

- Power take-offs and Hydraulic pumps, please refer to **"Product and variant information"** and the booklet **"Power Take-Offs and Hydraulic Pumps"**.
- Essential dimensions with the power take-off fitted to the vehicle, please refer to **"Supplementary Drawings"**
- Wiring diagram for connecting a power take-off to Powertronic gearboxes, please refer to Body builder instruction **"Vehicle electronics"**.
- Power take-off working conditions and parameter settings, please refer to Body builder instruction **"Vehicle electronics"**.

It is important to dimension an optimum hydraulic system, and to specify the correct pump size to provide sufficient oil flow and prevent overloading of the power take-off. For recommended instructions, please refer to: "Dimensioning of hydraulic system and hydraulic pumps", page 32 .

Note: The body builder should enclose an information binder, delivered with the truck, including **hydraulic system data** (system dimensioning description and dimensioning criteria).
Service, function and safety descriptions should also be enclosed.

Power take-off

There is a number of different power take-off variants available, with single or double outlets. The power take-off is supplied with either a flange connection and/or a direct connection to the hydraulic pump (opening with a splined DIN connection).

Power take-offs are classified into two family variants: **Clutch dependent** and **Clutch independent**

Abbreviations

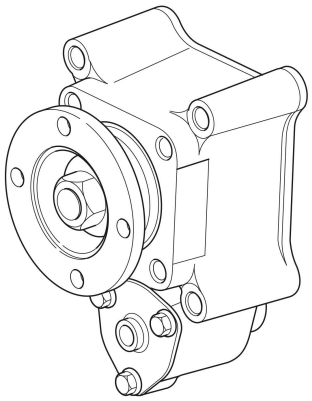
PTR	=	Single power take-off gearbox, rear mounted (**P**ower take-off **T**ransmission **R**ear). All are rear-facing.
PTRD	=	Double power take-off gearbox, rear mounted (**P**ower take-off, **T**ransmission, **R**ear mounted, **D**ouble).
PTPT	=	PowerTronic power take-off (**P**ower**T**ronic **P**ower **T**ake-off). Torque converter mounted. Available with rear-facing flange or opening for hydraulic pump, both located at 11 o'clock as seen from rear of gearbox — Not available for FH.
PTER	=	Engine mounted power take-off located at the rear end of the engine (**P**ower **T**ake-off **E**ngine **R**ear.)
EPTT	=	Maximum permitted torque on engine power take off (**E**ngine **P**ower **T**ake off **T**orque)
TPTT730	=	Gearbox power take-off torque capacity 730 Nm

Clutch dependent power take-off

Clutch dependent power take-offs are designed to work when the truck is parked. Common applications are tipping trucks, mobile cranes, tank trucks etc. They are mounted on the gearbox and stop working when the clutch pedal is depressed.

Note: The clutch pedal must be depressed to engage or disengage the power take-off.

- PTR-XX
- PTRD-XX
- PTR-X



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PTR-F

Clutch independent power take-off

A clutch independent power take-off is mainly used when work is to be done when driving. Refrigerators, hook lifts, concrete mixer, snow ploughs/sand spreaders, etc.

Gearbox PTO

These power take-offs are mounted on the front upper part of the gearbox and are driven by the engine via the gearboxes' torque converter housing..

- **PTPT-D** Automatic gearbox driven PTO, 1 front/upper DIN connection for plug-in pump
- **PTPT-F** Automatic gearbox driven PTO, 1 front/upper rear facing SAE flange connection for prop shaft

Engine PTO

An engine mounted power take-off is mounted on the rear of the timing cover.

D11, D13, D16

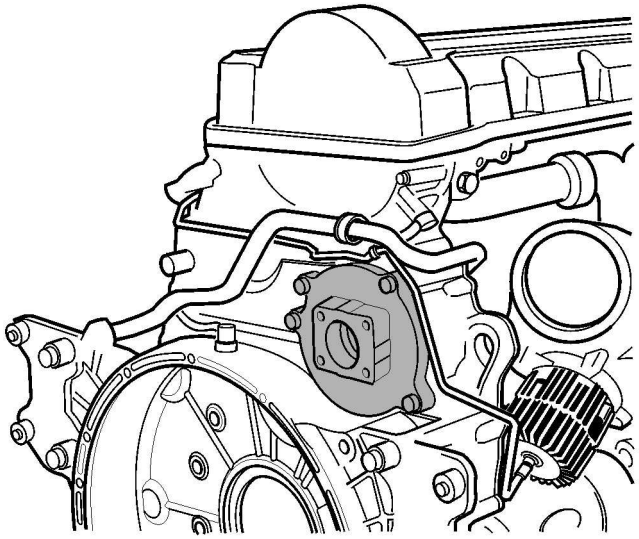
On the D11, D13 and D16 engines the power take-off is ordered separately, either as:

- **PTER-DIN** (DIN5462/ISO7653 connection)
- **PTER–100** (flange DIN 7646) (not D13)
- **PTER1400** (flange SAE1400)

The hydraulic pump (variants HPEXXX) is ordered separately on these engines together with PTO variant PTER-DIN:

- **PTER-DIN + HPEXXX**

(Engine power take off together with engine mounted hydraulic pump)



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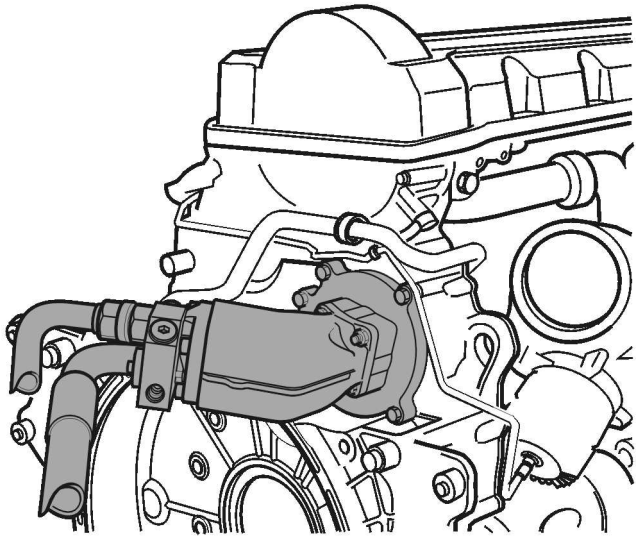
PTER-DIN



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PTER-DIN + HPEXXX

Power take-off, performance

Gearbox mounted power take-off

B	Backwards	R	Clockwise when facing rear of engine
YB	Outer shaft, backwards	R	
YF	Outer shaft, forwards	F	Anticlockwise when facing rear of engine
IB	Inner shaft, backwards		Anticlockwise when facing front of engine

Torque variants

The following variants are used to specify the PTO torque level:
TPTT730 — Torque capacity 730 Nm
TPTT870 — Torque capacity 870 Nm

Single PTOs

Power take-off	Connection		Direction of rotation	Power take-off, direction	Max torque (Nm)	Max power (kW)
	Type	Dimension				
PTR - FL	Flange	SAE1300	R	B	600	100[1]
PTR - FH						
PTR-D	Direct	DIN5462 / ISO 7653	R		1000	150[1]
PTR - F	Flange	SAE1400	R		1000	150[1]
PTR - DM	Direct	DIN 5462 / ISO 7653	R		600	100[1]
PTR - DH						

1 A gearbox oil cooler is required if power taken exceeds 75 kW for more than 15 minutes.

Double PTOs

Power take-off	Connection		Direction of rotation	Power take-off, direction	Outer shaft Max torque (Nm)	Max power (kW)
	Type	Dimension				
PTRD - F	Flange	SAE1400	R	YB	870	140[1 2]
PTRD - D (*)	Direct[3]	DIN 5462 / ISO 7653	F	YF	870	140[1 2]
	Direct[3]		R	YB		
PTRD - D1 (*)	Direct[3]	DIN 5462 / ISO 7653	F	YF	870	140[1 2]
	Flange	SAE1400	R	YB		
PTRD - D2 (*)	Direct[3]	DIN7653	F	YF	870[4]	140[1 2]
	Flange	SAE1300	R	YB		
		SAE1400	R	IB		

1 A gearbox oil cooler is required if power taken exceeds 75 kW for more than 15 minutes.

2 The total power inner and outer shaft must not exceed 120 kW for torque level 730 Nm or 140 kW for torque level 870 Nm

3 Max suitable pump. Forward facing outlet: VT/VTO 2009B, 2214B, 2514B, 2814B, 2412B without retarder max pump F1-61; VT/VTO 2009B, 2214B, 2514B, 2814B, 2412B with retarder max pump F1-101. AT2412D, AT2612D, ATO2612D, AT2812D, ATO3112D ATO3512D, AT2412E, AT2612E, AT2812E, ATO2612E, SPO2812, ATO3112E, ATO3512E max pump F1-101.

4 See Maximum PTO torque table below.

(*) For information regarding earlier double PTOs (before week 37, 2011), please refer to "Historical VBI".

Power take-off	Connection		Direction of rotation	Power take-off, direction	Outer shaft Max torque (Nm)	Max power (kW)
	Type	Dimension				
PTRD - F	Flange	SAE1400	R	YB	730	120[1] [2]
PTRD - D (*)	Direct[3]	DIN 5462 / ISO 7653	F	YF	730	120[12]
	Direct[3]		R	YB		
PTRD - D1 (*)	Direct[3]	DIN 5462 / ISO 7653	F	YF	730	120[12]
	Flange	SAE1400	R	YB		
PTRD - D2 (*)	Direct[3]	DIN7653	F	YF	730[4]	120[12]
	Flange	SAE1300	R	YB1		
		SAE1400	R	IB		

1 A gearbox oil cooler is required if power taken exceeds 75 kW for more than 15 minutes.

2 The total power inner and outer shaft must not exceed 120 kW for torque level 730 Nm or 140 kW for torque level 870 Nm

3 Max suitable pump. Forward facing outlet: VT/VTO 2009B, 2214B, 2514B, 2814B, 2412B without retarder max pump F1-61; VT/VTO 2009B, 2214B, 2514B, 2814B, 2412B with retarder max pump F1-101. AT2412D, AT2612D, AT2812E, ATO2612D, AT2812D, ATO3112D ATO3512D, AT2412E, AT2612E, ATO2612E, ATO3112E, ATO3512E, SPO2812, max pump F1-101.

4 See table below

For information regarding earlier double PTOs (before week 37, 2011), please refer to "Historical VBI".

Maximum PTO torque PTRD-D2			
Maximum torque 730 Nm FM (4), FH (4)		**Maximum torque 870 Nm FH (4) only**	
Inner shaft (Nm)	Outer shaft (Nm)	Inner shaft (Nm)	Outer shaft (Nm)
0	730	0	870
65	700	135	800
275	600	325	700
500	500	510	600
700	400	700	500
900	300	890	400
1000	200	1000	300
1000	0	1000	200
		1000	0

Speed ratios for gearbox mounted power take-offs

Speed ratio 1:X. (1 = engine speed; X = power take off speed)

H = High gear

L = Low gear

Single PTOs

Power take-off	Maximum torque (Nm)	Power take-off weight (kg)	VT2009B	VT2214B VT2514B VT2814B		VTO2214B VTO2514B		VTO2814B	
				L	H	L	H	L	H
PTR-FL		16.0	1:0.73	1:0.91		1:1.14	1:0.92	1:1.16	
PTR-FH		15.0	1:1.23	1:1.54		1:1.91	1:1.56	1:1.96	
PTR-D		6.5	1:0.70	1:0.88		1:1.10	1:0.89	1:1.12	
PTR-F		6.5	1:0.70	1:0.88		1:1.10	1:0.89	1:1.12	
PTR-DM		13.0	1:1.06	1:1.32		1:1.65	1:1.34	1:1.68	
PTR-DH		13.0	1:1.23	1:1.54		1:1.91	1:1.56	1:1.96	

Power take-off	Maximum torque (Nm)	Power take-off weight (kg)	AT2412D, AT2412E AT2612D, AT2612E AT2812D, AT2812E		ATO2612D, ATO2612E ATO3112D, ATO3112E ATO3512D, ATO3512E SPO2812	
			L	H	L	H
PTR-FL		16.0	1:0.73	1:0.93	1:0.93	1:1.18
PTR-FH		15.0	1:1.23	1:1.57	1:1.57	1:2.00
PTR-D		6.5	1:0.70	1:0.90	1:0.90	1:1.15
PTR-F		6.5	1:0.70	1:0.90	1:0.90	1:1.15
PTR-DM		13.0	1:1.06	1:1.35	1:1.35	1:1.72
PTR-DH		13.0	1:1.23	1:1.57	1:1.57	1:2.00

Double PTOs

Power take-off	Maximum torque (Nm) (TPTT870)	Power take-off weight (kg)	VT2009B	VT2214B VT2514B VT2814B		VTO2214B VTO2514B		VTO2814B	
				L	H	L	H	L	H
PTRD-F	870	23	1:1.04	1:1.04	1:1.30	1:1.30	1:1.62	1:1.32	1:1.65
PTRD-D (*)	870		1:1.04	1:1.04	1:1.30	1:1.30	1:1.62	1:1.32	1:1.65
PTRD-D1 (*)	870	28,5	1:1.04	1:1.04	1:1.30	1:1.30	1:1.62	1:1.32	1:1.65
PTRD-D2 Outer (*)	870		1:1.04	1:1.04	1:1.30	1:1.30	1:1.62	1:1.32	1:1.65
PTRD-D2 Inner, flange (*)	870	34,5	1:0.57	1:0.57	1:0.72	1:0.72	1:0.89	1:0.73	1:0.91

Power take-off	Maximum torque (Nm) (TPTT870)	Power take-off weight (kg)	AT2412D, AT2412E AT2612D, AT2612E AT2812D, AT2812E		ATO2612D, ATO2612E ATO3112D, ATO3112E ATO3512D, ATO3512E SPO2812	
			L	H	L	H
PTRD-F	870	23	1:1.04	1:1.32	1:1.32	1:1.69
PTRD-D (*)	870		1:1.04	1:1.32	1:1.32	1:1.69
PTRD-D1 (*)	870	28,5	1:1.04	1:1.32	1:1.32	1:1.69
PTRD-D2 Outer (*)	870		1:1.04	1:1.32	1:1.32	1:1.69
PTRD-D2 Inner, flange (*)	870	34,5	1:0.57	1:0.73	1:0.73	1:0.93

(*) For information regarding earlier double PTOs (before week 37, 2011), please refer to "Historical VBI".

Power take-off	Maximum torque (Nm) (TPTT730)	Power take-off weight (kg)	VT2009B	VT2214B VT2514B VT2814B		VTO2214B VTO2514B		VTO2814B	
				L	H	L	H	L	H
PTRD-F	730	23	1:1.29	1:1.29	1:1.61	1:1.61	1:2.01	1:1.64	1:2.05
PTRD-D (*)	730		1:1.29	1:1.29	1:1.61	1:1.61	1:2.01	1:1.64	1:2.05
PTRD-D1 (*)	730	28.5	1:1.29	1:1.29	1:1.61	1:1.61	1:2.01	1:1.64	1:2.05
PTRD-D2 Outer (*)	730		1:1.29	1:1.29	1:1.61	1:1.61	1:2.01	1:1.64	1:2.05
PTRD-D2 Inner, flange (*)	730	34.5	1:0.60	1:0.60	1:0.74	1:0.74	1:0.93	1:0.76	1:0.95

Power take-off	Maximum torque (Nm) (TPTT730)	Power take-off weight (kg)	AT2412D, AT2412E AT2612D, AT2612E AT2812D, AT2812E		ATO2612D, ATO3112D, ATO3112E, ATO3512D, ATO3512E, SPO2812	
			L	H	L	H
PTRD-F	730	23	1:1.29	1:1.65	1:1.65	1:2.10
PTRD-D (*)	730		1:1.29	1:1.65	1:1.65	1:2.10
PTRD-D1 (*)	730	28.5	1:1.29	1:1.65	1:1.65	1:2.10
PTRD-D2 Outer (*)	730		1:1.29	1:1.65	1:1.65	1:2.10
PTRD-D2 Inner, flange (*)	730	34.5	1:0.60	1:0.76	1:0.76	1:0.97

PT2106, PT2606 (Powertronic)

Speed ratio: 1:1

Power take-off	Connection		Direction of rotation[1]	Max torque (Nm)				Max power (kW)	
	Type	Dimension		600–1000 r/min		>1000 r/min	*Air crash tender only*		>2 minutes
							>1500 r/min <2 minutes	<2 minutes	
PTPT-F	Flange	SAE1400	 1	600 r/min 700 r/min 800 r/min 900 r/min 1000 r/min	650 700 750 800 850	850	1050	200	130
PTPT-D	Pump connection	DIN5462 /ISO7653							

1 Counter clockwise when facing back of engine

Engine mounted power take-off

Speed ratio: 1:X.x (1: = engine, X.x = power take-off)

Engine	Speed ratio	Direction of rotation[1]	Max permissible torque (Nm)[2]	Power take-off
D11	1:1.08	↶ 1	650	PTER-xxx
D13	1:1.26		650	PTER-XXX + EPTT650
			1000	PTER-XXX + EPTT1000
D16C	1:1.26		650	PTER-XXX + EPTT650
			1000	PTER-XXX + EPTT1000

1 Counter clockwise when facing back of engine

2 The engagement of the hydraulic pump must not give any pressure peaks exceeding the rated pressure.

Note: Low stiffness of the prop shaft and big inertia on the pump will give low resonance frequency, which can be excited by the vibration frequencies of the engine.
The engagement time has to be so long that no pressure peaks will occur, and the best way to verify this is to measure the pressure close to the pump.

Use the following formula to calculate the power output of an engine mounted PTO:

$$P = \frac{M \times X.x \times n_{eng} \times 3,14}{30000}$$

P = Power (kW)

M = PTO torque (Nm)

X.x = PTO speed ratio (see “Speed ratio” above)

$\mathbf{n_{eng}}$ = Engine speed of rotation (r/min)

Note: If the resulting power is greater than the diesel engine's power rating (at actual engine speed) the engine will not be able to drive the PTO equipment.

Resonance frequency

The minimum torsional resonance frequency is 300 Hz for the system propeller shaft to PTO pump. Failure to this demand can cause **severe damages** to the engine.

*Resonance frequency (**f**) for a propeller shaft driven PTO is calculated as:*

$$f = \frac{1}{2 \times \pi} \times \sqrt{\frac{k}{J}}$$

f = resonance frequency (Hz)

k = stiffness of prop shaft and coupling(s) (Nm/rad)

J = hydraulic pump and coupling mass moment of inertia (kgm2)

Example:

k = 2,8 x 10^5 Nm/rad

J = 0,05 kgm^2

$$f = \frac{1}{2 \times \pi} \times \sqrt{\frac{2.8 \times 10^5}{0.05}} = 377\,Hz$$

Engine PTO in combination with automized manual gearboxes

I-Shift — AT2412D, AT2612D, AT2812E, ATO2612D, AT2812D, ATO3112D, ATO3112E, ATO3512D, ATO3512E, AT2412E, AT2612E, ATO2612E, SPO2812,

When using the I-Shift gearbox, the engine power take-off can be engaged during driving (depending on parameter setting) but exceeding the maximum torque (shown in the table below) can cause problems during gear shifting. For this reason it is recommended that equipment shall be designed so that the torque limits in the table below are not exceeded during driving.

Engine	**Maximum torque (Nm)** while driving
D11	200
D13	300
D16	300

Gearbox mounted PTO in combination with retarder and D11 engine

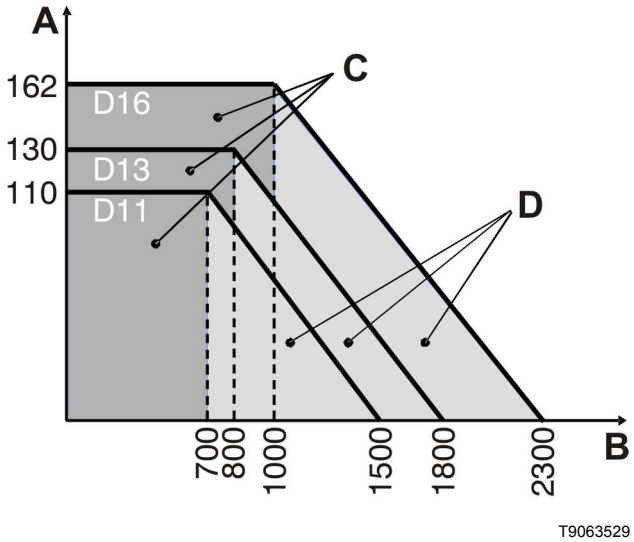
Combination D11 manual gearbox (VT2514B, VTO2514B, VT2009B, VT2214B, VTO2214B) and PTO (PTR, PTRD) is not allowed. This is due to the excessive transmission weight.

Splitbox PTO in combination with I-Shift

Note: The SPO2812 gearbox is not for use with Splitbox PTO.

Engine warmhold is recommended before using Splitbox PTO.
Usage of engine mounted PTO or gearbox mounted PTO in combination with Splitbox PTO will reduce the maximum permitted inertia and the maximum permitted startup torque.

It is important that the Splitbox PTO related information, in the VBI chapter “Vehicle electronics”, is taken into concideration.



A = Maximum inertia reduced to transmission output shaft (kgm^2.)
B = Maximum startup torque on transmission output shaft (Nm)

		Transmission	
		AT2412D, AT2412E AT2612D, AT2612E AT2812D, AT2812E ATO2612D, ATO2612E ATO3112D, ATO3512D ATO3112E, ATO3512E	
Parameter setting	P1ISL	No	Yes
Maximum inertia reduced to gearbox output shaft.		See diagram	
Maximum startup torque on gearbox output shaft.		See diagram	

Parameters for all AMT-E gearboxes

Description	Parameter	Comment
Choice of start gear, 7–12	P1ISL	Gear changing is done using the plus (+) button with the gear lever in position M. Gears 7–10 can be used for 60 seconds.
Make gear 12 (overdrive) available in ATO gearbox	P1ISM	
Limit of moment for gear 12 (overdrive) in ATO gearbox	P1KCL	Default setting: 1000 Nm

Note: Without adequate inertia in the driven equipment, it will not be possible to change to a higher gear. The split-box will stop during gear change.

Maximum permitted torque for ATO gearbox in gear 12

Split box (hours/year)	Maximum torque
<1000	100 %
1000 - 3000	70 %
>3000	50 %

Cooler requirements — All gearboxes

Split box engagement	Requirement
Split box engaged only on direct gear: Split box PTO usage >60 minutes	TC-MWO required
Split box engaged on indirect gear	TC-MAOH2 required

Hydraulic pumps

Abbreviations

HPE = Hydraulic pump mounted to an engine power take off (**H**ydraulic **P**ump **E**ngine mounted).

HPG = Hydraulic pump mounted to a gearbox power take off (**H**ydraulic **P**ump **G**earbox mounted).

Pump connections

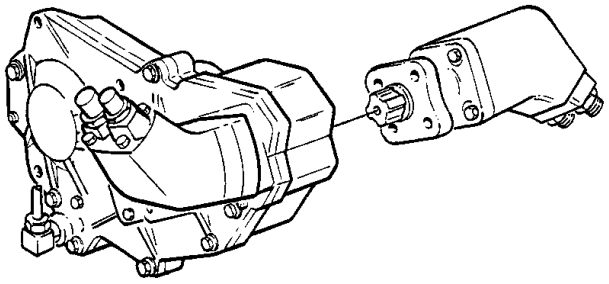
There are two types of connections for hydraulic pumps:

- Plugged-in pumps
- Flange mounted

Plugged-in pumps

Plugged-in pumps are connected directly to the power take-off via a splined shaft. Connection is done according to DIN5462/ISO 7653 standard.

The VP1- and F1 Plus pumps are available for plugged-in mounting.



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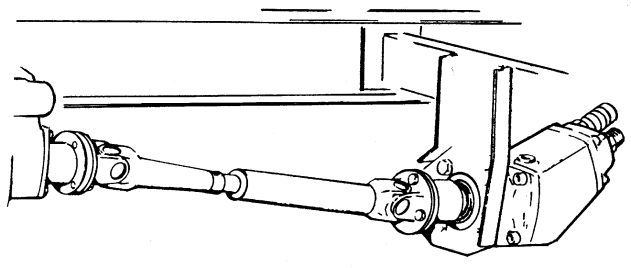
"Plugged-in"

Flange mounted pumps

The hydraulic pumps can also be connected to the power take-off via a propeller shaft. Connection is done to a flange according to SAE 1300 or SAE 1400 standard.

The VP1- and F1 Plus pumps are possible to connect to a propeller shaft.



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Flange mounted

Pump types

The following pump types are available from Volvo:

- Pumps with fixed displacement
- Pumps with variable displacement

Fixed displacement pump

This type of hydraulic pump is adapted for a single circuit system with fixed volume.

The fixed displacement pump consists internally of one or two single circuit(s), from the suction port to the pressure port(s).

Examples:

- HPE / HPG-F41 (Parker F1-41)
- HPE / HPG-F51 (Parker F1-51)
- HPE / HPG-F61 (Parker F1-61)
- HPE / HPG-F81 (Parker F1-81)
- HPE / HPG-F101 (Parker F1-101)
- HPE-T53 (Parker F2-53/53)
- HPE-T70 (Parker F2-70/35)
- HPE-T42 (Parker F2-42/42)
- HPE-T55 (Parker F2-55/28)
- HPG-T77 (Parker F2-70/70)

Fixed displacement pump with integrated clutch

These pumps are used with power take-offs that are always engaged (PTER-DIN).
The clutch makes it possible to disengage the pump from the power take-off. This saves energy as the pump can be disengaged when not in use or if a fault occurs in the hydraulic system.

The pump is activated by a switch on the dashboard.
A bypass valve ensures that the clutch is exposed to limited torque during engagement. With this solution the clutch can be very compact.
The bypass valve and suction nipple are fitted such that they do not interfere with other gearbox ancillaries.

- HPE81CF (Parker F3-81)
- HPE101CF (Parker F3-101)

Variable displacement pump

This type of hydraulic pump is adapted for a single circuit system.
The variable displacement pump consists internally of a single circuit from the suction port to the pressure port, but with variable displacement. When installed in a load sensing system, the variable displacement pump (VP1) supplies the correct amount of flow required by the various work functions currently engaged. This means that the energy consumption and heat generated are minimized and much reduced in comparison with a fixed displacement pump used in the same system.

Examples:

- HPE-V45 (Parker VP1-45)
- HPE-V75 (Parker VP1-75)
- HPE / HPG-V95 (Parker VP1-95)
- HPE / HPG-V130 (Parker VP1-130)

CAUTION

Hoses and pipes should not be routed too near the warm points in the truck. Avoid crossed pipes which could cause chafing. (Risk for fire if a leakage should occur and the transfer of heat to the hydraulic oil).

4x4, 6x6 All wheel drive

All gearbox mounted PTOs are possible to use for all wheel drive vehicles, except for PTR-FL, PTR-FH, PTRD-F, PTRD-D1 and PTRD-D2. (There is no space for propeller shaft from PTO due to transfer box.)

The two power take-offs for the Powertronic gearbox (PT2106 and PT2606) are available as variants.

Engine mounted hydraulic pump with PT2106/PT2606 (not available for FM) is not available from factory (lack of space).

Choice of power take-off / hydraulic pump

Some combinations of engine/gearbox/power take-off and engine/gearbox/power take-off with rear-mounted pumps can not be used on FAA20 and FAA21chassis. This is because of the risk of damage to gearbox, power take-off, pump and hydraulic connections due to the second steering axle. Recommended combinations are found in the table below.

Note: Power take-off PTRD-D has a forward-facing opening for a pump which can be installed in line with the gearbox.

This opening is not affected by the second steering axle, but check that a power take-off is permissible.

Combinations possible to build with FAS1995

FAS = Front axle spread

BI = Backward installation

FI = Forward installation

N.A. = Not applicable – (conflict with first spring bracket second front axle)

PTR-D, PTR-DM, PTR-DH, PTRD-F

Engine	Gearbox	PTR-D	PTR-DM/PTR-DH	PTRD-F	
		BI	BI	BI	FI
D11	TRA-SMT	HPG-F101	HPG-F101[1]	Flange	N.A.
	TRA-AMT	HPG-F101	HPG-V130	Flange	N.A.
D13	TRA-SMT	HPG-F101	HPG-F101[1]	Flange	N.A.
	VT2009B	HPG-F101	HPG-V130	Flange	N.A.
	TRA-AMT	HPG-F101	HPG-V130	Flange	N.A.
D16	TRA-SMT	HPG-F101	HPG-F101	Flange	N.A.
	TRA-AMT	HPG-F101	HPG-F101	Flange	N.A.

1 HPG-V130 does fit but is not available from factory as standard variant, the same goes for the variable pumps VP1–45, VP1–75 and VP1–95. Note! Be aware of the direction of rotation.

PTRD-D, PTRD-D1, PTRD-D2

Note: Variants PTRD-D1/-D2 together with double front axle are not available as standard from factory.

Engine	Gearbox	PTRD-D		PTRD-D1PTRD-D2	
		BI	FI	BI	FI
D11	TRA-AMT	HPG-F101[1]	N.A.	Flange	N.A.
	TRA-SMT	HPG-F101[1]	N.A.	Flange	N.A.
D13	TRA-AMT	HPG-F101[1]	N.A.	Flange	N.A.
	TRA-SMT	HPG-F101[1]	N.A.	Flange	N.A.
D16	TRA-AMT	HPG-F101	N.A.	Flange	N.A.
	TRA-SMT	HPG-F101	HPG-F101[2]	Flange	HPG-F101[2]

1 HPG-V130 does fit but is not available from factory as standard variant, the same goes for the variable pumps VP1–45, VP1–75 and VP1–95. Note! Be aware of the direction of rotation.

2 Maximum size of the hydraulic pump is: HPG-F61 gearbox without retarder, HPG–F101 gearboxes with retarder

Distance to second front axle

The table below shows the distance between the front edge of the second front axle and the mounting surface for the power take-off on the gearbox.

The length L of each power take-off must be deducted from the distances in the table to give the distance between the power take-off and the second front axle.

FAS1995 (Front axle spread 1995 mm)

Note: For VT gearboxes with retarder the distances shown here shall be reduced by 36 mm.

Engine	Gearbox			
	VT2009B	**VT2214B VTO2214B VT2514B VTO2514B VT2814B VTO2814B**	**AT2412D, AT2412E, AT2612D, AT2612E ATO2612D, ATO2612E AT2812E, ATO3112E ATO3512E**	**AT2812D ATO3112D**
D11	613 mm	538 mm	711 mm	—
D13	588 mm	513 mm	686 mm	—
D16	—	408 mm	581 mm	563 mm

The length of each power take-off is:

(*) For information regarding earlier double PTOs (before week 37, 2011), please refer to "Historical VBI".

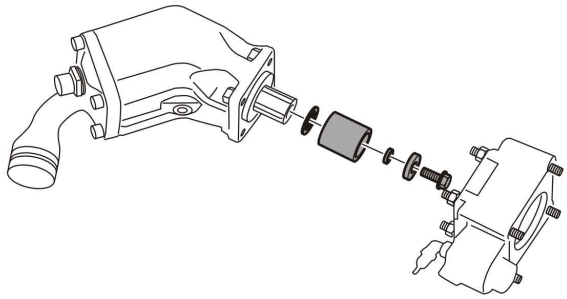
Power take-off	Length (mm)
PTR-D	98
PTR-DM	120
PTR-DH	120
PTRD-D (*)	125
PTRD-F	160
PTRD-D1 (*)	230
PTRD-D2 (*)	230

Accessibility of PTPT

If a top mounted power take-off is installed on the gearbox and there is a fixed body building, we recommend that a service hatch should be made in the body floor.

Delivery conditions for factory installed PTO

For trucks which are not equipped with a factory mounted hydraulic pump, a kit is available for mounting a pump onto power take-off variant PTR-D. The kit contains a sleeve, washers, a snap ring and a screw and can be found in the cab's left hand side storage box. Mount the pump and kit according to the adjacent illustration (tightening torque 85Nm).



T9008978

Delivery conditions for factory installed hydraulic pumps

CAUTION

Hydraulic pumps must never be in use without oil flow in the hydraulic system.

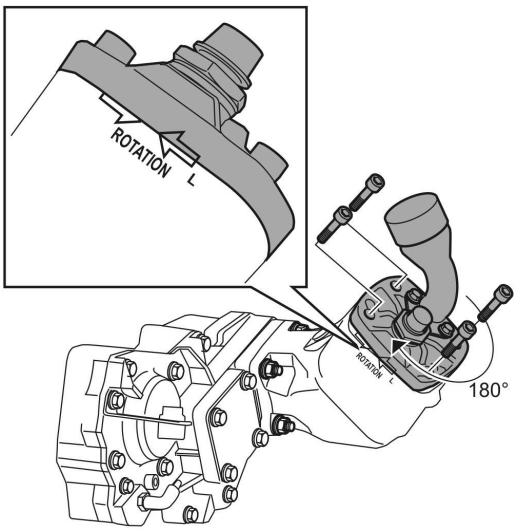
For trucks with gearbox mounted PTO:

To prevent the possibility to engage the hydraulic pump before definitive assembly, the following is done from factory:

- The PTO solenoid valve air outlet is blocked by a plastic plug (part number 992316). Please see the VBI chapter “Pipes, hoses and fittings” for disconnecting the plug.

One or two valves are plugged, depending on type of PTO.

For pumps mounted on PTR-D and rear mounted in outerport on PTRD-D, the direction of rotation must be changed to left hand rotation.



T9008795

For trucks with engine mounted PTO:

The following applies to all pumps except HPE81CF/ HPE101CF which are disconnected with the built-in clutch.

The hydraulic pump is always engaged; therefore sufficient lubrication is needed continuously for the pump.

- To establish lubrication during transport from factory to final assembly at body builder, **a temporary hydraulic transport kit** is added at the factory.
- The components in the kit (tank, hoses and unions) should be replaced; **they are not dimensioned for the working pressure** in the definitive hydraulic system.

  Note: The replacement must be performed in particularly clean conditions. Dirt and other contamination which finds its way into the hydraulic system could easily cause severe damage.

Please refer to “Supplementary Drawings” to see where the unions for connection to the permanent equipment are located.

Available harnesses:

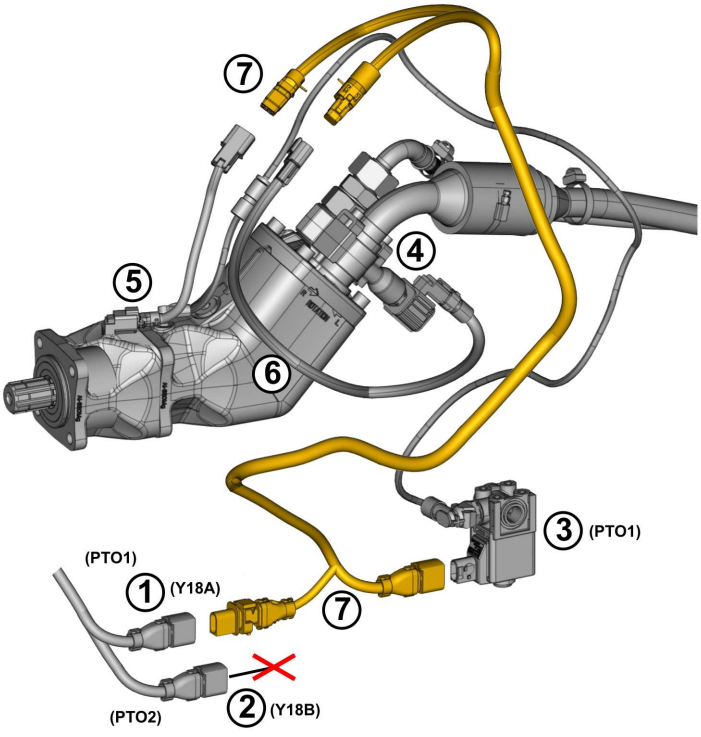
Part number	Variants	Variables
22203521	PDC-IF/-OFF/-OFM	L1=2500
22203522	PDC-OFR	L1=3800

The following applies to HPE81CF/HPE101CF/HPE-Fxxx/HPE-TXX pumps

To prevent the risk of engaging the hydraulic pump before definitive assembly, the following is done from factory:

- The cable, connecting the pump to the solenoid valve bridge, is delivered inside the cab.
- The PTO solenoid valve air outlet is blocked by a plastic plug (part number 992316). Please see the VBI chapter “Pipes, hoses and fittings” for disconnecting the plug.

See next page for wiring diagrams.

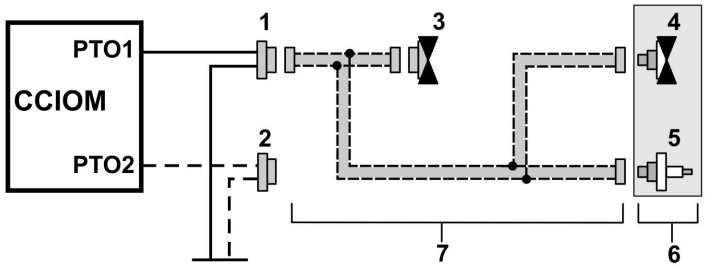


T9093618

The numbers in this illustration refer to the wiring diagrams on the next page.

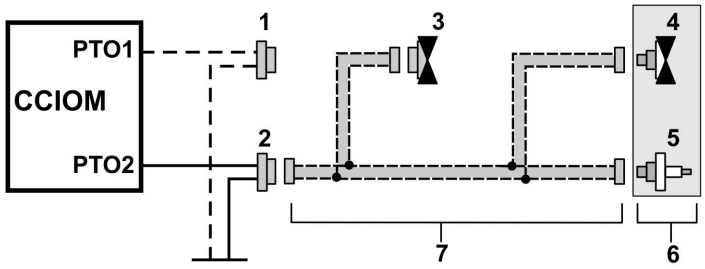
PTER-DIN with HPE81CF/HPE101CF and without gear-box PTO

1 Y18A Solenoid valve bridge (plugged from production – shall be connected by the body builder)
2 Y18B Solenoid valve bridge (plugged if connector present)
3 PTO1 Pneumatic valve
4 Hydraulic solenoid valve on pump
5 Sensor on pump
6 Clutchable engine mounted pump
7 Cable delivered in cab



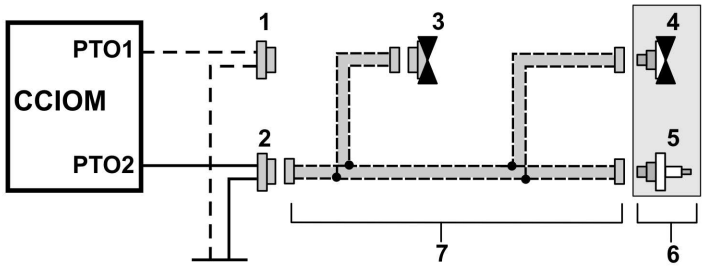
PTER-DIN with HPE81CF/HPE101CF and gearbox PTO (manual or I-shift)

1 Y18A Solenoid valve bridge — Gearbox PTO1 valve
2 Y18B Solenoid valve bridge (plugged from production – shall be connected by the body builder)
3 PTO2 Pneumatic valve
4 Clutchable engine mounted pump
5 Sensor on pump
6 Clutchable engine mounted pump
7 Cable delivered in cab



PTER-DIN with HPE81CF/HPE101CF and gearbox PTO (Powertronic)

1 Y18A Solenoid valve bridge (plugged)
2 Y18B Solenoid valve bridge (plugged from production – shall be connected by the body builder)
3 PTO2 Pneumatic valve
4 Clutchable engine mounted pump
5 Sensor on pump
6 Clutchable engine mounted pump
7 Cable delivered in cab

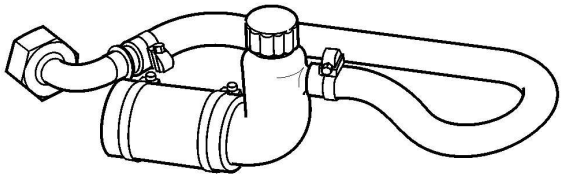


Temporary hydraulic transport kit

There are two different temporary kits, and the size of the oil reservoir differs:

1. Temporary hydraulic transport kit (for fixed displacement pumps)

Engine	Amount of oil if refill is needed:
D11/D13/D16 (HPE-FXX)	0.45 ± 0.05 litre
D11/D13/D16 (HPE-TXX)	



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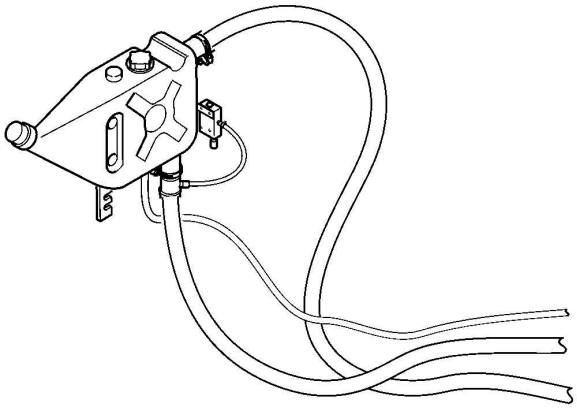
CAUTION

Too much oil will cause overheating of the pump.

2. Temporary hydraulic transport kit (for variable displacement or customer adaptation installed hydraulic pump)

Engine	Amount of oil if refill is needed:
D11 D13/D16 (HPE-VXX)	Minimum level on reservoir should be achieved after that the engine is started. Approx. 10 litre



T9008338

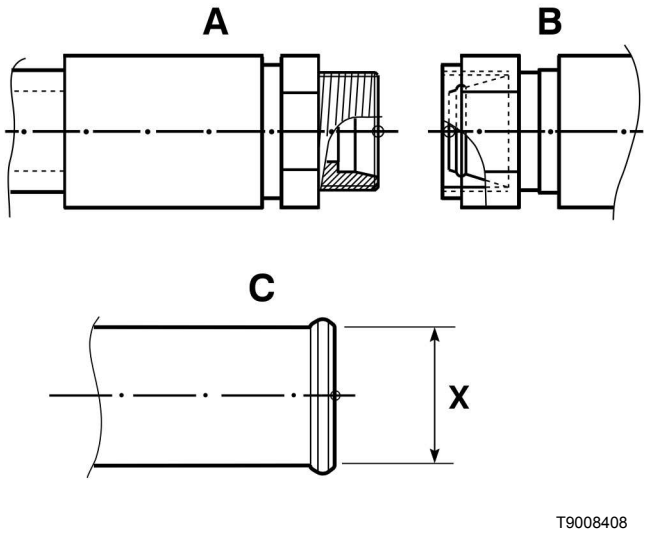
Connections to engine mounted hydraulic pump

A Factory delivered Factory installed connection from the hydraulic pump. Dimension 25S (M36 x 2).

B Body builder Body builder's connection. Hose connection with 24° cone.

C Suction side Smallest external connection diameter see table below:

Hydraulic pump	Diameter X (mm)
HPG-F41 HPG-F51 HPG-F61 HPE-V45 HPE-V75	50
HPE-FXX HPE-TXX HPEXXXCF HPG-F81/-101	63
HPE-V95 HPE-V130 HPG-V95 HPG-V130	75



X = smallest external connection diameter.

Installation requirements for hydraulic pump at final assembly

CAUTION

Hydraulic pumps must never be in use without oil flow in the hydraulic system.

Fixed displacement pump, HPE-FXX (F1 single flow)

- Remove the temporary oil reservoir kit, tank, fittings and hoses are not designed for use in high pressure installations
- Ensure that there is adequate oil flow (minimum 5l/min) running in the final hydraulic system back to the hydraulic tank when the hydraulic pump is running unloaded. If not, a drain line must be installed from bypass valve to hydraulic tank entering below oil surface (to avoid “foaming” the oil).

Fixed displacement pump with integrated clutch, HPEXXXCF (F3 single flow)

- Ensure that there is adequate oil flow (minimum 5 l/min) when the pump clutch is engaged (in the same way as for HPE-FXX).

Fixed displacement pump, HPE-TXX (F2 twin flow)

- Remove the temporary oil reservoir kit, tank, fittings and hoses are not designed for use in high pressure installations.
- The drain hose from bypass valve, supplied loose from factory, must be connected to hydraulic tank entering below oil surface (to avoid “foaming” the oil). Dimension of hose fitting is M12x1,5 DIN 20078N. It is allowable to shorten the drain hose, but a new fitting must be attached in a proper way.

Variable displacement pump, HPE-VXX (VP1)

- Remove the temporary oil reservoir kit, tank, fittings and hoses are not designed for use in high pressure installations.
- The bypass valve attached to the tank together with the hose between pump and by pass valve shall be kept and a drain hose should be connected between port “T” and hydraulic tank.It is allowable to shorten the drain hose between pump and bypass valve but a new fitting (M12x1,5 DIN 20078N) must be attached to fit onto fitting in bypass valve.
- The load signal on its way to port “LS” at the load sensing regulator on the hydraulic pump shall be connected in port “X” on the bypass valve as well.
- A drain line must be installed between port “T” on the hydraulic pump and the hydraulic tank since the load sensing regulator is not internally drained.

Permissible pump bending moment

The hydraulic pump mounted to a power take-off causes bending moment at the power take-off.

A gearbox mounted power take-off as well as an engine mounted power take-off has the following maximum permissible moment:

PTR/PTRD/PTOF/PTPT/PTER

PTO	Maximum bending moment (Nm)
PTR	40
PTOF-DIH	40
PTPT-D	40
PTER	40
PTRD	40

Note: If dual mounted pumps are used, the total moment must not exceed 40 Nm.

Calculation of pump bending moment

Torque is calculated with the formula below:

$$M_b = m \times g \times A$$

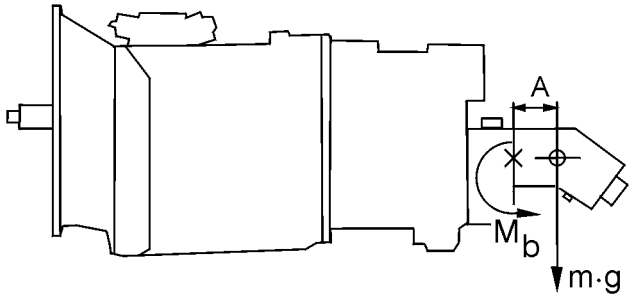
Mb Bending moment at pump connection to power take-off (Nm).

m Pump weight (kg).

g Standard gravity = 9.81 N/kg.

A Distance between pump centre of gravity and anchorage on power take-off (m).

Note: This calculation method is used irrespective of PTO/ pump location.



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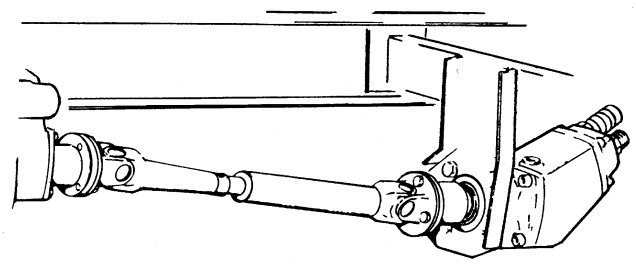
Propeller shaft installation

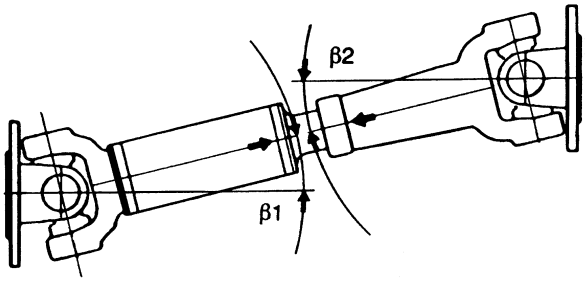
If a power take-off with coupling flange is to be used, the pump is installed by means of a bracket, either on an existing crossmember or on the sub-frame. An alternative method is to install an extra crossmember and install the pump on it. In this case, it is important to design the crossmember so that it can withstand the forces involved when the chassis twists and bends. The best way to achieve this is to design the crossmember as a normal, intermediate crossmember.



T9006112

The same requirements apply to power take-off propeller shafts as for drive line propeller shafts.
For best service life, the true joint angle should be kept between 0.5 to 4 degrees (the joint angle is not to be more than 8 degrees).

It is important that angles β1 and β2 are equal.



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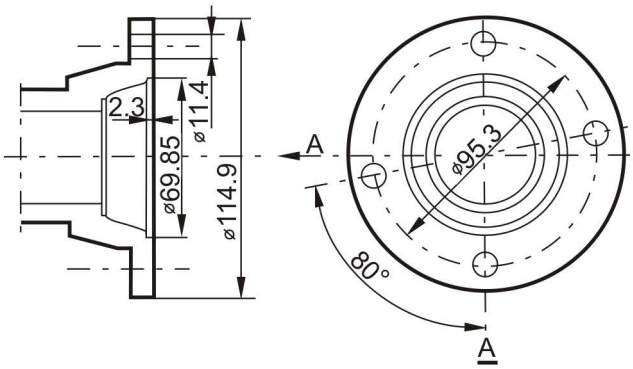
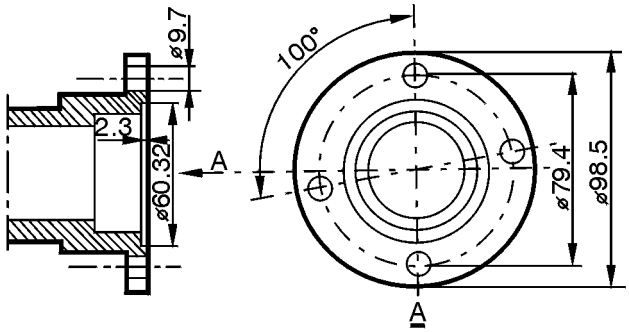
Dimensions of Volvo's power take-off flanges



T9008927

SAE1400



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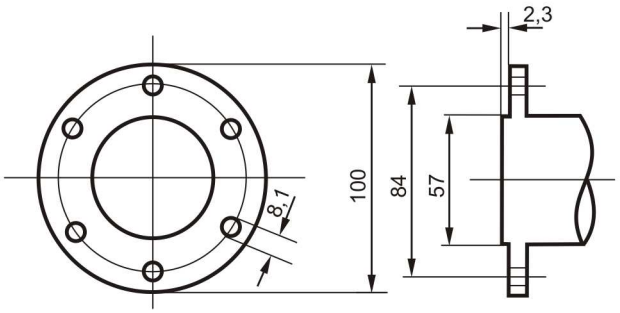
SAE1300



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DIN-100/ISO7646

Position in the truck

All dimensions specified in mm.

For information about **Gearbox mounted, rear power take-off** and **Powertronic power take-off** please refer to “Supplementary Drawings”.

For information regarding Engine and gearbox power take-offs, please refer to “Supplementary drawings” and “BEP drawings” (chassis unique drawings).

Dimensioning of hydraulic system and hydraulic pumps

It is important to dimension an optimum hydraulic system, and to specify the correct pump size to provide sufficient oil flow and prevent overloading of the power take-off.

Note: The body builder should enclose an information binder, delivered with the truck, including **hydraulic system data** (system dimensioning description and dimensioning criteria).
Service, function and safety descriptions should also be enclosed.

Pipes, lines and hoses

Connected to the hydraulic pump are a high-pressure hose, suction and drain lines.

When dimensioning the hydraulic system, it is important that:

- Hoses and lines must be connected to the pump with unions. Sealing rings must be used between pump and union.
- Teflon tape or similar must not be used since pieces can break off and get into the hydraulic system and eventually cause damage.
- If steel piping is used, it must be installed so that movements and vibrations do not cause leakage. Normally hoses should be used nearest the pump.
- Oxide scale must be removed from pipes which have been heat-bent or welded. Flush or blow the pipes clean before installing them.

CAUTION

Hoses and pipes should not be routed too near the warm points in the truck. There are two reasons for this, namely risk for fire if a leakage should occur, and the transfer of heat to the hydraulic oil.

High-pressure hose

These hoses must have a minimum of four steel wire coil inserts in order to withstand the high pressure in the hydraulic system.

When mounting an high-pressure hose:

- Make sure the hoses are not twisted when connected up.
- Make sure the hoses are long enough.
- Strive to get as few bends as possible on a hose.
- Avoid kinks by using correct unions. Only pressed unions may be used when replacing hose unions.

Note: Check for oil leakage and for high noise levels in the system when the truck is in motion.

Suction line

The suction line is made of piping or armoured hose which retains its shape even when there is vacuum in the line.

To avoid cavitation:

- The suction line should be as short as possible and **should not exceed 4 metres**. In the event longer lines are required, larger line dimensions must be used.
- The suction line should connect to the bottom of the tank and must be correctly tightened to prevent air getting into the oil.
- The suction line must have a wide diameter and must be free from kinks and constrictions.

Note: Avoid suction lines of high-pressure hooks and hooks made locally from pipe pieces welded together. They could cause unnecessary suction resistance.

Suitable suction line sizes at different flow quantities and with a flow speed of less than 0,8 m/s:

Inner diameter Ø (mm)	Flow up to litre/minute
50	0–120
64	101–150
75	> 150

Drain line and bypass valve

If the hydraulic pump is installed to a constantly running PTO, it is provided with a bypass valve.

The bypass valve reduces the oil flow through the pump to obtain low heat generation and to avoid cavitation.

Drain line — Fixed displacement pump

HPE81CF/HPE101CF (F3 single flow)

The information below is also valid for the pumps with integrated clutch when the clutch is engaged and the pump is running.

HPE-FXX (F1 single flow)

In order to prevent heat build-up in the pump during transportation, it is important that at least 5 litre/minute comes out of the filter at “q” (refer to the schematic below). This applies to an “open centre” system when the valve is in the bypass mode (non-activated solenoid).

Note: If the flow at “q” is less than 5 litre/minute (caused, for example, by a high pressure drop in the main system) when the valve is in the bypass mode or if the hydraulic system is of the “closed centre” type, then an external drain line (7) **must be installed** from the bypass valve drain port (6) directly to the hydraulic tank, entering below oil level (preferable to the filter housing on the oil tank).

HPE-TXX (F2 twin flow)

In order to secure a cooling flow through the system, a separate drain line (7) is already connected to the bypass valve from factory and the other end of the hose is temporary plugged. At final assembly the hose (7) should be connected to the hydraulic tank, entering below oil level (preferable to the filter housing on the oil tank).

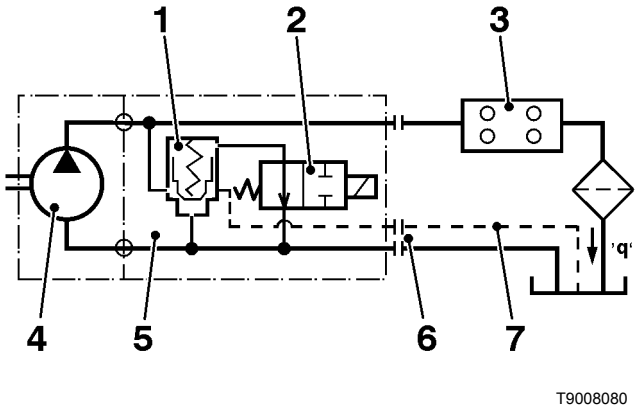
Bypass valve — Fixed displacement pump

For the fixed displacement hydraulic pumps the bypass valve is attached directly on top of the end cap of the hydraulic pump. It is electrically operated and the valve function must only be activated or released at no-load (below 20 bar) system pressure.

For the fixed displacement hydraulic pumps with clutch integrated the bypass valve can only be activated to get flow and pressure to the hydraulic system when a signal is received from the clutch indicator that the clutch is in the engaged position.

For the F2 twin flow hydraulic pump, the bypass valve can be used when one of the two circuits is (temporarily) not required. The power loss is thus reduced as the unrequired flow is not forced through lines and “open centre” valves.

1 Pilot operated check valve
2 Solenoid valve
3 Directional control valve (“open centre”)
4 Hydraulic pump
5 Valve block
6 Drain port
7 (Drain line)



HPE-FXX

Drain line — Variable displacement pump

HPE-VXX (VP1)

At final assembly, since the control valve on the hydraulic pump is not internally drained, there must be an external drain line installed between port “T” and the hydraulic tank.

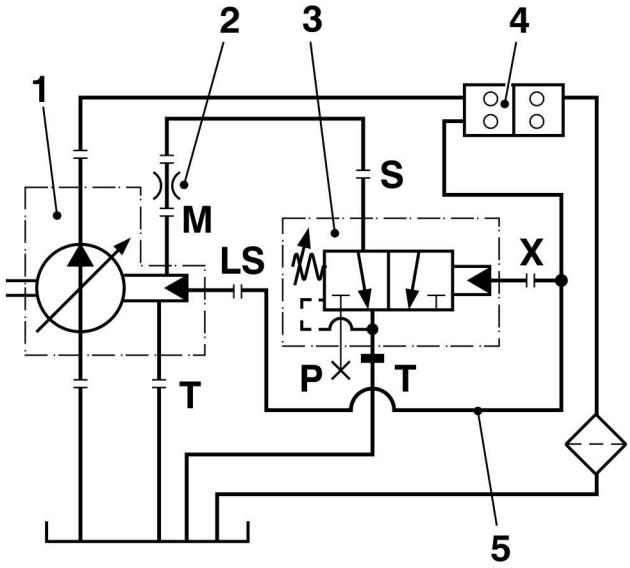
Bypass valve — Variable displacement pump

For the variable displacement pump the bypass is, from factory, attached to the temporary oil reservoir and connected to the hydraulic pump via a hose to the port for gauge outlet, (on VP1-45 and VP1-75 port beside the suction port and on the VP1-095/VP1-130 port “M” on the control valve).

The valve, which requires no additional control valve, allows the pump to operate on-load or off-load up to its maximum self priming speed.

When a load sensing valve function is engaged, the bypass flow is cut off (as port “X” is being pressurized).

1 Hydraulic pump
2 Nipple with orifice
3 Bypass valve
4 Load sensing valve
5 Load sensing (LS) signal



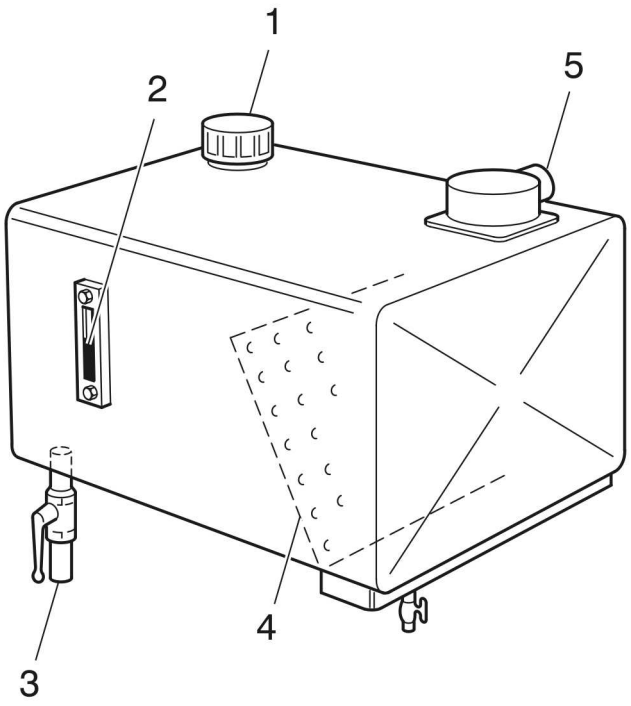
VP1-095/VP1-130

Hydraulic oil tank

The tank must be large enough to avoid cavitation and overheating. A suitable volume is 1,5 times the nominal pump flow per minute.

The tank includes:

1 Air filter, fitted (as required) in a tube and provided with a non-return valve
2 Level gauge
3 Suction connector equipped with full-flow tap
4 Angled, perforated plate on which air bubbles accumulate and rise to the surface
5 Return oil filter



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When installing a hydraulic tank:

- The volume of the hydraulic tank must be dimensioned 1,5 times the nominal pump flow during normal working conditions.
- Make sure that the placing of the hydraulic tank does not limit the performance of the hydraulic pump.
  For example: The suction fitting must not be placed below the inlet of the return pipe.
- It is important that the deaeration surface is big enough. Prevent external dust and dirt from entering the hydraulic system. The inside of the tank must be well cleaned. To prevent dust getting into the system, the air filter should have the same filtration degree as the return oil filter.
- Oil is topped-up through the return oil filter, preferably via a rapid joint on the return line where the oil can be pumped in.
- Check oil level and ensure that it is oil of recommended type and viscosity.

Return oil filter

A return oil filter should be installed in the tank or in the return line. The filter should be dimensioned for a capacity which is approx. twice that of the pump flow.

Recommended filtration level:

- 25 µm (absolute) in clean environment or at low pressures (0–200 bar).
- 10 µm (absolute) in contaminated environment or at high pressures (200–300 bar).

Check return pipe and filter condition and check for oil leakage.

Note: The filter must be replaced at least once a year.

Note: Filtration should meet ISO standard 4406: code 20/18/13.

Hydraulic oil

Hydraulic fluids type HLP (DIN51524), ATF (automatic transmission fluid) and engine oil type API/CD can be used.

Recommended viscosity:

- 20-30 mm²/s (cSt).

CAUTION

Do not mix oils of different quality.

Starting up

Make sure the entire hydraulic system is clean before filling it with a recommended fluid. In particular the pump, which must be purged to remove any entrapped air in the pump housing (use the uppermost purge port).

CAUTION

Make sure the suction connector always is below the minimum level of the hydraulic oil.

Calculation of hydraulic pump size

See also the VBI site “Calculation tools”, “PTO and hydraulic pump calc”.

Control the pump environment with the **Parker** calculation program.
Go to ***Introduction*** on the VBI homepage, choose ***Software requirement*** and click on ***Parker***.

The following information is required to dimension the hydraulic system:

- **Oil flow Q (l/min)**, to the equipment
- **Oil pressure p (bar)**, to do the work intended
- **Permissible torque or power taken from the engine**
- **Permissible pump speed**
- **PTO Gear ratio**

Engine speed

Engine speed limit for engine mounted hydraulic pumps

Vehicles specified with engine mounted hydraulic pumps will always have a maximum engine speed (r/min) pre set from factory.

Depending on the pump size the setting is between 1450–2000 r/min.
This is governed by the setting of data parameters and when the hydraulic pump is in service, the maximum engine speed can therefore not be overridden by pressing the throttle.

Additional limits for HPE81CF/HPE101CF.
Preset data parameters from factory.
When engaging pump: Maximum 800 r/min engine speed and the air pressure must have reached 8 bar. This limitation ensures that the pump clutch is not damaged — It is not permitted to change these settings.
When pump engaged: Maxumum 30 km/h vehicle speed and maximum 1450 r/min engine speed.

If the hydraulic system is designed in such way that the self-suction speed of the hydraulic pump is reduced, then the limited value should be modified using **Volvo Tech Tool**.

Engine speed control

Check that the permissible speed, specified by the pump manufacturer on the pump, is not exceeded.

Pump speed per minute **n** is governed by engine speed **ne** and power take-off gear ratio **Z**:

$$n = ne \times Z$$

n = Pump speed (r/min)
ne = Engine speed (r/min)
Z = Power take-off gear ratio

Pump speed

See also the VBI site “Calculation tools”, “PTO and hydraulic pump calc”.

The maximum (self-suction) speeds given in the catalogue apply at 1.0 bar (abs.) intake pressure.

To achieve correct pump speed the following is required:

- Oil level approx. 0.5 m above pump inlet
- Correctly dimensioned suction pipe
- Original suction nipple
- Correctly designed hydraulic fluid reservoir

The flow speed in the suction pipes should be less than **1 m/s**. Poor suction conditions lead to cavitation, high noise levels, shorter operational lifetime and, in the worst case, pump failure.

Pump capacity

The pump capacity or size **D** (cm³/rotation) should be able to give sufficient oil flow **Q** (l/min) for the equipment. The choice of size depends on the oil flow required, engine speed and power take-off gearing. A small pump can give a large oil flow if the power take-off gear ratio is large, or if the engine speed is high.

Pump size is calculated as:

$$Q = \frac{D \times n \times \eta v}{1000} <=> D = \frac{Q \times 1000}{n \times \eta v}$$

n = Pump speed (ne x Z)

D = Pump size (cm³/rotation)

ne = Engine speed

Q = Oil flow (l/min)

Z = Power take-off gear ratio

ηv = Volymetric efficiency

Control the pump environment with the **Parker** calculation program.
Go to ***Introduction*** on the VBI homepage, choose ***Software requirement*** and click on ***Parker***.

Torque control

A certain torque, **Mku** is required from the power take-off at the pump shaft to drive the pump. This torque must not exceed the permissible torque for the power take-off. Expressed in Nm, this torque is:

$$M_{ku} = \frac{D \times p}{63 \times \eta hm} < M_{ku,till.}$$

Mku = Torque at power take-off (Nm)

D = Pump size (cm³/rotation)

p = Hydraulic working pressure (bar)

Mku, till. = Permissible torque for the power take-off (Nm)

ηhm = Mechanical efficiency

< = Less than

Torque control, engine

Torque control of the engine **Mmot** must not exceed the permissible torque for the engine (please refer to Body builder instructions “Power take-off, performance”) at a given engine speed.

Engine torque is equal to power take-off torque x gear ratio.

$$M_{mot} = Mku \times Z < M_{mot,till.}$$

Mmot = Engine torque (Nm)

Z = Power take-off gear ratio

Mku = Torque at power take-off (Nm)

Mmot, till. = Permissible engine torque (Nm)

< = Less than

Power requirements

The power **N** needed to drive the pump is proportional to the flow and working pressure and inversely proportional to the efficiency of the pump **η**.

Check that pump power curve, to see that it has the capacity needed to provide the calculated power **N**.

$$N = \frac{Q \times p}{600 \times \eta t}$$

N = Power (kW)

Q = Flow through pump (l/min)

p = Working pressure (bar)

ηt = Overall pump efficiency **(approximately 0.95)**

$$\eta t = \eta v \times \eta hm.$$

ηt = Overall pump efficiency

ηv = Volymetric efficiency

ηhm = Mechanical efficiency

Example 1 (Tipper), Selecting pump size clutch dependent PTO

Operating conditions

Flow:	60-80 l/min
Pressure:	230 bar
Engine r/min:	800 r/min
PTO ratio:	1:1.53

Determine the pump speed

n = ne x Z=800 x 1.53 = 1200 r/min

Choosing the pump size

$$Q = \frac{D \times n \times \eta v}{1000}, \quad D = \frac{Q \times 1000}{n \times \eta v}, \quad \frac{70 \times 1000}{1200 \times 0,98} = 60\ cm^3/rotation$$

Select F1-61 and check torque and power.

Torque requirement of the pump

$$Mku = \frac{D \times p}{63 \times \eta hm} = \frac{59,5 \times 230}{63 \times 0,98} = 222\ Nm$$

Power requirement of the pump

$$N = \frac{Q \times p}{600 \times \eta t} = \frac{70 \times 230}{600 \times 0,95} = 28\ kW$$

Example 2 (General crane), Selecting pump size clutch independent PTO

Operating conditions

Flow:	80 l/min
Pressure:	250 bar
Engine r/min:	800 - 900 r/min
PTO ratio:	1:0.97

Determine the pump speed

n = ne x Z = 800 x 0,97 = 800 r/min

Choosing the pump size

$$Q = \frac{D \times n \times \eta v}{1000} \quad D = \frac{Q \times 1000}{n \times \eta v} \quad \frac{80 \times 1000}{800 \times 0,98} = 102\ cm^3/rotation$$

Select F1-101 and check torque and power.

Torque requirement of the pump

$$M = \frac{D \times p}{63 \times \eta hm} = \frac{102,9 \times 250}{63 \times 0,98} = 417\ Nm$$

Power requirement of the pump

$$N = \frac{Q \times p}{600 \times \eta t} = \frac{102 \times 250}{600 \times 0,95} = 45\ kW$$