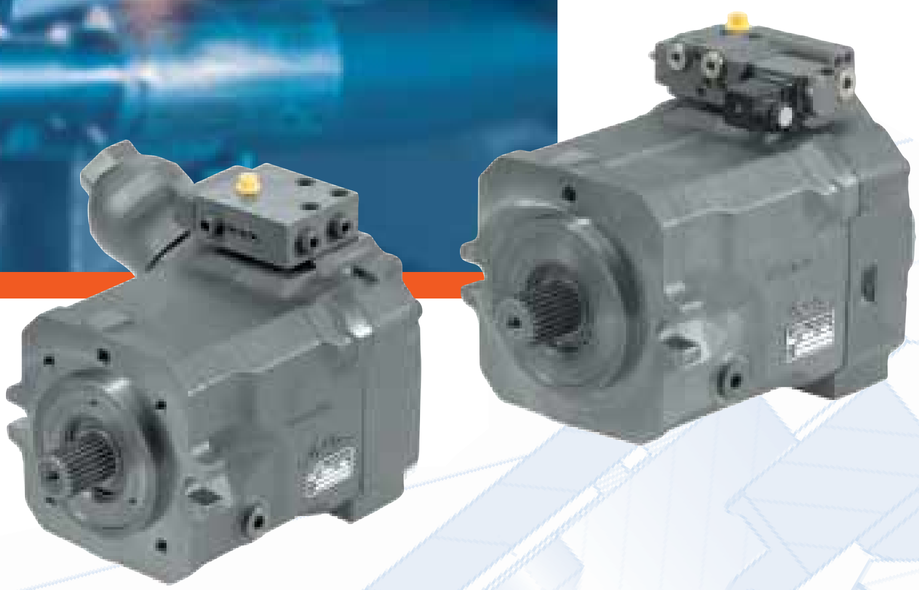
HPR-02



REGULATING PUMPS
for open loop

We move the world.

Hydraulic Components + Electronic Components from Linde this means total Vehicle Management through the complete Linde System.

Linde – the pioneer in **mobile hydraulics** – discovered and perfected hydrostatics as the ideal drive system for mobile machinery. Since 1959, Linde has equipped more than two million vehicles in the fields of

- Construction Equipment
- Agricultural Machinery
- Forestry Equipment
- Municipal Vehicles
- Material Handling

with hydrostatic drives and working systems. The use of these systems in our own fork lift trucks has made Linde the world market leader! Electronics also play an important role in those applications.

Linde products have been leaders in the field of mobile hydraulics for many years. Our customers can rely on our systems expertise and our know-how.
Linde engineers are masters of their field – whether it involves better power utilization, the best possible interaction among the total-system components, ease of operation or safety.

Components and systems from Linde are also widely used in **stationary machines**. Many different uses and applications can be served: woodworking machines, mixers, agitators and centrifuges in process engineering, presses, drilling machines, cable winches, plastic-processing machines, theater engineering, ships' helms and other marine applications, rotary drums for the cement and sugar industries, material handling systems, amusement park rides, and many others.

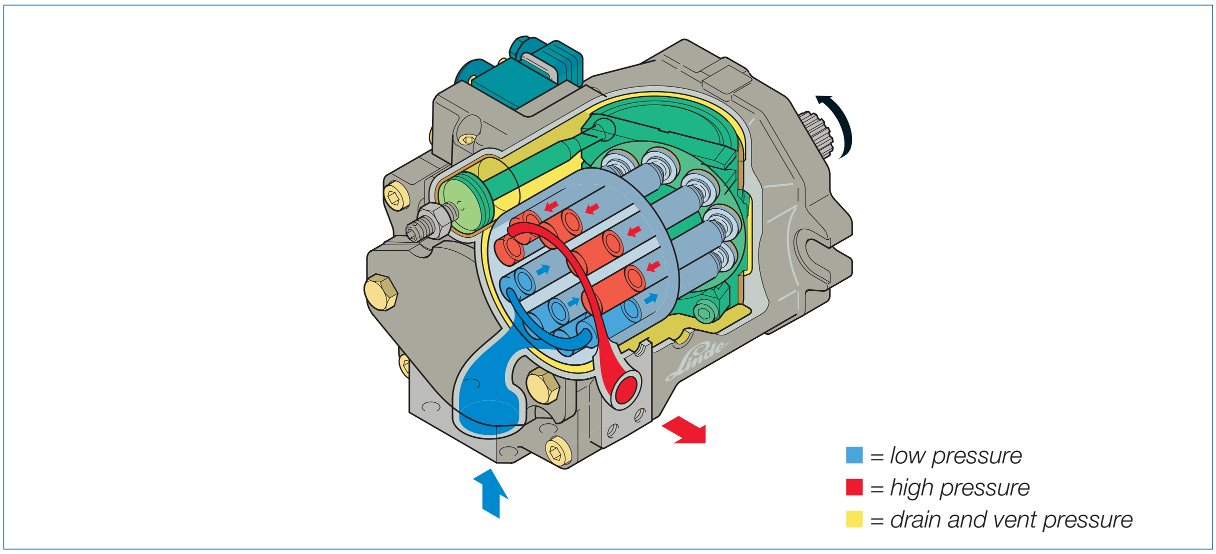
Whether it's closed or open loop systems,

Linde hydraulics is always the right choice.

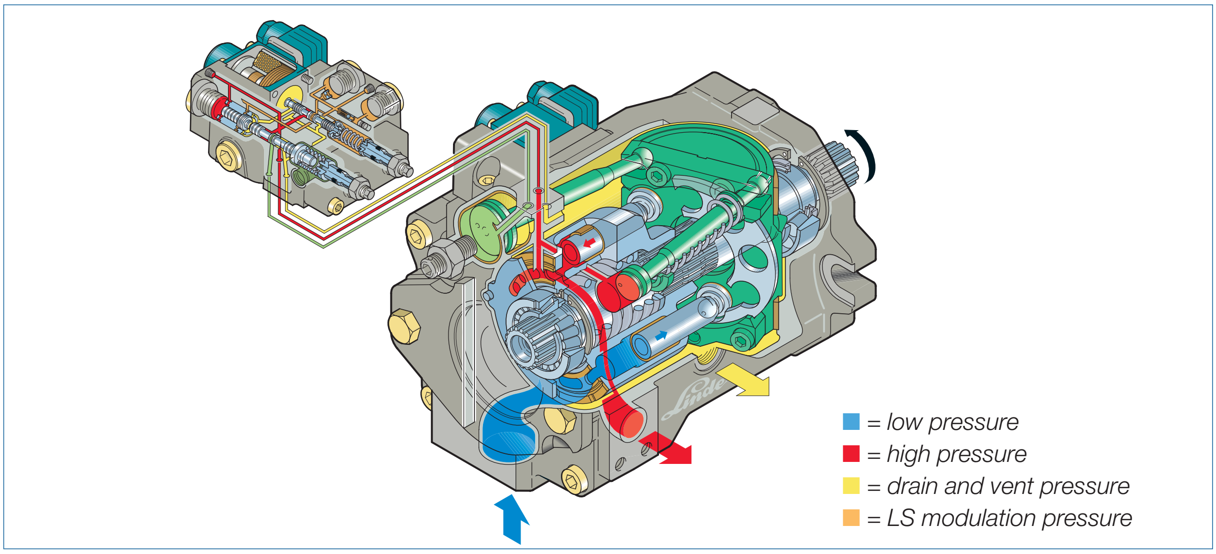
HPR-02

CONTENTS **Page**

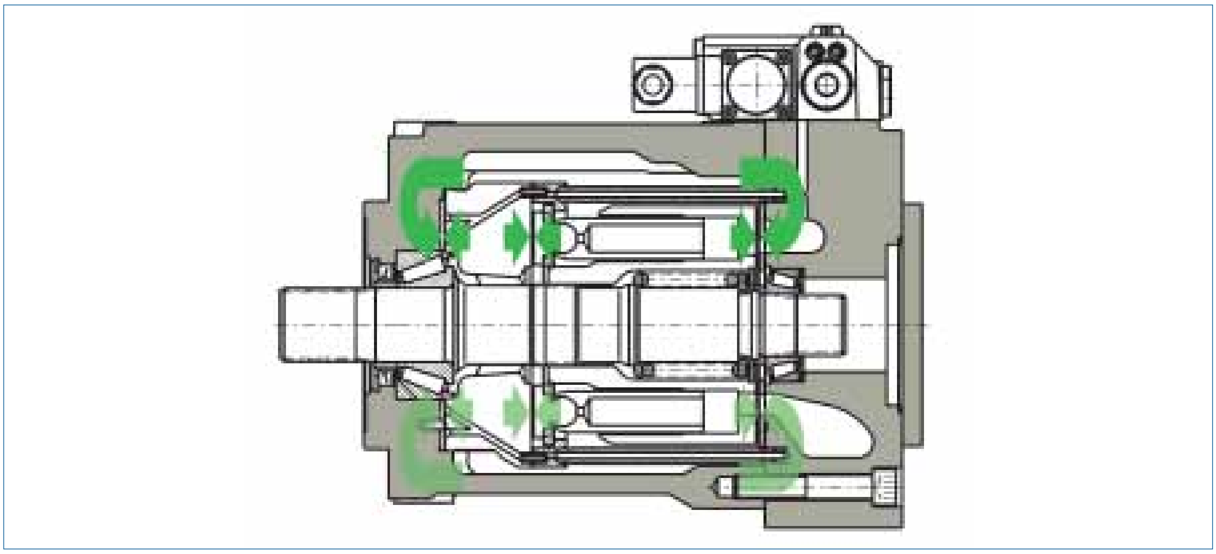
1. PUMP DESIGN



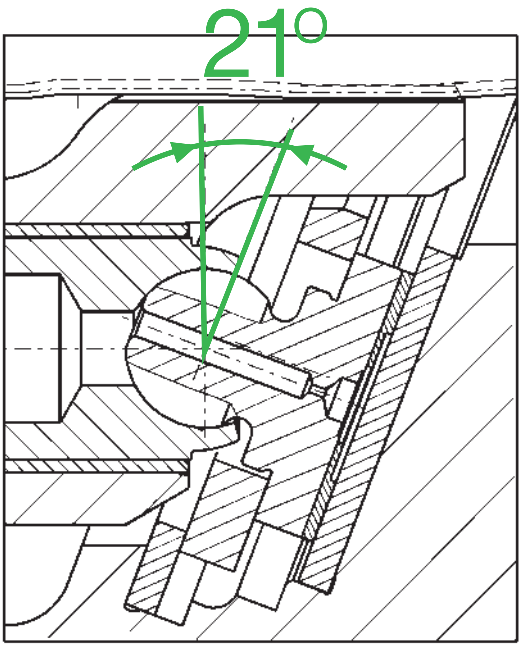
Pressure areas



Regulator mechanism



Linear force compensation 100 % hydrostatic



- high swash angle
  (21° technology)
- compact design
- low radial load
- long lifetime
- high efficiency

Advanced design of piston/slipper assembly

Response Times

Swashing from maximum displacement (V_{max}) to minimum displacement (V_{min}).
Response times are for swashing from high pressure (HD) to stand-by-pressure.

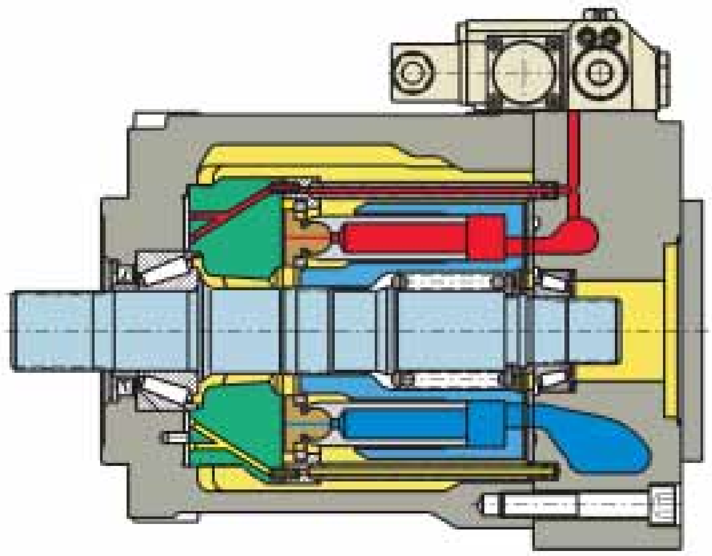
	Speed	HD 100 bar	HD 200 bar
HPR 75-02	2000 rpm	120	70
HPR 105-02	1500 rpm	120	70
HPR 135-02	1500 rpm	130	70
HPR 210-02	1500 rpm	200	70

Swashing from minimum displacement (V_{min}) to maximum displacement (V_{max}).
Response times are for swashing from stand-by-pressure to high pressure (HD).

	Speed	HD 100 bar	HD 200 bar
HPR 75-02	2000 rpm	400	300
HPR 105-02	1500 rpm	450	350
HPR 135-02	1500 rpm	300	300
HPR 210-02	1500 rpm	160	130

Response times are in milliseconds (ms), measured at an oil temperature of 60 °C.
The indicated HD-values refer to the respective operating pressure at max. displacement.

2. CHARACTERISTICS, FEATURES, SIZES



HPR-02 E1L

Characteristics

- Axial piston, swash-plate pump for open loop circuit application, designed as a regulated capacity pump with variable volume displacement.
- Load-sensing control (flow on demand) for energy-saving operation of the entire system.
- Self-priming up to rated speed, with excellent suction capacity.
  Speed can be increased by tank pressurisation or reducing the swash angle.
- Optimum interaction with Linde-LSC directional control valves
  (Closed-Centre, Load-Sensing, directional control valves) and LINTRONIC electronic control unit with associated peripherals, developed by Linde
- Noise optimisation: significant reduction of structure-borne and fluid noise by means of a silencer (SPU) which considerably diminishes pressure peaks and pulsation levels, the major causes of system noise.
- Compact design, high power density.
- Superior quality due to appropriate design and construction and the latest production methods.
- Optimised for high reliability, long service life, high efficiency.
- Fast response times.
- HPR-02 Pumps can be used in both mobile and stationary applications.

Design Features

- Maximum 21° swash angle
- Clockwise or anti-clockwise rotation possible
- Various load sensing control methods
- Service life increased by supporting the cradle in plain bearings and a new, stable piston/slipper connection. The plain bearings contribute significantly to noise reduction and improved control response of the pump
- High safety factors and conservative ratings
- Rugged precision regulating mechanisms (mechanical, hydraulic, electrical)
- External venting of decompression fluid for suction side stability
- Single piece housing eliminates leakage and improves rigidity
- Hydrostatic compensation of axial forces generated during operation
- Installation : see Chapter 10, Main Dimensions
- Through Drive (PTO) for fitting further hydraulic pumps
- SAE high-pressure connections (6000 psi)

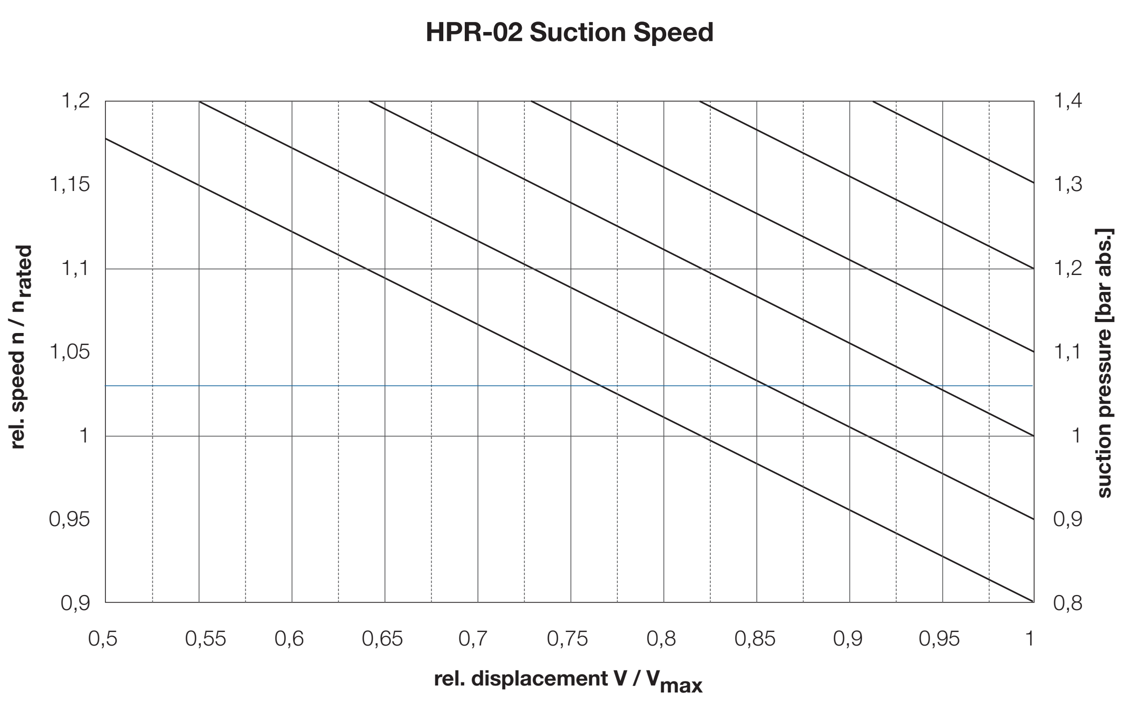
Sizes

- 55, 75, 105, 135, 210, 2 x 105 cm^3/rev
  Tandem Pumps and Multiple Pump configurations optional

3. TECHNICAL DATA

Nominal displacement / Size		55	75	105	135	210	105 D
Actual displacement	cm³/rev	54,8	75,9	105	135,6	210	2x105
Rated speed, continuous w/o pre-pressurizing	min^{-1}	2700	2600	2300	2300	2000	2300
with pre-pressurizing	min^{-1}	see diagramme below					
Max. oil flow	l/min	147,9	197,3	241,5	311,9	420	483
Max. operating pressure	bar	420	420	420	420	420	420
Max. intermittent pressure	bar	500	500	500	500	500	500
Permissible casing pressure (abs.)	bar	2,5	2,5	2,5	2,5	2,5	2,5
Max. input torque*)	Nm	368	508	702	907	1404	1404
Shaft load, axial (pull)	N	2000	2000	2000	2000	2000	2000
Shaft load, axial (push)	N	2000	2000	2000	2000	2000	2000
Shaft load, radial	N	on request					
Permissible casing temperature	° C	90	90	90	90	90	90
Weight	kg	39	39	50	65	116	107
Max. moment of inertia	kgm^2x10^{-2}	0,79	0,79	1,44	2,15	4,68	2,88
Main dimensions (see Chapter 10)		-	-	-	-	-	-

*) at max. operating pressure and max. displacement V_{max}, all values are theoretical



The data on which this brochure is based correspond to the current state of development. We reserve the right to make changes in case of technical progress. The dimensions and technical data of the individual installation drawings are prevailing.

4. LOAD SENSING (LS) TECHNOLOGY

4.1 Basics

The main feature of Load Sensing control is: Continuous detection of the load and thus pump pressure in the hydraulic system, with constant adjustment of the pump delivery volume according to the requirements of the moment. This control method is also referred to as “flow on demand control”.

The technical solution to this task is answered as follows:

The load signal (pressure) is measured between an adjustable orifice and the consumer (hydraulic motor or cylinder) (see figure / circuit diagram). The signal activates the LS controller of the pump, which adjusts the pump flow such that the pressure differential (Δp) across the orifice remains constant at all times. Pump flow Q obeys the equation $Q \sim A \times \sqrt{\Delta p}$. With a constant Δp pressure differential, the pump flow Q is therefore solely dependent on the open cross-sectional area A of the valve: $Q \sim A$. This system relieves the operators’ workload considerably, as there is no need for ongoing adjustment when the load changes since the system, being independent of load, compensates automatically. For example, the orifice might be a proportional valve or a fully hydraulic controller with an LS signal connection.

The most striking advantage of a Load Sensing System is the significant energy saving, compared to conventional hydraulic systems.

Further advantages of an LS system:

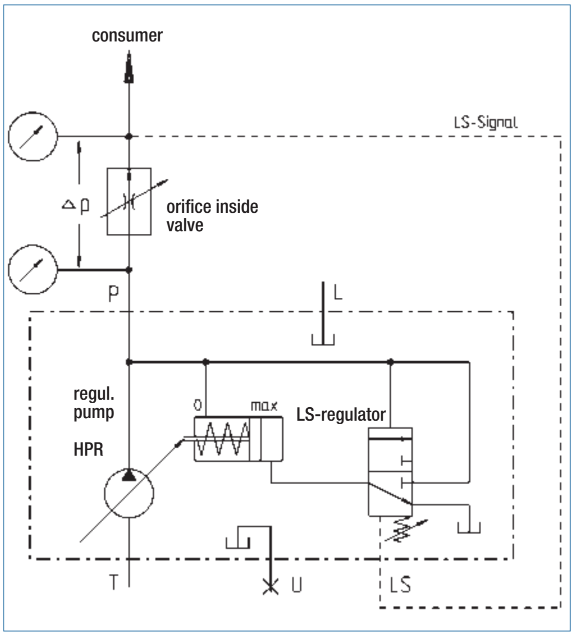
- Longer pump service life due to lower overall working load
- Fast, accurate control of the pump flow, irrespective of load at any given time
- Less heat generated, so a smaller oil cooler is sufficient
- Overall system noise reduction thanks to lower working pressures

Load Sensing pumps and systems are used very successfully in large numbers of working hydraulic circuits (open loop) e.g.: construction and agricultural machinery, transport vehicles, materials handling, industrial and marine equipment.

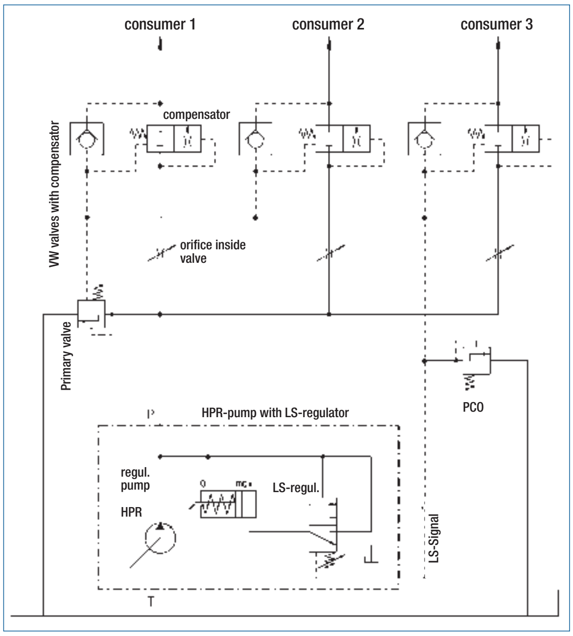
Common to all LS applications are the significant energy saving and better utilisation of the prime mover (diesel engine, electric motor) compared to conventional systems.

In addition to reduced environmental impact, in some applications this means that a prime mover (diesel engine, electric motor) of the next rating class down can be used.

The advantages for both equipment manufacturer and operator are obvious.



Schematic of Regulating Pump with LS-Regulator



Total System of HPR-Pump with LSC-Direct Control Valves

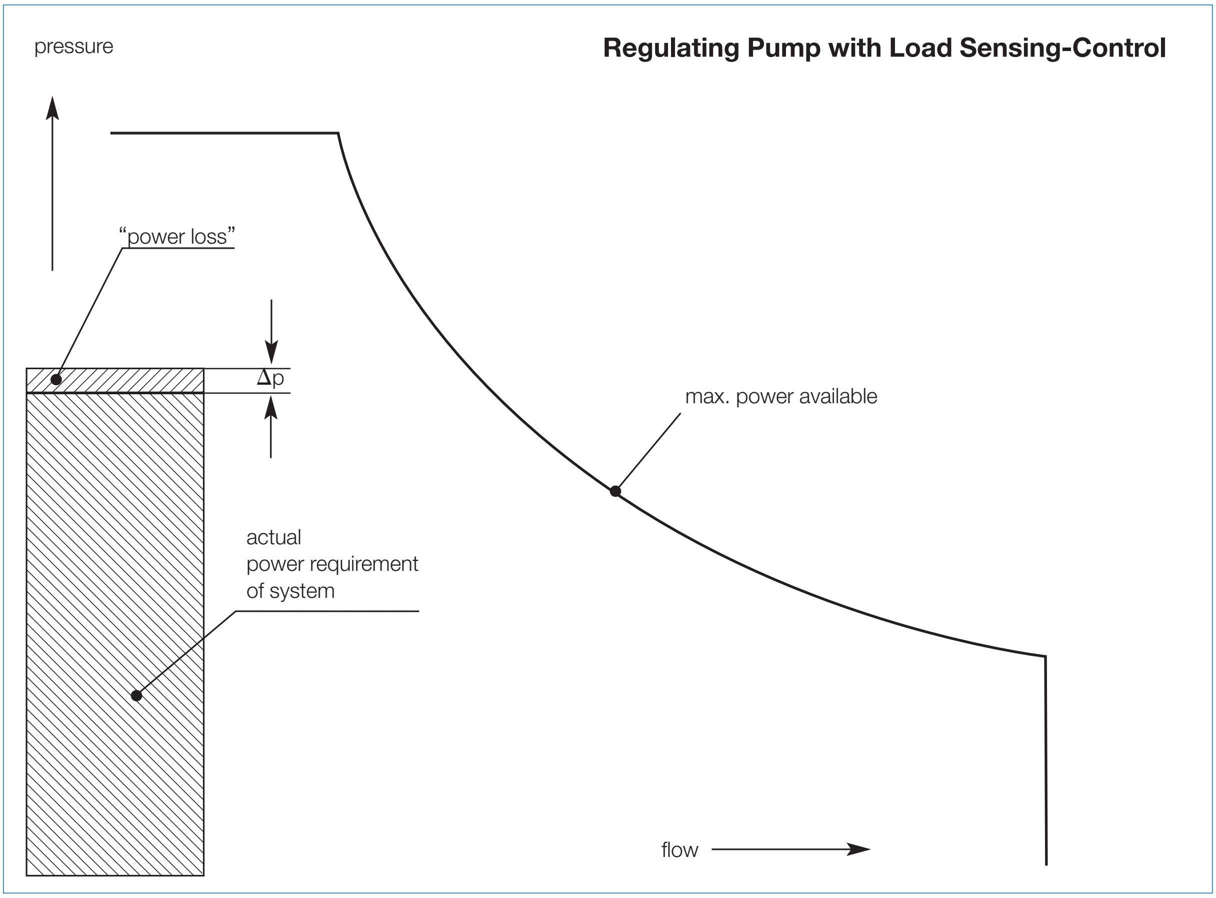
4.2 LS Pump Realization

This is the most favourable pump design in terms of energy utilisation. Compared to the power-regulated variable displacement pump, this model represents a further substantial improvement. The additional improvement in energy consumption produced by flow on demand control applies not just to the pump but to the entire system (reduced power consumption, lower heat generation, lower noise level).

Unlike a power-regulated variable displacement pump, a hydraulic pump with an LS regulator can operate at any point below the power hyperbola, i.e. the pump is not “bound” to the power hyperbola. It delivers exactly the flow demanded by the system without producing any excess flow which then has to be dissipated by means of high pressure valves resulting in wasteful heat generation. To ensure this strikingly economic operation the LS pump controller constantly measures the load pressure at the LS valves.

The only “loss” arises from maintaining a pressure differential Δp of about 20 bar. This relatively small excess pressure over system pressure makes the pump highly responsive.

In addition, the pressure supports the swivel action of the pump once started up, because it swashes back towards zero on low stand-by pressure when there is no flow requirement.



Energy Consumption within a Hydraulic System

5. REGULATOR VERSIONS

5.1 Load Sensing with Electrical Override Control (E1L)

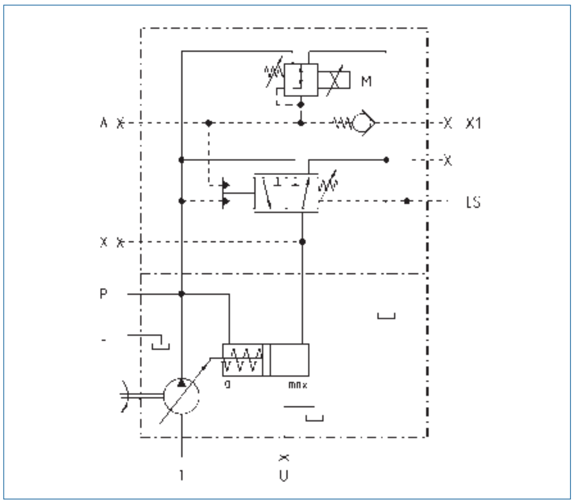
HPR 210-02 E1L, SPU

HPR 105-02 E1L

The LS regulator is designed so that external LS pressure signals arriving from the consumer are conducted to a spring chamber, where they act against the pump pressure. The LS regulator spring is preloaded to circa 20 bar (standard setting) and therefore the pressure generated by the pump is above the system pressure by this amount.

The basic design of the HPR-02 hydraulic pump makes it eminently suitable to supplement this regulator concept by adding an electrical override to the LS regulating signal.

A pressure-reducing valve operated by a control solenoid produces a proportional pressure, which acts against the 20 bar spring and thereby reduces its effect. The pump thus receives a modulated Δp LS value and as a result, reduces its flow output.



The control solenoid and the pressure-reducing valve it actuates are integrated in the pump regulator, so that the transmitted signal is direct and instantaneous. The regulator design caters for solenoid voltages of 12 or 24 V from the vehicle electrical systems (in the case of mobile applications) or from an external supply (mostly stationary applications).
The regulator concept described here is an ingenious solution for

- power limit regulation (reduction control) and
- mode switching (mode selection)

The power limit regulator detects speed reductions in the prime mover (e.g. diesel engine), caused by overload. As a result, the pump delivery volume (and consequently the power demanded by the pump) is reduced, and the prime mover then "recovers" so that it is available with full power (speed) for other consumers.

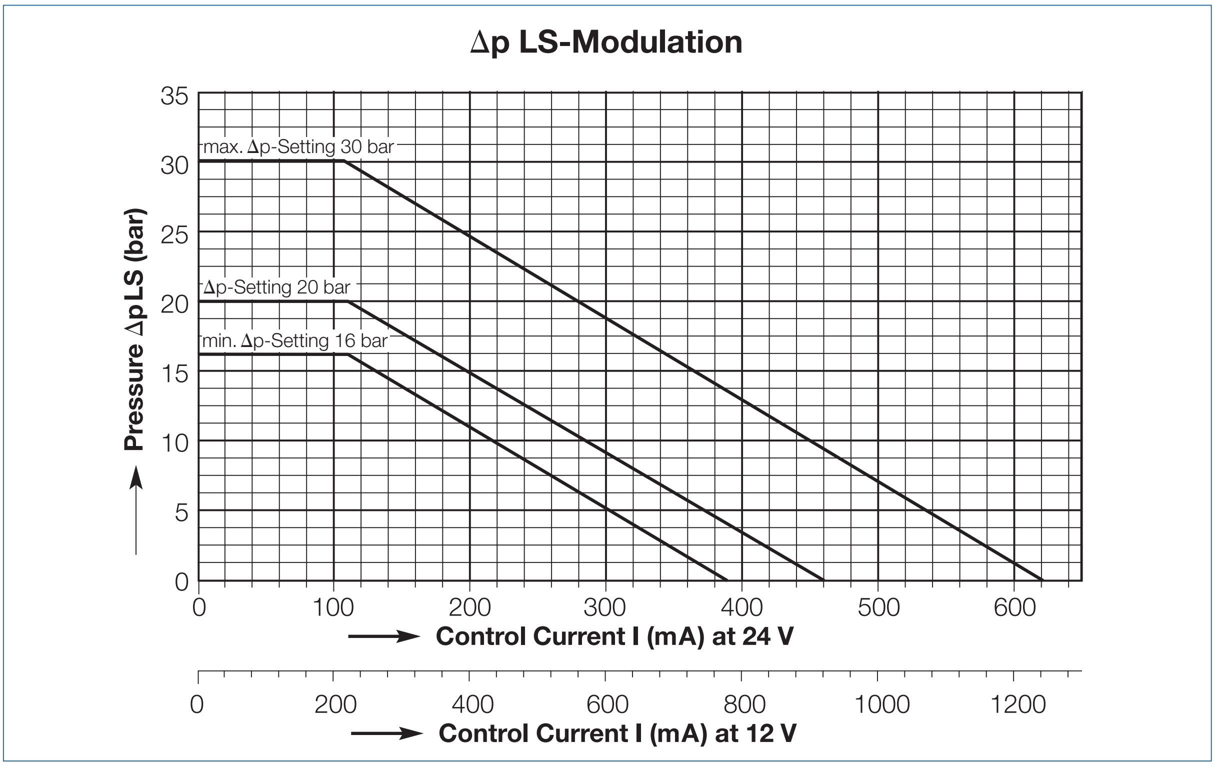
Power limit regulation is made possible by system components from the Linde transmission technology range: the CEB/CED electronic control units and the CEH speed sensor. These components are thoroughly proven and operate in an optimum combination with the HPR-02 hydraulic pump.

Mode switching (mode selection) allows for specific external action to be taken to influence LS regulator behaviour, thus overriding the LS signal. This can be effected proportionately or in steps. By actuating the control solenoid (e.g. from a potentiometer in the cabin), the instantaneous effective Δp LS value can be modulated to a smaller value by the pressure-reduction valve described above so that the pump reduces its delivery volume. In this way, the control range can be "fine-tuned" for precision sensitive work. Signals are processed by the tried and tested Linde CEB/CED electronic controllers.

The relationship between the proportional current (I) to the solenoid and Δp LS is shown in the graph below (Δp LS = f (I)).

The LS regulator spring provides a basic setting range for Linde HPR-02 pumps (test rig setting) of between Δp LS = 16 bar and 30 bar. The standard Linde factory setting is Δp LS = 20 bar.

In principle, the Δp LS acting on the LS pilot can be decreased to a value of 0 bar if required, although in this case it should be noted that at low values of Δp LS, pump system response times can be slower.



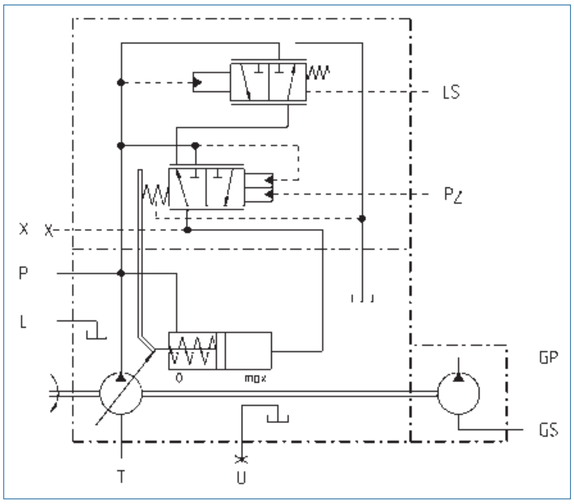
5.2 Load Sensing with Power Limiter (TL)

HPR 75-02 TL, SPU

HPR 75-02 TL, SPU with pilot pump

For applications where the input power for a hydraulic system is limited but where optimum use must nevertheless be made of the available power, the power limiter can be used as a regulating device.
It limits the mathematical product of flow volume Q (working velocity) and pressure p (force) according to an approximated characteristic curve.
When the set value of the adjusted power limiter is reached it reduces the flow volume (i.e. the displacement of the HPR pump), such that product p x Q corresponds to the set value. The approximated exponential regulator characteristic is implemented by a spring system incorporated in the controller.

If the power consumption of the system remains below the set value of the power limiter the LS regulator alone controls the pump. This enables the pump/valve system to operate at any point below the power characteristic. The overall working range is only limited upwards by reaching the set power, as the power limiter overrides the LS regulator and thereby prevents the prime mover from being overloaded.



5.3 Load Sensing with Pressure Cut-off (LP)

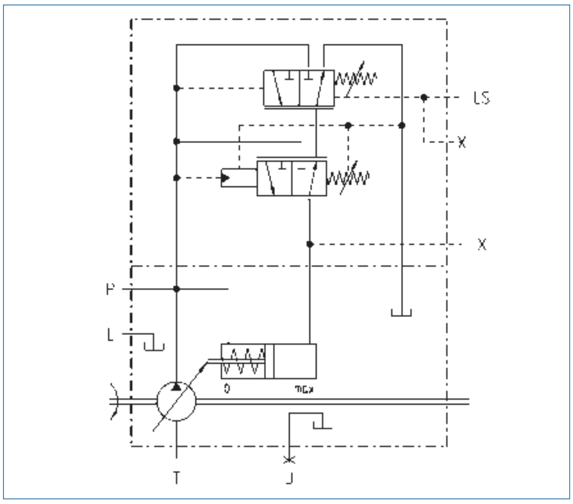
HPR 135-02 LP

HPR 135-02 LP

One advantage of hydraulic systems is their simple protection against overloads. Nonetheless, relying on the response of high pressure-relief valves during overload is inefficient because the fluid power dissipated is uncontrolled and generates excessive heat. The fast response of the pressure cut-off valve in an HPR pump means that there are no power losses due to the slow response by pressure relief valves. The pump displacement is limited by the maximum pressure regulator whilst, at the same time, maintaining the operating pressure.

The pump displacement can be reduced to near zero during this operating period, only delivering sufficient flow to make up system leakage in order to maintain the system pressure. The pump can stay at this operating point for considerable periods thus demanding minimal power, which is highly advantageous for the overall energy consumption of the system.

Similar to the situation described under Section 5.2, in this mode the pump is also controlled solely by the LS regulator characteristic. Here as well the pump/valve system can operate at any point below the power hyperbola. The LS regulator is not overridden until the pressure set on the maximum pressure regulator is reached, when the pump is reduced to near zero displacement.



6. NOISE OPTIMISATION WITH SPU SILENCER

HPR 105-02 LP, SPU

HPR 105-02 LP, SPU

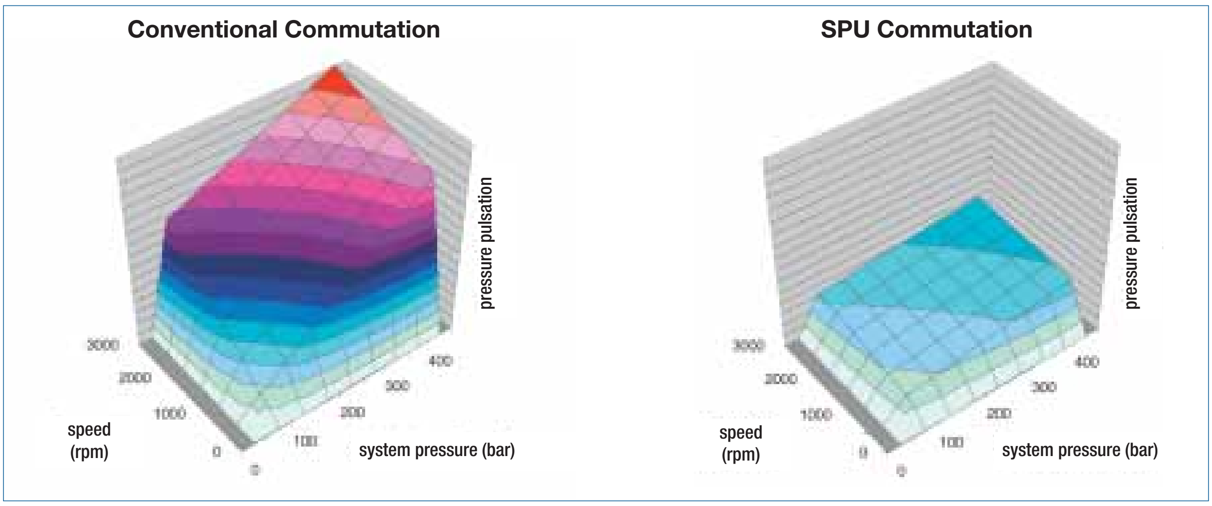
The noise characteristics of a hydraulic pump have become a major quality feature, not least because of increased environmental awareness. Linde have taken account of this and developed an appropriate technical solution.

In principle, every hydraulic system will inevitably develop noise, regardless of which components are coupled together (pumps, motors, valves, orifices, restrictors, piping). These noises are ultimately transmitted to the human ear as airborne noise. This airborne noise is the result mainly of structure-borne noise (caused by the inevitable pressure changes), that in turn is largely fed by fluid noise (caused by the equally inevitable pressure pulsation due to the number of working pistons, the compressibility of the pressure fluid and valve operation). Every hydraulic circuit is inescapably associated with this unwanted noise sequence.

The task of the designer is to minimise noise where it occurs and to check or prevent its propagation as much as possible. Linde designers, together with an experienced research team, have come up with an optimal solution to this problem for the HPR-02 open loop pump.

Noise is now reduced as soon as it occurs. The measures taken are primary measures, which are always more effective than measures introduced subsequently into an existing system (secondary measures). Secondary measures are always time-consuming and costly.

Pressure pulsating is disadvantageous, not only in terms of noise development but also because of the mechanical load on all the components and parts of the overall hydraulic circuit. The main cause of pressure



Influence of Speed and System Pressure

pulsation is the finite number of working pistons in conjunction with the high pressure produced by the pump, and the pump speed.

The volume flow and pressure pulsations are both significantly reduced by a self-compensating silencer. This results in a major reduction in the fluid and structure-borne noise emitted from the pump and consequently in a considerable reduction of the overall system noise.

The fact that the technical solution realised keeps pulsation at a low level over the entire operating range (pressure, speed, temperature), is highly advantageous and in turn leads to a balanced noise characteristic of the system over the whole operating cycle. However, it should not be forgotten that by far the largest noise component is generated, not by the pump, but by vibration of the mechanical elements of the whole system (sheet metal parts, floors, walls, girders, mountings, etc.).

The solution found to produce a substantial reduction in noise emissions is the

Linde SPU Silencer

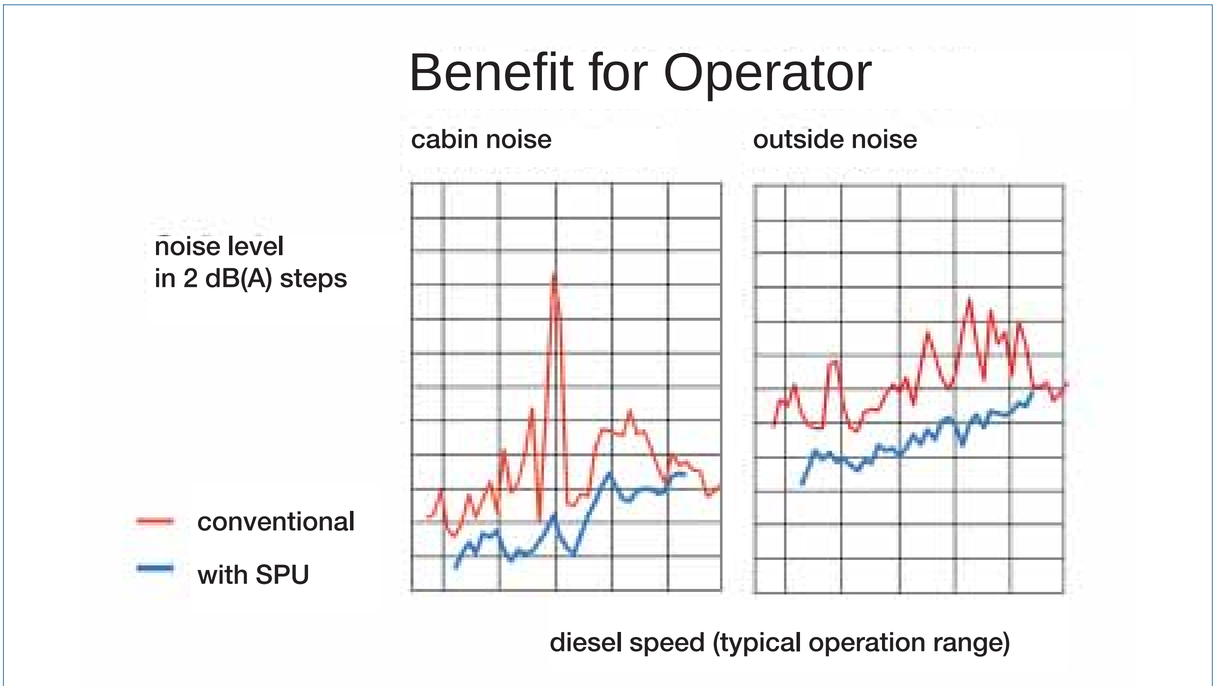
which consists of an optimised arrangement of an additional chamber (silencer chamber) immediately adjacent to the valve (timing) plate and therefore to the prime source.

This new concept of a silencer chamber enables major practical requirements to be met and these are:

- a reduction in volume fluctuations over a wide operating range
- a reduction in pressure pulsation over a wide operating range
- no decrease in efficiency
- simple, maintenance-free design
- acceptable weight and volume increases
- self-compensating, so no adjustment necessary

Figure (page 14) shows a comparison of the pressure pulsation as a function of high pressure and speed in a standard unit and in a unit optimised with a silencer. The reduction in pressure pulsating, resulting directly in a marked reduction in noise is clear.

Figure (page 15) shows a comparison of the noise level of a standard unit and of a unit optimised with a silencer as a function of the prime mover (e.g. diesel engine) speed. The significantly reduced noise level of the SPU variable capacity pump is striking. Not only does the noise reduction apply over the entire speed range both inside and outside the cabin, but also the peaks are smoother than those occurring with the standard unit.



7. DOUBLE AND MULTIPLE PUMPS

Double Pump HPR 105D-02 E1L, SPU

Multiple Pump with SAE3 bell housing
HPR 135-02 LP, SPU + HPV 105-02 E1

Multiple Pump with SAE3 bell housing
HPR 135-02 LP + HPV 105-02 E1 + MPR 45 LP + double gear pump

Double and multiple pumps consist of single units arranged in series.

The swash plate design is highly advantageous for this.

Multiple Pump:	HPR regulated pump coupled to an HPV variable displacement pump
Double Pump:	2 equal-sized pump bodies arranged back-to-back, 1 common suction manifold, 2 pressure manifolds Option: 1-circuit pump or 2-circuit pump

Multiple pumps may consist of only open circuit pumps or only closed circuit pumps but it is also possible to combine both types and the order of their assembly (i.e. 1st pump/2nd pump + further pumps) is, in essence, completely free. Similarly, their orientation to each other (e.g. respective positions of controls, regulators and/or pressure and suction ports) is flexible and determined only by installation limitations. The critical factor ruling the order of the individual units is primarily the admissible shaft torque that can be transmitted from one to the other. The timing of their respective work cycles is predominant when considering this.

Knowledge of each pump's load cycle is, therefore, the key to the unit assembly order and thus ensuring reliable and trouble-free operation.

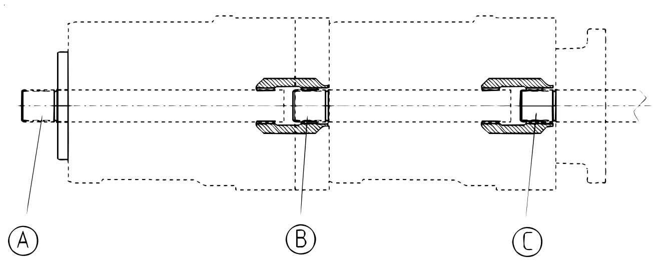
The Tandem Pump is, by definition, a special multiple pump usually comprising two equal size units of the same type and orientation of controls/regulators and porting.

Otherwise, the individual units in a Multiple Pump assembly may be of differing sizes, types and orientations.

Possible Combinations

Rated size of the rear pump \ Rated size of the front pump	55	75	105	135	210
55	yes	yes	yes	yes	yes
75	-	yes	yes	yes	yes
105	-	-	yes	yes	yes
135	-	-	-	yes	yes
210	-	-	-	-	yes

Transmittable Shaft Torques



Max. transmittable torque \ Nominal size of the front pump			55	75	105	135	210
at A		**[Nm]**	570	790	1090	1410	2174
at B	**with rear pump nominal size**	**55 [Nm]**	350	485	570	570	350
	with rear pump nominal size	**75 [Nm]**	-	485	670	790	485
	with rear pump nominal size	**105 [Nm]**	-	-	670	870	670
	with rear pump nominal size	**135 [Nm]**	-	-	-	870	870
	with rear pump nominal size	**210 [Nm]**	-	-	-	-	1338
at C	**(at the PTO)**	**[Nm]**	see the Table in Chapter 8				

8. POWER TAKE-OFF (PTO)

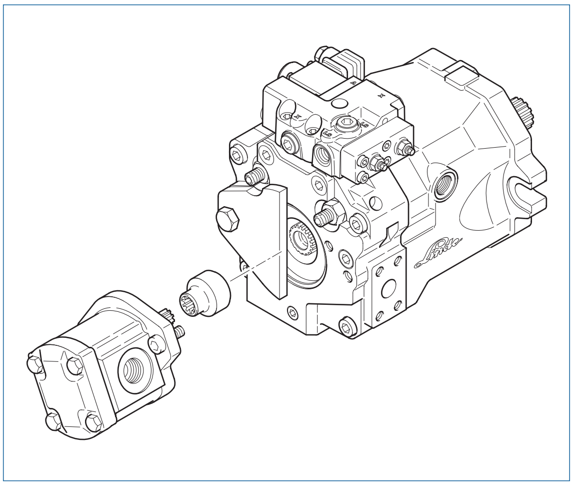
HPR 105-02 LP, SPU with PTO-connection SAE A

HPR 75-02 TL, SPU with pilot pump added

Technical description

Ancillary drives, e.g. for further working pumps, drive pumps, cooling pumps, power steering pumps or servo pumps, can be connected via the spline on the end of the pump through-drive shaft.

The Power Take-Off (PTO) can be fitted with an SAE A-, B-, B-B- or C- flange, as required. The SAE A connection has no intermediate flange and the coupling sleeve is lining up with the HPR shaft end. SAE B, B-B and C connections use an intermediate flange together with a coupling sleeve.



SAE A attachment (directly mounted)

Transfer Torque at the HPR through-shaft end

Nominal size	55	75	105	135	210
Continuous (Nm)	220	305	420	540	836
Max. (Nm)	350	485	670	870	1338

For exact dimensions, please, refer to respective Installation Drawing (EBZ)

9. PRESSURE FLUIDS AND FILTRATION

Permitted Pressure Fluids

- Mineral oil HLP to DIN 51524
- Biodegradeable fluids upon request
- Other pressure fluids upon request

Technical Data

Working Viscosity Range	[mm²/s] = [cSt]	10 to 80
Optimum Working Viscosity	[mm²/s] = [cSt]	15 to 30
Max. Viscosity (short time start up)	[mm²/s] = [cSt]	1000

The hydraulic components and parts are designed for a temperature range of -20 °C to max. +90 °C.

Viscosity Recommendations

Working temperature [°C]	Viscosity class [mm²/s] = [cSt] at 40 °C
ca. 30 to 40	22
ca. 60 to 80	46 or 68

Linde recommend using only pressure fluids which are confirmed by the producer as suitable for use in high pressure hydraulic installations. For the correct choice of suitable pressure fluid it is necessary to know the working temperature in the hydraulic circuit. The pressure fluid chosen must allow the working viscosity to be within the optimum viscosity range (refer to above table).

Attention!
Due to pressure and speed influences the leakage fluid temperature is always higher than the circuit temperature. The temperature must not exceed 90 °C in any part of the system. Under special circumstances, if the stated conditions cannot be observed then please consult Linde.

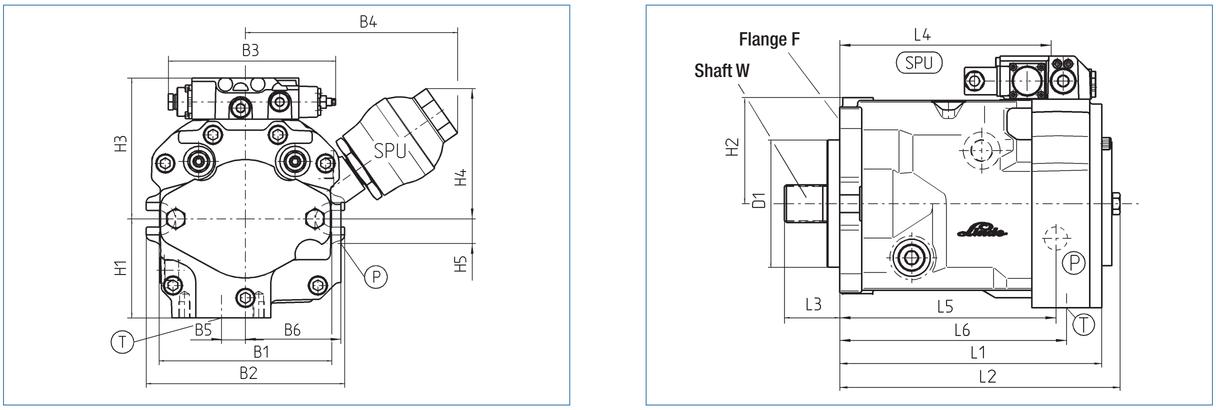
Filtration

In order to guarantee proper functions and efficiency of the hydraulic pumps the purity of the pressure fluid over the entire operating period, must comply to at least class 18/13 according to ISO 4406. With modern filtration technology, however, much better values can be achieved which contributes significantly to extending the life and durability of the hydraulic pumps and complete system.

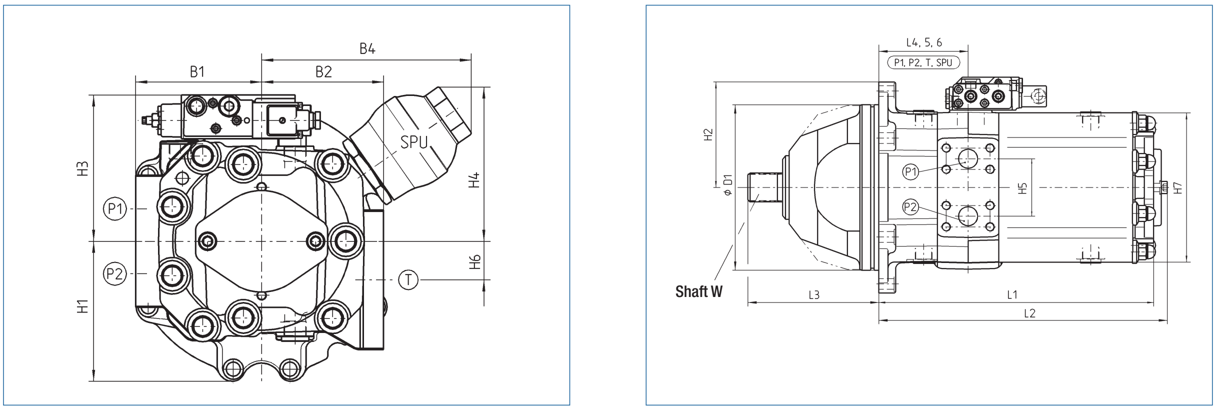
10. MAIN DIMENSIONS

Size	55	75	105	135	210	2x105	2x105
Mounting Flange F	SAE C			SAE D	SAE E	plug-in	SAE 3
Fixing	2-hole				4-hole*	-	bell
Shaft Profile W	ANSI B92.1						
Spline pitch	12/24		16/32		8/16	16/32	16/32
Teeth	14		23	27	15	23	23
D1 [mm]	127			152,4	165,1	216	409,6
D2 [mm]	-			-	-	-	428,6
D3 [mm]	-			-	-	-	456
B1 [mm]	181			229	225□	124	124
B2 [mm]	208			256	269□	120	120
B3 [mm]	176			173	174	-	-
B4 [mm] (SPU)	215		222	236	262	222	222
B5 [mm] (T)	21		25	40	57	-	-
B6 [mm] (P)	91		100	107	145	-	-
H1 [mm]	94		104	120	145	141	141
H2 [mm]	93		106	100	135	141	141
H3 [mm]	145		148	155	178	144	144
H4 [mm] (SPU)	147		137	146	145	137	137
H5 [mm] (P)	24		26	30	27	75	75
H6 [mm]	-		-	-	-	38	38
H7 [mm]	-		-	-	-	196	196
L1 [mm]	232		262	285	346	358	450
L2 [mm]	250		280	303	370	376	468
L3 [mm]	55			75		171	79
L4 [mm] (SPU)	192		215	236	278	116	208
L5 [mm] (P)	194		218	244	293	116	208
L6 [mm] (T)	201		227	250	296	116	208
P (SAE) pressure port	¾"		1"	1¼"	1½"	2 x 1"	2 x 1"
T (SAE) suction port	1½"		2"	2"	3 "	1 x 3"	

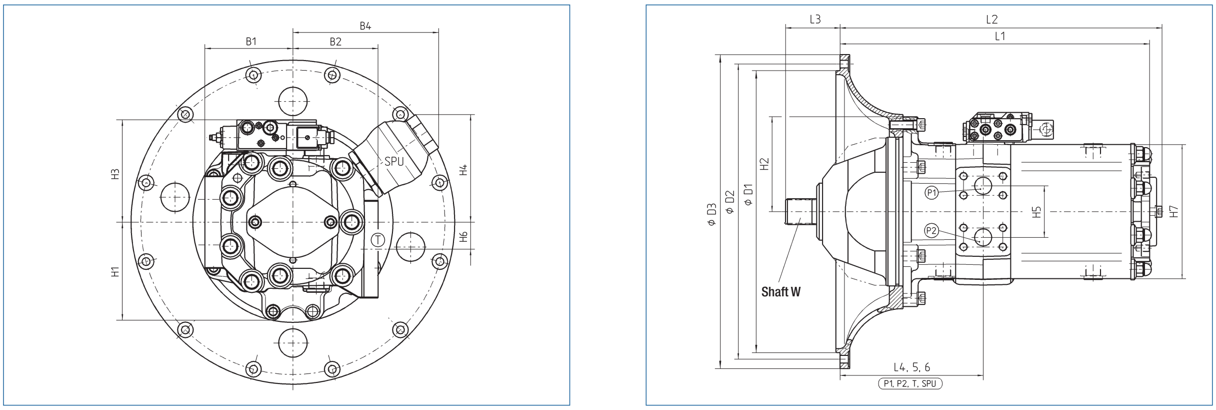
*HPR 210-02 with square 4-hole-mounting-flange (not shown in schematics of page 21)



Single Pump HPR-02 E1L, SPU

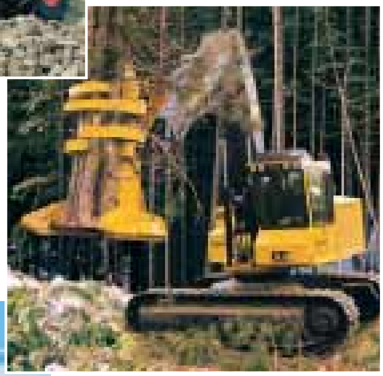


Double Pump HPR-105 D-02 E1L, SPU
plug-in version (without bell housing)



Double Pump HPR-105 D-02 E1L, SPU
with SAE 3 bell housing

11. APPLICATIONS



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