HANSA-FLEX

TECHNICAL INFORMATION **HYDRAULIC COMPONENTS**

REV. A / 10 / 2024

Technical information Hydraulic components

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Technical information for hydraulic components

1. General

The potential hazards to man and the environment posed by hydraulic systems are very often underestimated in practice. The wrong choice or improper use of components, hoses, fittings and accessories can compromise the product's functional reliability, causing it to fail and possibly pose a threat of personal injury or material damage. Hydraulic fluid injections, torn-out fittings and ruptured lines can cause severe or fatal injuries. Exceeding the maximum permissible working pressure must always be avoided.

We expressly recommend that the applicable safety guidelines are strictly observed!

The machine operator (the employer) also bears a particular responsibility.

The machine operator is responsible for:

- Ensuring that all components and parts are used only for their intended purpose
- Scheduled monitoring and systematic inspection by qualified persons
- Detecting and eliminating defects
- Carrying out planned maintenance activities such as the replacement of hose lines

This active assumption of responsibility is enshrined in the legal framework. Based on the principles of industrial safety, the German equipment and product safety act, the EU machinery and pressure equipment directives and the ordinance on industrial safety and health, tasks are to be specified further and set out in procedural regulations for those concerned.

2. Information on the Machinery Directive 2006/42/EC regarding components and assemblies from HANSA-FLEX AG

The EU Machinery Directive (MD) 2006/42/EC came into force on 29.12.2009 and directly replaced Directive 98/37/EC. The aims of the Machinery Directive are to ensure high levels of safety and quality for machines / machinery and to facilitate the free movement of goods within the European Union.

Components and assemblies from the HANSA-FLEX AG product range are generally not subject to this directive.

Directive 2006/42/EC demands from the machine manufacturer the identification of the necessary safety functions with the definition of a safety level for the safety-related control system. Relevant in this sense are only the components used in the safety circuit, such as for the dead man’s circuit or safety temperature controller. These safety components are components that are not necessary for the actual function of the machine or that can be replaced by components that are normally used for the function of the machine. Only in these circumstances would hydraulic components be regarded as safety components and would have to bear the CE marking. If these special safety components are placed on the market, the MTBF values (mean time between failures) for calculation of the performance level (PL) are to be shown in the documentation.

With the coming into force of the MD 2006/42/EC, manufacturer’s declarations are no longer issued for components and assemblies. For components requiring a CE marking, an EC Declaration of Conformity is issued.

An important extension to the scope of the MD 2006/42/EC is “partly completed machinery”. According to the CETOP position paper PP07 dated 26 June 2009 on the Machinery Directive 2006/42/EC, hydraulic power units are specifically included under “partly completed machinery”.

Because partly completed machinery is intended to be installed in other machinery, it needs to be accompanied on delivery only by a Declaration of Incorporation and the Assembly Instructions. After installation, these documents become a constituent part of the operating instructions for the machinery in which the partly completed machinery was installed. While the Declaration of Incorporation must be issued in the official EU language of the country of use, the Assembly Instructions must be drawn up in an official EU language accepted by the manufacturer of the machinery in which the partly completed machinery is installed, or its authorised representative. We recommend choosing the official EU language of the country in which the assembly of the partly completed machinery is to take place.

The components, assemblies and power units supplied by HANSA-FLEX AG are in accordance with the provisions of the EU directives valid at the time and the product-specific national and international standards and safety regulations.

3. Commissioning of hydraulic systems

The proper functioning of hydraulic systems presupposes compliance with the respective commissioning and maintenance instructions. All work on hydraulic systems and the components contained must be carried out in strict observance of the safety regulations. There must be no pressure inside the hydraulic circuit, i.e. loads must be lowered, pumps switched off and pressure accumulators relieved.

The maximum loads (pressures, forces, temperatures) given in the product documentation must not be exceeded. Furthermore, the hydraulic system must be protected by a pressure relief valve (even if a variable displacement pump with a pressure regulator is used) and contamination must be prevented by the use of appropriate filters.

Installation and commissioning of hydraulic systems or their components may be carried out only by suitably qualified personnel. This applies in particular to the connection and commissioning of all electrical assemblies, such as electric motors and electrically actuated components. Operating voltages and the direction of rotation of the electric motor and the pump must be strictly observed.

Hydraulic systems with electronic controllers are subject to special commissioning conditions. Pressures and speeds of the pump(s) must first be set to a low value in order to avoid damage caused by faults in the circuitry (electrical or hydraulic). Only when it is certain that the switching sequences are correct, the consumers are correctly controlled and limits are properly monitored by limit switches etc. can pressure and delivery rates be increased to the required values.

Hydraulic systems and components may only be employed for their intended use. With pipe and hose installations, all lines must be flushed and welded pipes must be inspected and, if necessary, pickled. Only approved screw fittings and seal systems may be used for sealing.

The hydraulic systems must be filled with the hydraulic fluids of the specified viscosity class intended for their operation.

4. Fundamental calculation formulae

Formula lexicon / Hydraulic pump

Flow rate	$Q_{eff} = \frac{V \cdot n \cdot \eta_{vol}}{1000} \left[\frac{l}{min}\right]$	Q_{eff} = Effective flow rate of hydraulic pump [l/min] V = Geometric displacement [cm³] η_{vol} = Volumetric efficiency n = Drive speed of the pump [rpm] (Standard speeds of electric motors: 2800/1450/1000 rpm)
Displacement	$V = \frac{Q_{eff} \cdot 1000}{n \cdot \eta_{vol}} \left[cm^3 / U\right]$	V = Geometric displacement [cm³] Q_{eff} = Effective flow rate of hydraulic pump [l/min] η_{vol} = Volumetric efficiency n = Drive speed of the pump [rpm] (Standard speeds of electric motors: 2800/1450/1000 rpm)
Drive power	$P_{An} = \frac{p \cdot Q_{eff}}{600 \cdot \eta_{ges}} [kW]$	PAn = Required drive power of the pump [kW] P = Working pressure [bar]; [daN/cm²] Q_{eff} = Effective flow rate of hydraulic pump [l/min] η_{ges} = Overall efficiency (0.8 – 0.85)
Overall efficiency	$\eta_{ges} = \eta_{mech} \cdot \eta_{vol}$	η_{ges} = Overall efficiency (0.8 – 0.85) η_{mech} = Mechanical efficiency (0.9 – 0.95) ηvol = Volumetric efficiency (0.9 – 0.95)
Drive torque	$M_{an} = \frac{\Delta p \cdot V \cdot 1,59}{100 \cdot \eta_{mech}} [Nm]$	M_{an} = Drive torque Δp = Pressure difference between inlet and outlet port of pump [bar] or [daN/cm2] V = Geometric displacement [cm3] η_{mech} = Mechanical efficiency (0.9 – 0.95) 1.59 = $\frac{10}{2\pi}$

Formula lexicon / Hydraulic motor

Displacement flow rate	$Q = \frac{V \cdot n}{1000 \cdot \eta_{vol}} \left[\frac{l}{min}\right]$	Q = Displacement flow rate of hydraulic motor [l/min] V = Geometric displacement [cm³] η_{vol} = Volumetric efficiency n = Output speed of the hydraulic motor [rpm]
Output speed	$n = \frac{Q \cdot \eta_{vol} \cdot 1000}{V} \left[min^{-1}\right]$	n = Output speed of the hydraulic motor [rpm] Q = Displacement flow rate of hydraulic motor [l/min] V = Geometric displacement [cm³] η_{vol} = Volumetric efficiency
Output torque	$M_{ab} = \frac{\Delta p \cdot V \cdot \eta_{mech}}{2\pi \cdot 100} [daNm]$ $M_{ab} = \frac{1,59 \cdot V \cdot \Delta p \cdot \eta_{mech}}{1000} [Nm]$	M_{ab} = Output torque Δp = Pressure difference between inlet and outlet port of motor [bar] or [daN/cm²] V = Geometric displacement [cm³] η_{mech} = Mechanical efficiency (0.9 – 0.95)
Drive power	$P_{ab} = \frac{\Delta p \cdot Q \cdot \eta_{ges}}{600} [kW]$	P_{ab} = Drive power of hydraulic motor [kW] Δp = Pressure difference between inlet and outlet port of motor [bar] or [daN/ cm²] Q = Displacement flow rate of hydraulic motor [l/min] η_{ges} = Overall efficiency (0.8 – 0.85)

Formula lexicon / Hydraulic cylinders – geometric dimensions

Piston area	$A_K = \frac{\pi}{4} \bullet \frac{d_K^2}{100} \ [cm^2]$	A_K = Piston area of the hydraulic cylinder [cm2] d_K = Piston diameter of the hydraulic cylinder [mm] π = pi ~ 3.14
Piston rod area	$A_S = \frac{d_S^2 \bullet 0,785}{100} \ [cm^2]$	A_S = Piston rod area of the hydraulic cylinder [cm2] d_S = Piston rod diameter of the hydraulic cylinder [mm] 0.785 = $\frac{\pi}{4}$
Piston annulus area	$A_R = \frac{(d_K^2 - d_S^2) \bullet 0,785}{100} \ [cm^2]$	A_R = Piston annulus area of the hydraulic cylinder [cm2] d_K = Piston diameter of the hydraulic cylinder [mm] d_S = Piston rod diameter of the hydraulic cylinder [mm]

Formula lexicon / Hydraulic cylinders – forces

Compressive force F_D

Tensile force F_Z

Differential force F_S

Force (general)	$F = p \bullet A \ [daN]$	F = Force [daN] p = Working pressure [bar] or [daN/cm²] A = Effective area [cm²]
Pressure (general)	$p_{th} = \frac{F}{A} \left[\frac{daN}{cm^2}\right]$	p_{th} = Theoretical pressure without allowance for any frictional losses [daN/cm²] F = Force [daN] A = Effective area [cm²]
Effective compressive force FD	$F_{D(eff)} = \frac{p \bullet d_K^2 \bullet 0,785 \bullet \eta}{10.000} \ [kN]$	FD_{eff} = Effective compressive force of hydraulic cylinder [kN] p = Working pressure [bar] or [daN/cm²] d_K = Piston diameter of the hydraulic cylinder [mm] η = Extending efficiency
Effective tensile force FZ	$F_{Z(eff)} = \frac{p \bullet (d_K^2 - d_S^2) \bullet 0,785 \bullet \eta}{10.000} \ [kN]$	FZ_{eff} = Effective tensile force of hydraulic cylinder [kN] p = Working pressure [bar] or [daN/cm²] d_K = Piston diameter of the hydraulic cylinder [mm] d_S = Piston rod diameter of the hydraulic cylinder [mm] η = Retraction efficiency
Effective differential force FS	$F_{S(eff)} = \frac{p \bullet d_S^2 \bullet 0,785 \bullet \eta}{10.000} \ [kN]$	FS_{eff} = Effective differential force of hydraulic cylinder [kN] p = Working pressure [bar] or [daN/cm²] d_S = Piston rod diameter of the hydraulic cylinder [mm] η = Extending efficiency

Efficiency η of hydraulic cylinders: Extend 95% (0.95), retract 92% (0.92)

Formula lexicon / Hydraulic cylinders – speeds and stroke times

Stroke speed	$v = \frac{s}{t \bullet 1.000} \left[\frac{m}{s}\right]$	v = Stroke speed [m/s] s = Cylinder stroke [mm] t = Extension or retraction time over complete stroke [s]
Stroke speed	$v = \frac{Q}{A \bullet 6} \left[\frac{m}{s}\right]$	v = Stroke speed [m/s] Q = Inlet volumetric flow at hydraulic cylinder [l/min] A = Effective area [cm²]

Formula lexicon / Hydraulic cylinders – speeds and stroke times

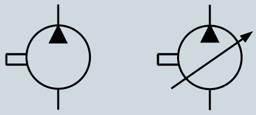
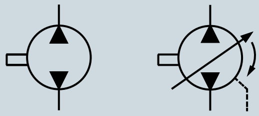
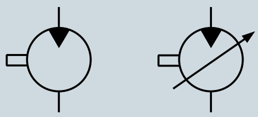
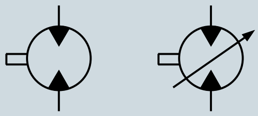
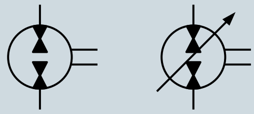
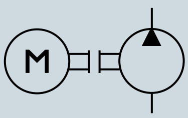
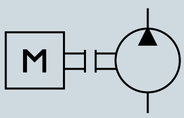
Required (theoretical) flow rate	$Q_{th} = A \bullet v \bullet 6 \left[\frac{l}{min}\right]$	Q_{th} = Required (theoretical) flow rate of the hydraulic pump without leakage losses [l/min] A = Effective area [cm²] v = Stroke speed [m/s]
	$Q_{th} = \frac{V}{t} \bullet 60 \left[\frac{l}{min}\right]$	Q_{th} = Required (theoretical) flow rate of the hydraulic pump without leakage losses [l/min] V = Effective volume [l] or [dm³] t = Extension or retraction time over complete stroke [s]
Required flow rate for “Extend”	$Q_{th} = \frac{0,785 \bullet d_K^2 \bullet s \bullet 6}{t \bullet 100.000} [l/min]$	Q_{th} = Required (theoretical) flow rate of the hydraulic pump without leakage losses [l/min] d_K = Piston diameter of the hydraulic cylinder [mm] s = Cylinder stroke [mm] t = Extension or retraction time over complete stroke [s]
Required flow rate for “Retract”	$Q_{th} = \frac{0,785 \bullet (d_K^2 - d_S^2) \bullet s \bullet 6}{t \bullet 100.000} [l/min]$	Q_{th} = Required (theoretical) flow rate of the hydraulic pump without leakage losses [l/min] d_K = Piston diameter of the hydraulic cylinder [mm] s = Cylinder stroke [mm] t = Extension or retraction time over complete stroke [s]
Required (effective) flow rate	$Q_{eff} = \frac{Q_{th}}{\eta_{vol}} \left[\frac{l}{min}\right]$	Q_{eff} = Required (effective) flow rate of the hydraulic pump [l/min] Q_{th} = Theoretical flow rate of the hydraulic pump [l/min] η_{vol} = Volumetric efficiency
Extension or retraction volume	$V = \frac{A \bullet s}{10.000} [l]$	V = Effective volume [l] or [dm³] A = Effective area [cm²] s = Cylinder stroke [mm]
Stroke time	$t = \frac{A \bullet s \bullet 6}{Q \bullet 1.000} [s]$	t = Extension or retraction time over complete stroke [s] A = Effective area [cm²] s = Cylinder stroke [mm] Q = Inlet volumetric flow at hydraulic cylinder [l/min]

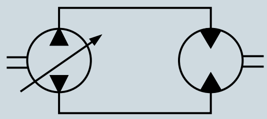
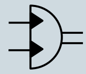
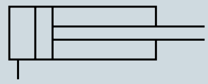
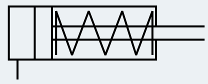
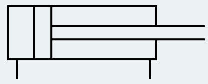
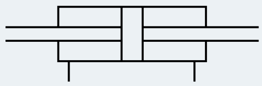
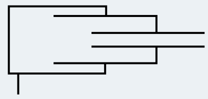
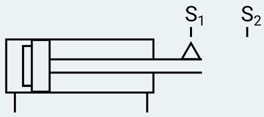
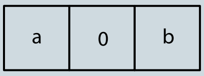
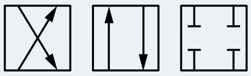
Formula lexicon / Pressure losses in straight pipelines

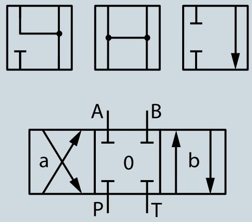
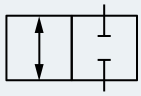
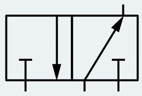
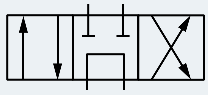
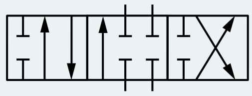
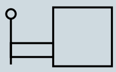
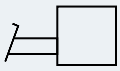
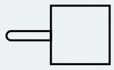
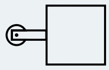
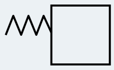
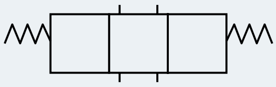
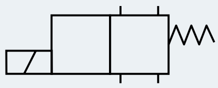
Pressure loss	$\Delta p = \lambda \bullet \frac{l \bullet \rho \bullet \omega^2 \bullet 5}{d} [bar]$	Δp = Pressure loss in straight pipelines (laminar or turbulent flow) [bar] λ = Pipe coefficient of friction l = Line length in [m] ρ = Density (~0.89) [kg/dm³] ω = Flow velocity [m/s] d = Inside diameter of the pipeline [mm]
Pipe coefficient of friction for laminar flow	$\lambda_{lam} = \frac{64}{Re}$	λ_{lam} = Pipe coefficient of friction for laminar flow Re = Reynolds number
Pipe coefficient of friction for turbulent flow	$\lambda_{turb} = \frac{0,316}{\sqrt{Re}}$	λ_{turb} = Pipe coefficient of friction for turbulent flow Re = Reynolds number

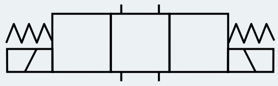
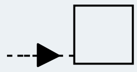
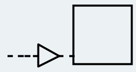
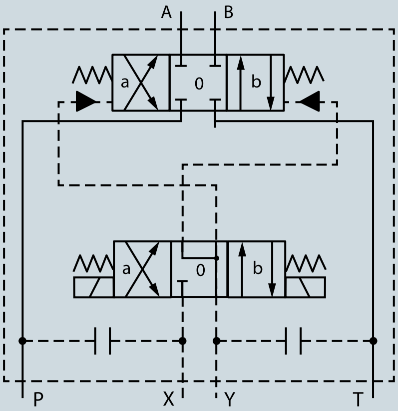
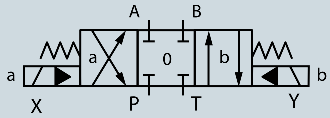
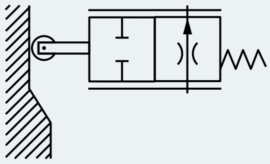
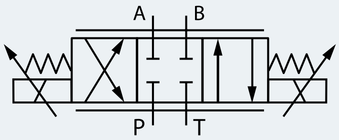
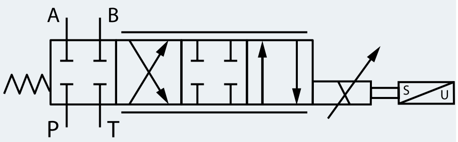
Formula lexicon / Flow velocities in pipelines		
Reynolds number	$Re = \frac{\omega \cdot d}{v} \cdot 1000$	Re = Reynolds number ω = Flow velocity [m/s] d = Inside diameter of the pipeline [mm] v = Kinematic viscosity of the fluid [cSt] or [mm²/s]
Flow velocity	$Re = 21232 \frac{Q_{eff}}{d \cdot v}$	Re = Reynolds number Qeff = Fluid flow rate in the pipeline [l/min] d = Inside diameter of the pipeline [mm] v = Kinematic viscosity of the fluid [cSt] or [mm²/s]
Determination of the pipe inside diameter in pressure lines	$\omega = \frac{Q_{eff}}{d^2} 21{,}232 \left[\frac{m}{s}\right]$	ω = Flow velocity [m/s] Qeff = Fluid flow rate in the pipeline [l/min] d = Inside diameter of the pipeline [mm]
Pipe coefficient of friction for turbulent flow	$d = \sqrt{\frac{Q_{eff}}{\omega} \cdot 21{,}232}\ [mm]$	d = Inside diameter of the pipeline [mm] Qeff = Fluid flow rate in the pipeline [l/min] ω = Flow velocity [m/s]

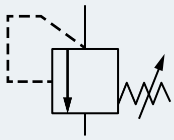
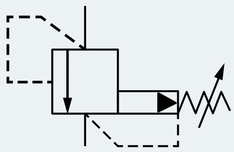
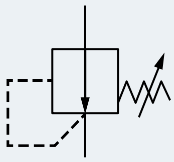
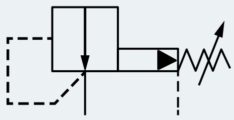
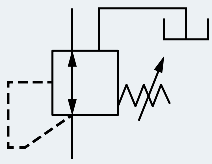
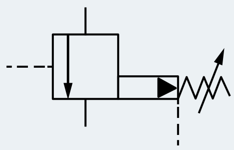
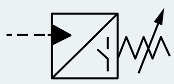
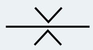
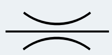
5. Circuit symbols

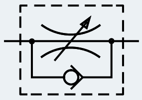
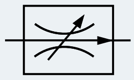
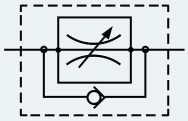
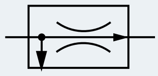
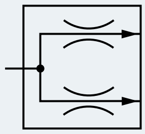
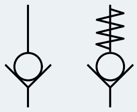
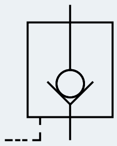
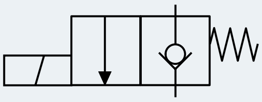
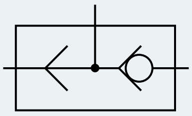
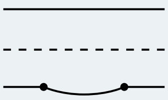
Designation	Explanation	Symbol
PUMPS	Conversion of mechanical into hydraulic energy	Displacement volume constant variable
• With one flow direction		
• With two flow directions (reversible)		
HYDRAULIC MOTORS	Units that function both as pumps and as hydraulic motors	constant variable
• With one flow direction		
• With two flow directions		
PUMP/MOTOR	Conversion of hydraulic energy into mechanical energy with rotational movement	constant variable 
PUMP DRIVE	With electric motor	
	With internal combustion engine	

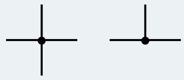
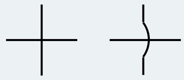
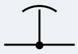
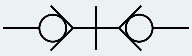
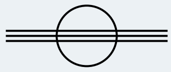
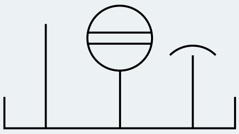
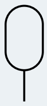
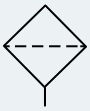
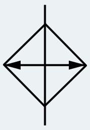
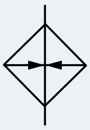
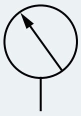
Designation	Explanation	Symbol
HYDROSTATIC GEARBOXES	Torque converter, consisting of variable displacement pump and hydraulic motor	
SWIVEL MOTOR	Rotation angle < 360°	
CYLINDERS • Single-acting	Conversion of hydraulic energy into mechanical energy with linear movement	
• Single-acting with spring return		
• Double-acting differential cylinder		
• Double-acting cylinder with piston rod on both sides		
• Cylinder with end position cushioning		
• Cylinder with adjustable cushioning on both sides		
• Telescopic cylinder		
• Cylinder with limit switches		
DIRECTIONAL CONTROL VALVES Valves that serve to open and shut off different flow paths. Directional control valves are essentially characterised by • the number of switching positions; represented by a corresponding number of squares, identified by 0, a, b (*)		
• the number of ports and connections within the switching positions; • represented by lines and arrows		

Designation	Explanation	Symbol
Identification of the ports with letters (in the home position 0)* P... Pump, pressure T... Tank, return line A, B... Consumer X,Y,Z... Control ports L... Leak oil Designation, e.g.: 4/3-way valve 3 → Number of switching positions 4 → Number of ports		
• 2/2-way valve		
• 3/2-way valve		
• 4/3-way valve (pressureless circulation)		
• 6/3-way valve		
METHODS OF ACTUATION FOR DIREC-TIONAL CONTROL VALVES **a) Direct acting** • Hand lever, with latching	Installation in the respective switching position	Version ISO 1219-1 
• Pedal	Rotation angle < 360°	
• Tappet	Conversion of hydraulic energy into mechani-cal energy with linear movement	
• Roller		
• Spring return		
• Spring centring		
• Electromagnetic actuation	Example: On one side with spring return Example: On two sides with spring return	

Designation	Explanation	Symbol
• Hydraulic actuation		
• Pneumatic actuator		
• Cylinder with limit switches		
b) Pilot-controlled • Hydraulically actuated, electromagnetically controlled	Larger directional control valves are actuated hydraulically via a pilot valve. This pilot valve is in turn controlled electrically or pneumatically.	 
THROTTLING DIRECTIONAL CONTROL VALVES Directional control valves with stepless transition between the individual switching positions with variable throttling effect. Represented by parallel lines over the length of the symbol.		
• Sensor valve with roller tappet, acting against a return spring		
• Electrohydraulic proportional directional control valve		
• Electrohydraulic control valve with position control of the valve spool		

Designation	Explanation	Symbol
PRESSURE VALVES Valves which influence the pressure. Represented by a single square with an arrow, the throttling cross-section is infinitely variable.		
• Pressure-relief valve; directly controlled	Normally closed; opens when the set inlet pressure is reached	
• Pressure-relief valve; pilot-controlled	Control oil discharge normally internal	
• Pressure reduction valve (pressure control valve); directly controlled	Normally open; closes when the set outlet pressure is reached; external leak oil port	
• Pressure reduction valve; pilot-controlled	Control oil discharge only external	
• 3-way pressure reduction valve; directly controlled	On relief of the consumer via the third port	
• Externally controlled sequence valve; pilot-controlled	Switches a hydraulic connection when the set pressure is reached	
• Pressure switch	Switches an electrical connection when a certain pressure is reached	
FLOW CONTROL VALVES Valves which influence the volumetric flow. Represented by a constriction of the line cross-section.		
• Orifice	Short throttled length	
• Throttle (fixed or variable)	Volumetric flow dependent on the	 

Designation	Explanation	Symbol
• Flow control check valve	pressure difference	
• Flow control valve	Volumetric flow independent of the pressure difference or load	
	With bypass non-return valve	
• 3-way flow regulating valve	Excess flow is diverted via the third port (irrespective of viscosity, orifice)	
• Flow divider	Split in a fixed ratio	
SHUT-OFF VALVES Valves which seal off pressure and volumetric flow in one direction by means of a valve seat.		
• Check valve	With or without closing spring	
• Closed check valve	Opens the closed direction when pressure is applied to the control port	
• Magnetically actuated seat valve	Opens the closed direction when electricity is supplied to the solenoid	
• Shuttle valve	"OR" function	
LINES AND CONNECTIONS		
• Lines	Main lines Control and leak oil lines Flexible hoses	

Designation	Explanation	Symbol
• Line connection		
• Crossed line without connection		
• Venting		
• Quick release coupling		
• Rotary connection		
OIL TREATMENT, MEASURING INSTRUMENTS, MISCELLANEOUS		
• Tank with lines, oil level indicator and vent		
• Hydraulic accumulator		
• Filter		
• Cooler		
• Heater		
• Pressure gauge		
• Volume flow meter