Technical Information

TECHNICAL INFORMATION – HYDRAULIC COMPONENTS

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1. GENERAL NOTES

The potential hazards to man and the environment posed by hydraulic systems is 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 posing a threat of personal injury or material damage. In extreme cases, violently spraying oil, shearing fittings and ruptured lines can even cause fatal injuries. Exceeding of the maximum permissible working pressure must be avoided.

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

The owner of machines also bears a particular responsibility.

He is responsible for:
- Ensuring that all components and parts are used only for their intended purpose
- Scheduled monitoring and systematic inspection by qualified persons
- Identifying and eliminating defects
- Scheduled maintenance and replacement of hoses

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

2. 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 oil-dynamic 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 and soiling must be prevented by the use of appropriate filters.

Installation and commissioning of hydraulic systems or their components may only be carried out 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 (with DC motors also the polarity) 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 you have ensured 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 respective intended use. With pipe and hose installations, all lines must be flushed and welded pipes must be inspected and pickled, if necessary. Only approved screws fittings and seal systems may be used for sealing.

The hydraulic systems must be filled with the hydraulic fluids intended for their operation. The components in this catalogue are designed for use with mineral oils to DIN 51524 Part 2 HLP (viscosity 32 – 68 mm^2/s at 40°C). Use of other hydraulic fluids (e.g. rapidly biodegradable oils, water/glycol mixtures, etc.) is possible only after consultation with us.

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3. FUNDAMENTAL CALCULATION FORMULAE

Formula lexicon ➜ Hydraulic pump		
Displacement	$Q_{eff} = \frac{V \cdot n \cdot \eta_{vol}}{1000} \left[\frac{l}{min}\right]$	Q_{eff} = Effective displacement 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)
Delivery rate	$V = \frac{Q_{eff} \cdot 1000}{n \cdot \eta_{vol}} \left[cm^3 / U\right]$	V = Geometric displacement [cm³] Q_{eff} = Effective displacement 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	$P_{An} = \frac{p \cdot Q_{eff}}{600 \cdot \eta_{ges}} \left[kW\right]$	P_{An} = Required drive power of the pump [kW] P = Working pressure [bar]; [daN/cm²] Q_{eff} = Effective displacement of a hydraulic pump [l/min] η_{tot} = Overall efficiency (0.8 – 0.85)
Overall efficiency	$\eta_{ges} = \eta_{mech} \cdot \eta_{vol}$	η_{tot} = Overall efficiency (0.8 – 0.85) η_{mech} = Mechanical efficiency (0.9 – 0.95) η_{vol} = Volumetric efficiency (0.9 – 0.95)
Drive torque	$M_{an} = \frac{\Delta p \cdot V \cdot 1,59}{100 \cdot \eta_{mech}} \left[daNm\right]$	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	$Q = \frac{V \cdot n}{1000 \cdot \eta_{vol}} \left[\frac{l}{min}\right]$	Q = Displacement flow of hydraulic motor [l/min] V = Geometric displacement [cm³] η_{vol} = Volumetric efficiency n = Output speed of the hydraulic motor [rpm]
Drive 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 of hydraulic motor [l/min] V = Geometric displacement [cm³] η_{vol} = Volumetric efficiency
Drive torque	$M_{ab} = \frac{\Delta p \cdot V \cdot \eta_{mech}}{2\pi \cdot 100} \left[daNm\right]$	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)
	$M_{ab} = \frac{1,59 \cdot V \cdot \Delta p \cdot \eta_{mech}}{1000} \left[daNm\right]$	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	$P_{ab} = \frac{\Delta p \cdot Q \cdot \eta_{ges}}{600} \left[kW\right]$	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 of hydraulic motor [l/min] η_{tot} = Overall efficiency (0.8 – 0.85)

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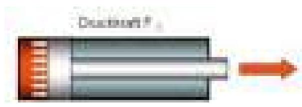
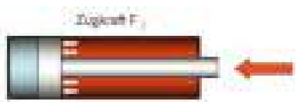
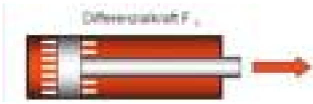
Formula lexicon ➜ Hydraulic cylinders – geometric dimensions

Piston area	$A_K = \frac{\pi}{4} \cdot \frac{d_K^2}{100} \; [cm^2]$	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	$A_S = \frac{d_S^2 \cdot 0,785}{100} \; [cm^2]$	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 ring area	$A_R = \frac{(d_K^2 - d_S^2) \cdot 0,785}{100} \; [cm^2]$	A_R = Piston ring 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







Force (general)	$F = p \cdot A \; [daN]$	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	$F_{Deff} = \frac{p \cdot d_K^2 \cdot 0,785 \cdot \eta}{10.000} \; [kN]$	F_{Deff} = 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	$F_{Zeff} = \frac{p \cdot (d_K^2 - d_S^2) \cdot 0,785 \cdot \eta}{10.000} \; [kN]$	F_{Zeff} = 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	$F_{Seff} = \frac{p \cdot d_S^2 \cdot 0,785 \cdot \eta}{10.000} \; [kN]$	F_{Seff} = 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

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

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Formula lexicon ➜ Hydraulic cylinders – speeds and stroke times

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

Formula lexicon ➜ Pressure losses in straight pipelines

Pressure loss	$\Delta p = \lambda \cdot \frac{l \cdot \rho \cdot \omega^2 \cdot 5}{d}$ [bar]	Δp = Pressure loss in straight pipelines (laminar or turbulent flow) [bar] λ = Pipe friction coefficient l = Line length in [m] ρ = Density (~0.89) [kg/dm^3] ω = Flow velocity [m/s] d = Inside diameter of the line [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 line [mm] v = Kinematic viscosity of the liquid [cSt] or [mm²/s]
	$Re = 21232 \frac{Q_{eff}}{d \cdot v}$	Re = Reynolds number Q_{eff} = Fluid flow rate in the line [l/min] d = Inside diameter of the line [mm] v = Kinematic viscosity of the liquid [cSt] or [mm²/s]
Flow velocity	$\omega = \frac{Q_{eff}}{d^2} 21,232 \left[\frac{m}{s}\right]$	ω = Flow velocity [m/s] Q_{eff} = Fluid flow rate in the line [l/min] d = Inside diameter of the line [mm]
Determination of the pipe inside diameter in pressure lines	$d = \sqrt{\frac{Q_{eff}}{\omega} \cdot 21,232} \; [mm]$	d = Inside diameter of the line [mm] Q_{eff} = Fluid flow rate in the line [l/min] ω = Flow velocity [m/s]

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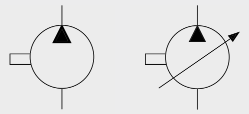
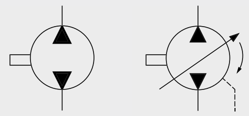
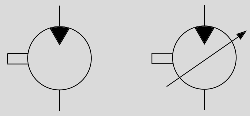
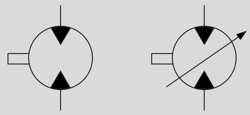
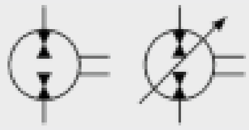
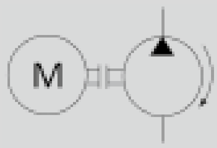
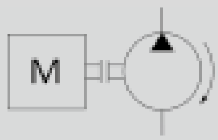
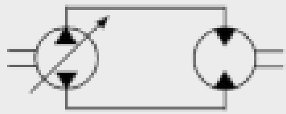
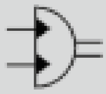
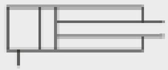
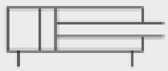
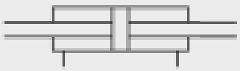
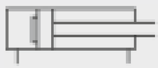
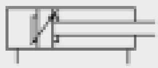
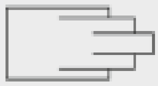
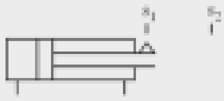
4. CIRCUIT SYMBOLS

Standardised circuit symbols are required for the representation of hydraulic circuit diagrams. In Germany, these follow the recommendations of ISO 1219 (June 2012). A selection of the most important symbols is shown below:

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	Conversion of hydraulic energy into mechanical energy with rotational movement	constant variable
• with one flow direction		
• with two flow directions (reversible)		
Pump/motor	Units that function both as pumps and as hydraulic motors	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		

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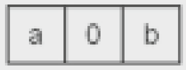
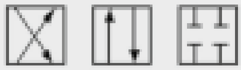
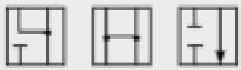
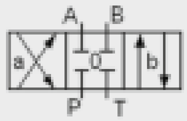
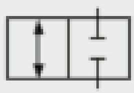
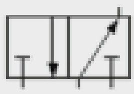
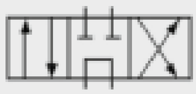
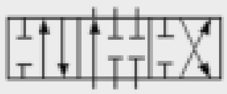
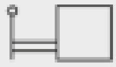
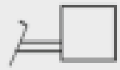
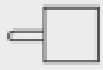
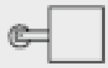
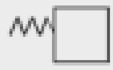
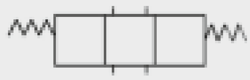
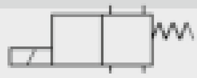
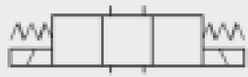
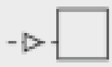
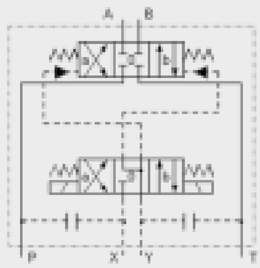
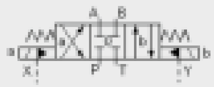
Designation	Explanation	Symbol
Directional control valves Valves that serve to open and shut off different flow paths. Directional control valves are essentially characterised by • The number of switching positions; represented by a corresponding number of squares, identified by 0, a, b (*)		
• The number of ports and connections within the switching positions; represented by lines and arrows		
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		

Designation	Explanation	Symbol
Methods of actuation for directional control valves **a) Direct acting** • Hand lever, with latching	Installation in the respective switching position	Version ISO 1219-1 
• Pedal		
• Tappet		
• Roller		
• Spring return		
• Spring centering		
• Electromagnetic actuation	Example: On one side with spring return Example: On two sides with spring return	 
• Hydraulic actuation		
• Pneumatic actuation		
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.	 

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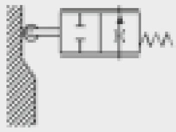
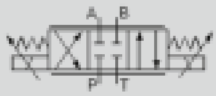
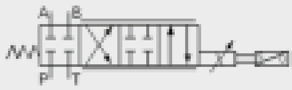
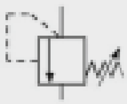
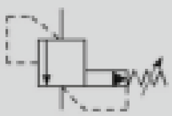
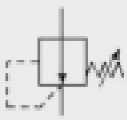
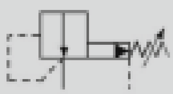
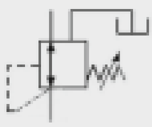
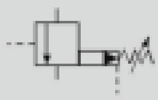
Designation	Explanation	Symbol
Throttling directional control valves Directional control valves with stepless transition between the individual switching positions with variable throttling effect. Represented by parallel lines over the length of the symbol.		
• Sensor valve with roller tapped, acting against a return spring		
• Electrohydraulic proportional directional control valve		
• Electrohydraulic control valve with position control of the valve spool		
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	

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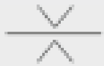
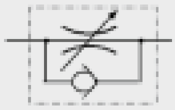
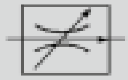
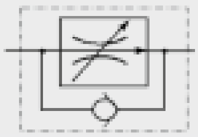
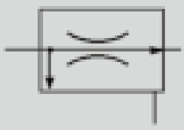
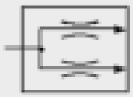
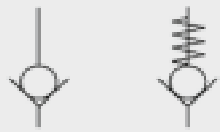
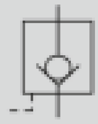
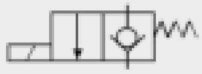
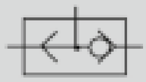
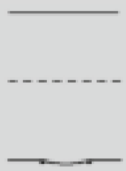
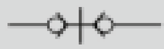
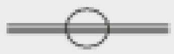
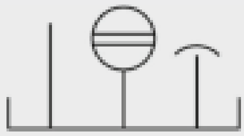
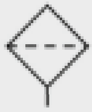
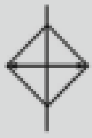
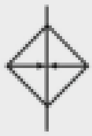
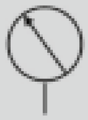
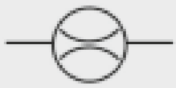
Designation	Explanation	Symbol
Flow control valves Valves which influence the volumetric flow. Represented by a constriction of the line cross-section.		
• Orifice	Short throttled length	
• Throttle (fixed or variable)	Volumetric flow dependent on the pressure difference	 
• Throttle check valve		
• Flow control valve	Volumetric flow independently of the pressure difference or load	
	With bypass non-return valve	
• 3-way flow control valve	Excess flow is diverted via the third port (irrespective of viscosity, orifice)	
• Flow divider	Split in a fixed ratio	

Designation	Explanation	Symbol
Check valves Valves which seal off pressure and 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	
• Line connection		
• Crossed line without connection		
• Venting		
• Quick release coupling		
• Rotary connection		

Designation	Explanation	Symbol
Oil treatment, measuring instruments, miscellaneous		
• Tank with lines, oil level indicator and vent		
• Hydraulic accumulators		
• Filters		
• Coolers		
• Heater		
• Pressure gauge		
• Volume flowmeter		

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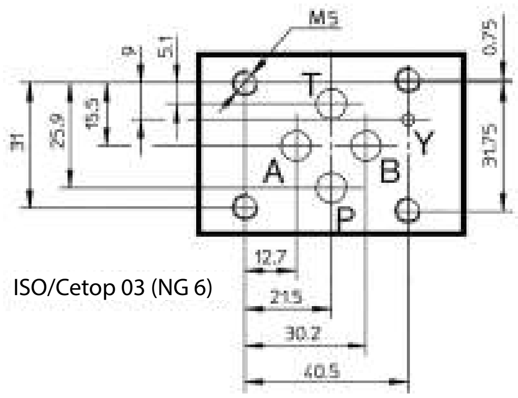
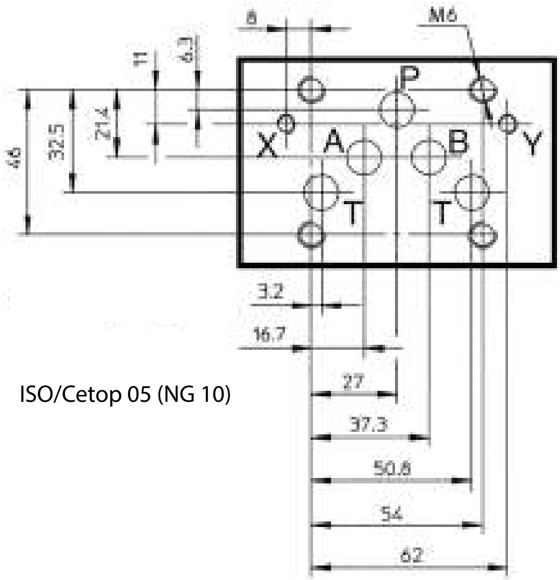
5. HYDRAULIC VALVES – MOUNTING DIAGRAMS / BORE HOLES

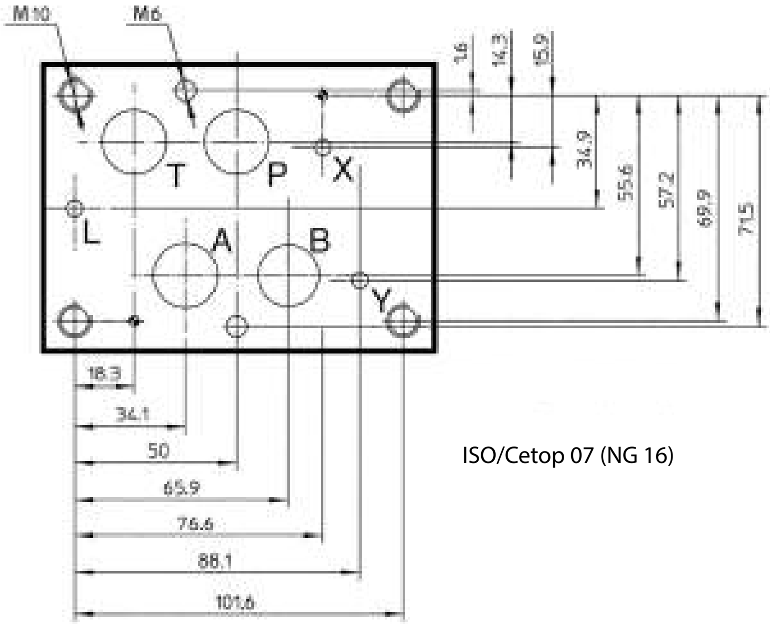
5.1 CETOP MOUNTING DIAGRAMS



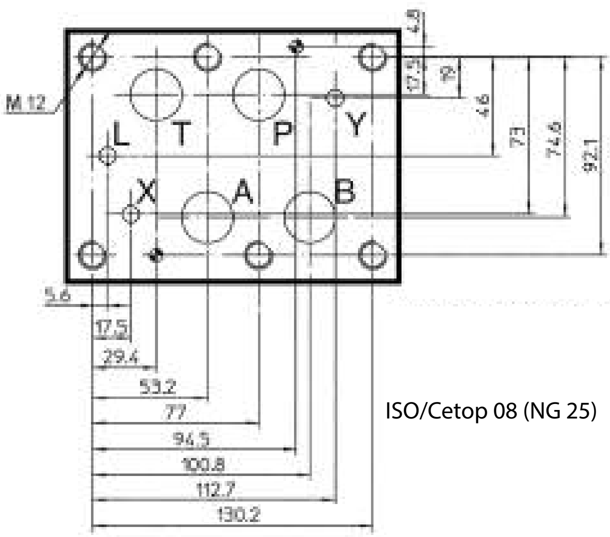
ISO/Cetop 03 (NG 6)



ISO/Cetop 05 (NG 10)



ISO/Cetop 07 (NG 16)



ISO/Cetop 08 (NG 25)

5.2 BORE HOLES

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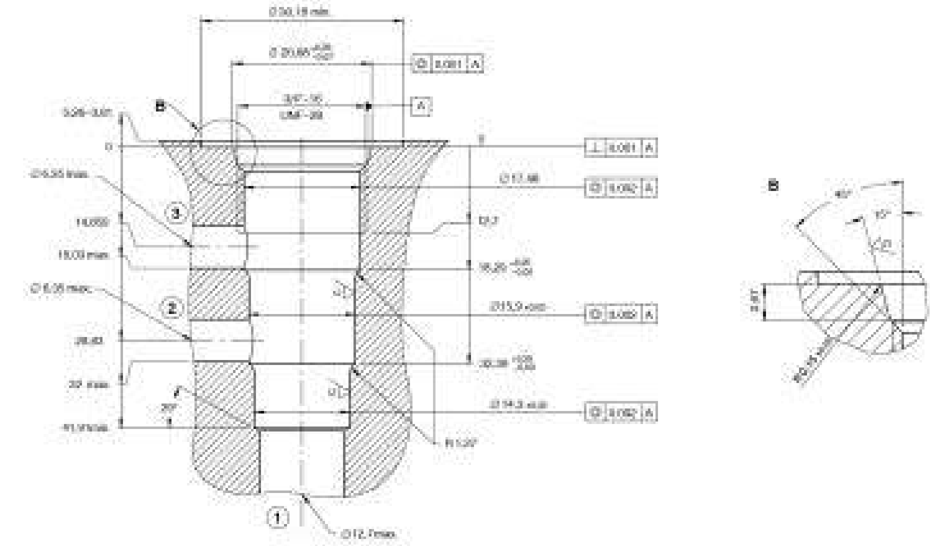
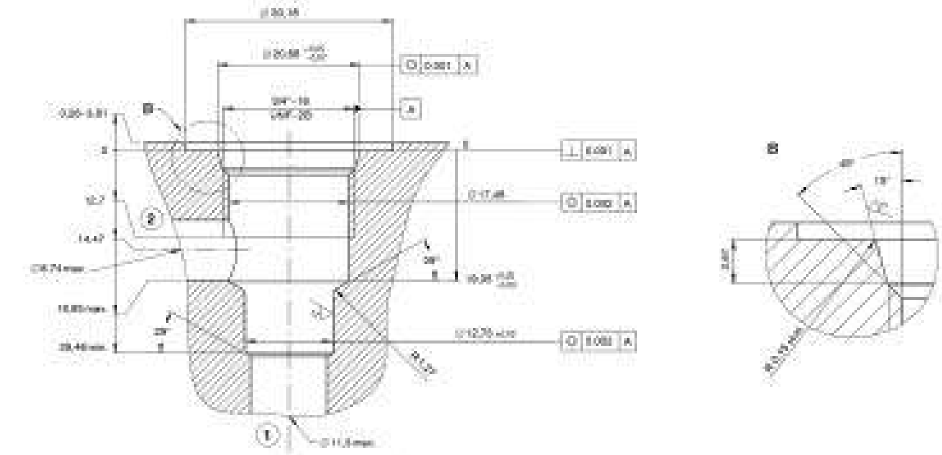
Cavity Type C0830



Cavity Type C0820



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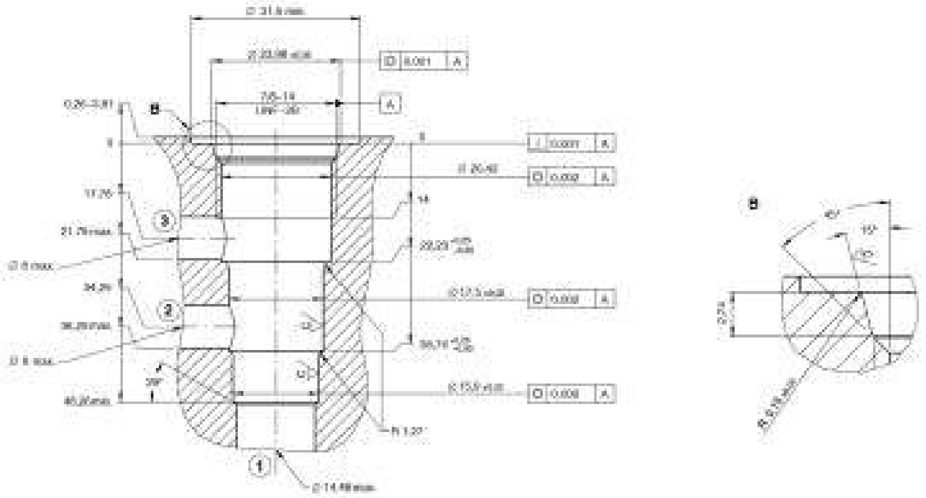
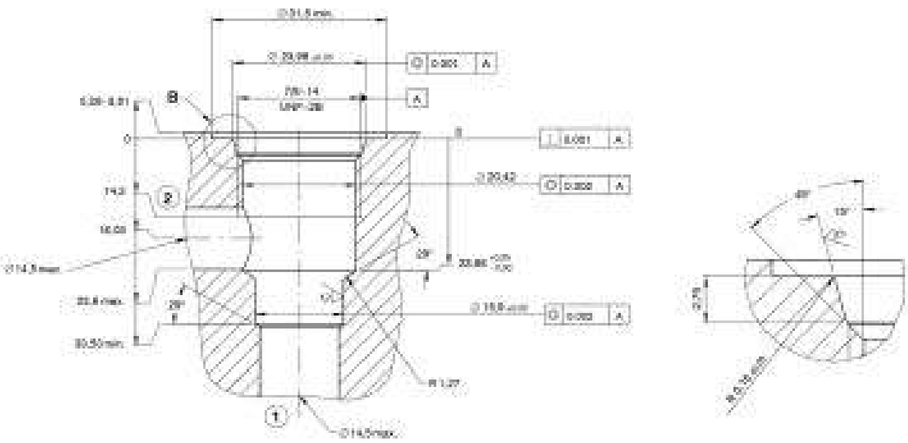
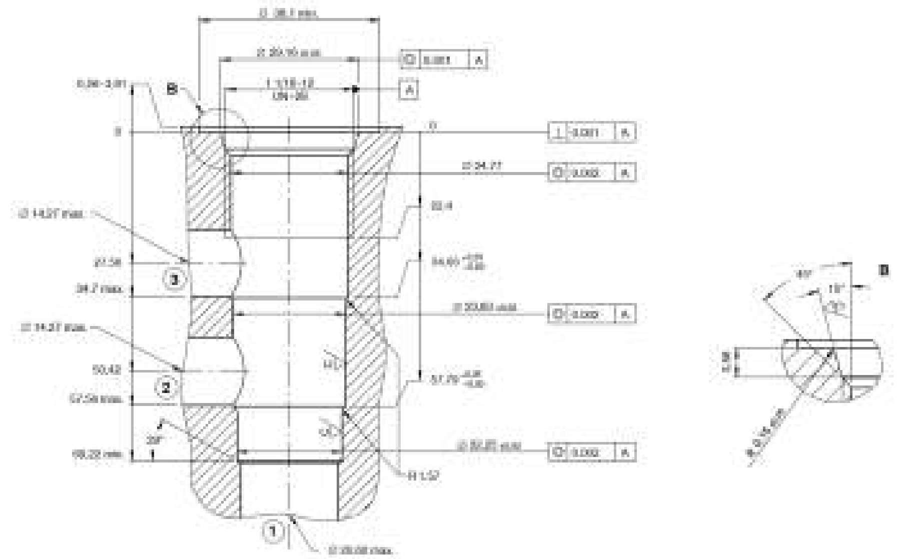
Cavity Type C1030



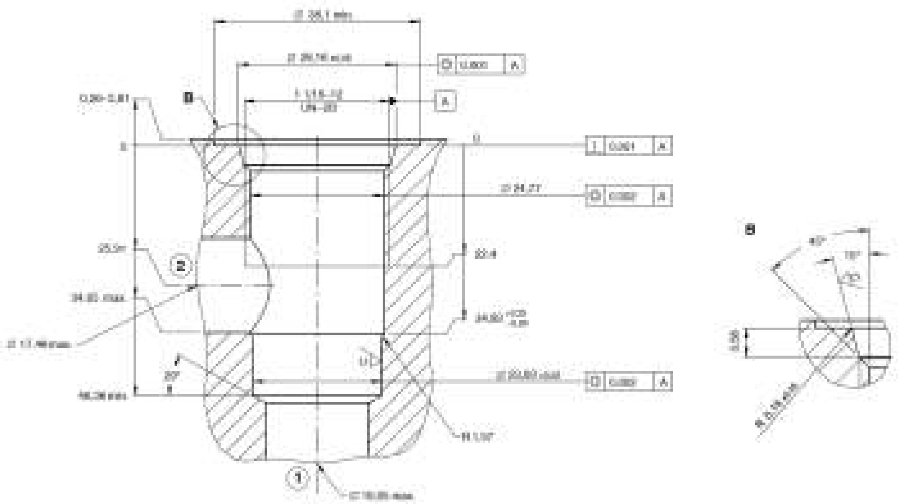
Cavity Type C1020



Cavity Type C1230



Cavity Type C1220



6. TECHNICAL INFORMATION FOR HYDRAULIC CYLINDERS

6.1 GENERAL

Please observe the provisions of EN ISO 4413 (2011) "Hydraulic fluid power - General rules and safety requirements for systems and their components" as well as specifications and safety requirements based on statutory regulations when selecting, installing and operating cylinders. The maximum loads (pressures, forces, temperatures) given in the product documentation must not be exceeded.

The pressure is boosted by throttling the oil draining from the piston rod side. Further pressure can be built up by a load pulling on the piston rod, and this combination can easily lead to failure of the cylinder.

Loosening of a consumer port on the cylinder can result in a free fall or uncontrolled lowering of loads. Unauthorised removal of the cylinders or their components can lead to a voiding of warranty claims.

The chrome coating of the piston rod and external components on the cylinder must be protected during transport.

Hydraulic cylinders must be stored dry and at the most constant possible ambient temperature in order to avoid the formation of condensation. The storage locations must be free of vapours and corrosive substances. The oil ports must be sealed with protective caps.

If hydraulic cylinders are not required for longer than 2 months, they must be stored upright with fully retracted piston rod. There is otherwise a risk of permanent deformation of the seals. The cylinders must be filled with a suitable hydraulic fluid in order to avoid corrosion.

6.2 TECHNICAL CHARACTERISTICS

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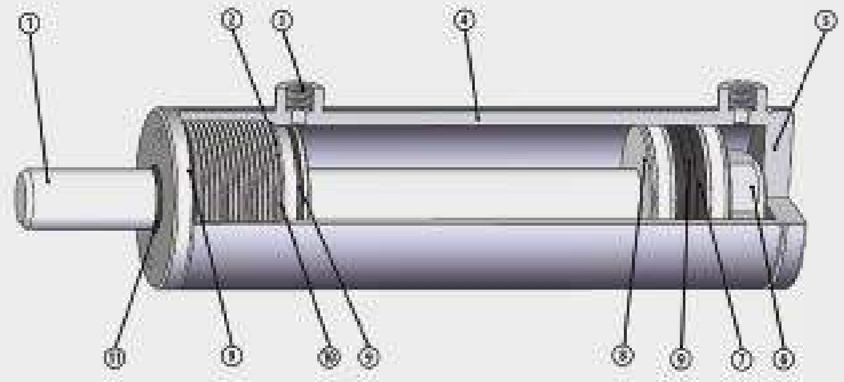
Standard cylinders up to 200 bar



1 Piston rod	steel 20MnV6 Chrome 25 µm ± 5 (120 hour salt spray test to ISO 3768 - evaluation in accordance with ISO 4540 Class 9)
2 Piston rod guide	hydraulic casting UNI 5007 G25
3 Oil ports	steel 9SMn28
4 Polished cylinder barrel	St 52.3 DIN 2393-ISO H9
5 Cylinder base	FE 510-A105
6 Nut	steel 8UNI EN20898/2
7 Seal TPM	NBR
8 Piston	steel 9SMn28
9 Seal OR	NBR Fluorosil Viton
10 Seal TSE-TTS-TTI/L	NBR + fabric / polyurethane
11 Seal GHM-GHK	NBR / polyurethane
Piston speed referred to standard seals	max. 25 m/min - 0.42 m/sec
Piston speed in the end positions	max. 6 m/min - 0.10 m/sec
Temperature range	-25°C to +80°C
Max. working pressure (to DIN EN 982)	200 bar
Test pressure (to DIN EN 982)	240 bar
Medium	HLP fluids

6.3 INSTALLATION

Hydraulic cylinders must be installed such that lateral loads are avoided during operation. The installation position can be freely selected as long as the buckling safety is observed. The stroke end of the hydraulic cylinders must not be used as an end stop.

With bored piston rods (double-acting cylinders), attention must be paid to the pivot pin (shear forces).

Where driving loads are involved, external end stops and load-holding or counterbalancing valves must be installed.

When connecting to the pressure supply, pay attention to the correct identification of the connecting lines (see marks, if necessary). Furthermore, the admissible pressure values for screw fittings, pipes and hose lines must be observed.

When using double-acting cylinders as single-acting cylinders, the second oil port must be connected to the hydraulic oil tank so that oil can be drawn in.

The piston rod should be protected against foreseeable damage and corrosion.
Pipes, screw fittings, etc. must be cleaned of dirt, chips, scale, etc. before installation and then securely fitted.

Before connecting the hydraulic cylinder to the drive unit, flush the aggregate and the supply lines. The consumer lines must be connected together in order to do this. The flushing process is intended to remove dirt and air from the consumer lines.

Hydraulic cylinders must be vented before commissioning. To do this, slightly loosen the oil ports or the vent plugs on the cylinders and place a suitable vessel underneath to collect the oil. Then move the cylinder pressure-free between the two end positions until the oil runs out bubble-free and without foaming. Turn the oil ports to the highest possible position for quicker venting.

6.4 COMMISSIONING

- Check of the complete and proper installation (incl. electrical components such as stroke measuring system, end position switches, etc.)
- Switch on the system in jog mode and check that no hazardous movement occurs, then switch the system to continuous mode
- Allow the system to run for approx. 2–3 minutes pressure-free and check the lines and devices for leaks
- Set operating values (pressure, speed) according to the system documentation

Valves already set by HANSA-FLEX are sealed with lacquer or a lead seal and must not be adjusted without consultation. The correct setting of these valves is safety-relevant.

6.5 NOTES ON WELDING ON FASTENERS AND PAINTING

- The piston rod must be completely extended; on cylinders with stroke <400 mm they must be completely removed before welding (protect seals from heat).
- The piston rod must be protected from weld spatter.
- The ground cable must always be connected to the part to be welded on, never to the piston rod or cylinder barrel.
- Retract the piston rod only when the cylinder has cooled down.
- During painting, the chrome-plated surface of the piston rod and the oil ports must be protected from paint spray mist.
- When drying in a drying cabinet after painting, the temperature must not exceed 100°C.

6.6 SEALS, MAINTENANCE AND CARE

Seals in hydraulic cylinders are wear parts. If the admissible values for external or internal leakage are exceeded, the seals must be replaced. Complete seal kits should always be replaced together.

In general, hydraulic cylinders require no particular maintenance. Where heavy-duty operation is involved, ensure proper lubrication of the bearing points (pivot bearings, swivel bearings, etc.). After commissioning, pay particular attention to leak tightness and functional safety.
The maintenance intervals for the system (oil and filter changes) in the system manufacturer's specifications must be observed.

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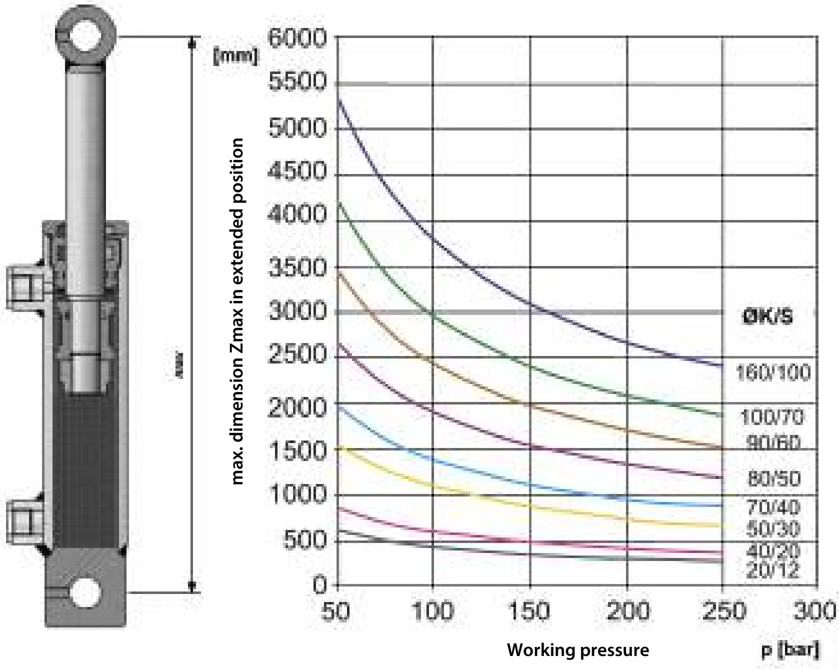
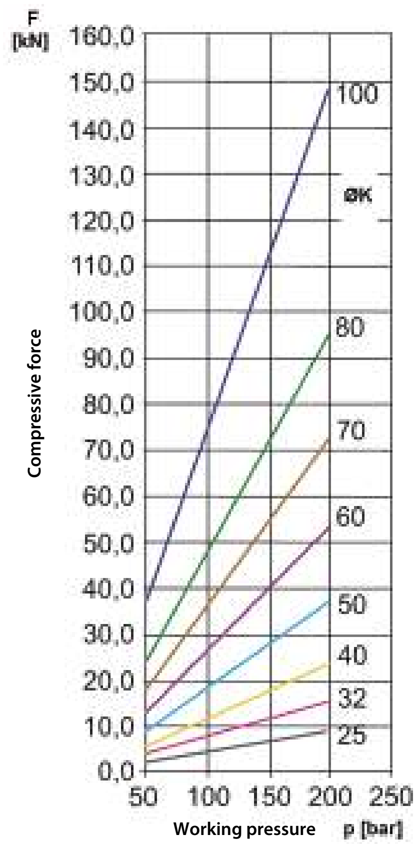
6.7 TABLES FOR CYLINDERS

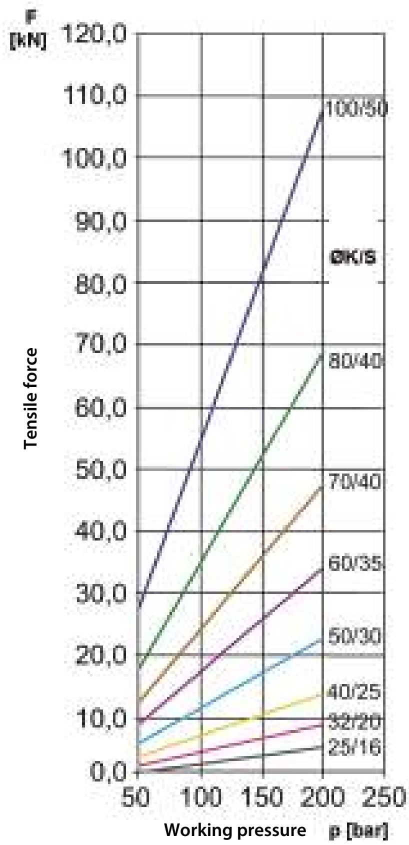
Buckling diagram for single and double-acting cylinders (buckling safety factor 3.5)



Pressure force diagram for single and double-acting cylinders (efficiency 95%)



Tensile force diagram for double-acting cylinders (efficiency 92%)



7. SAFETY PRECAUTIONS FOR WORKING WITH 700 BAR EQUIPMENT

- Observe the operating instructions
- Utilise only 80% of the equipment’s loading capacity
- Wear protective work clothing
- Use equipment only on a level surface of sufficient load-bearing strength
- Secure raised loads mechanically
- Do not stand or walk under raised loads
- Position the equipment under the middle of the load
- Protect the equipment against heating > 65°C
- Avoid overloading the equipment
- Use a pressure gauge
- Do not actuate hand levers using tools or extensions
- Clean the equipment and pack away properly after use
- Clean quick-couplers before use
- Protect hoses from sharp edges, kinks and other forms of damage

8. FILTRATION

8.1 BASIC PRINCIPLES

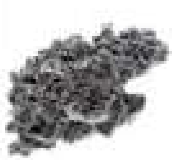
75% of all hydraulic systems are heavily contaminated. 80% of all machine failures or hydraulic damage are attributable to oil contamination. Wear and ageing are two reasons why the oil has to be changed at regular intervals.

The time for an oil change depends on the performance of the oil and on the operating and service conditions. This is no guarantee, however, of permanently clean oil, since even fresh oil is often already heavily contaminated on delivery. This results in increased component wear, machine failure and possibly production standstills. Machine standstill times can be minimised by selective and consistent use of filters.

8.2 CAUSES OF OIL CONTAMINATION

8.2.1 SOLID PARTICLES (HARD OR SOFT)

- Due to installation work or when changing parts
- Due to topping up with new (contaminated) hydraulic fluid
- Via the wipers and seals of the cylinders
- Due to a faulty tank seal
- Due to internal abrasion in the components



Dust particle
100 µm

Human hair
75 µm

Pollen
40 µm

Sold particles can result in mechanical wear to all the components in the hydraulic system.
Typical particle sizes in a hydraulic system range from 4 µm to 14 µm (for comparison: Pollen particle 40 µm, human hair 75 µm, dust particle 100 µm).

8.2.2 FREE WATER IN THE SYSTEM

- Due to a faulty tank seal
- Due to cleaning work (e.g. with high-pressure cleaners)
- Via the ambient air (tank breather)
- Condensation
- Leaks in the cooling system

With water droplets with a size of over 2–10 µm, the oil becomes cloudy and the saturation limit of the oil is reached. The water content in the hydraulic oil should not exceed 0.03%. Consequences of water in the hydraulic oil can be: Metal corrosion, oxidation, saponification, gumming, swelling, cavitation, acid formation, increased coefficient of friction with increased wear.

Water content			
10,441 ppm (1.04 %)	2,871 ppm	423 ppm	approx. 200 ppm (0.02%)

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8.2.3 UNDISSOLVED AIR IN THE HYDRAULIC FLUID

- Due to leaks in the system (vacuum)
- Due to installation work
- Oil return to the tank (swirling, air mixing)

If the air is dissolved in the oil, this has no influence on the properties. The air is dissolved in the water in proportion to the pressure (up to approx. 300 bar). Dissolved air is discharged to the saturation limit at low pressure. Due to the differences between discharge rate and solution rate, however, air bubbles remain in the oil even in the event of a renewed increase in pressure.

Undissolved air can lead to serious damage. This is caused e.g. by the micro-diesel effect (spontaneous ignition of an air/gas mixture in the high-pressure range, similar to cavitation). Gas bubbles in the hydraulic system can enter the seal gap and the gap edges of the valves and explode as a result of the compression. These seals are destroyed in a minimum of time and the gap edges of the valves are damaged.

8.2.4 OIL AGEING

- Mixing of different oils
- Excessive operating temperatures due to inadequate cooling
- Poor material compatibility of the oil
- Inadequate oxidation stability of the base oils

8.3 CLASSIFICATION OF OIL PURITY

ISO Standard ISO 4406: 1999 is a preferred method of classifying oil purity (contamination by solid particles). The code consists of a combination of three numerical values. The first figure describes the number of particles larger than 4 µm in one millilitre of test fluid. The second figure stands for the number of particles larger than 6 µm. The third figure stands for the number of particles larger than 14 µm.

ISO 4406:1999 | Table of solid contaminants in hydraulic oils

Number of particles per 1 ml of fluid		CODE
larger than:	up to:	
1,300,000	2,500,000	28
640,000	1,300,000	27
320,000	640,000	26
160,000	320,000	25
80,000	160,000	24
40,000	80,000	23
20,000	40,000	**22**
10,000	20,000	21
5,000	10,000	20
2,500	5,000	**19**
1,300	2,500	18
640	1,300	17
320	640	16
80	320	15
40	160	**14**
20	80	13

In the example the code 22/19/14 means
20,000 – 40,000 particles > 4 µm
2,500 – 5,000 particles > 6 µm
80 – 160 particles > 14 µm

The oil purity is generally determined in accordance with ISO 4406:1999 using a laser particulate counter.

Typically recommended oil purity specifications for hydraulic components							
Component	Typical specification						
Servo valve	●	●	●				
Proportional valve		●	●	●			
Variable displacement pumps			●	●	●		
Cartridge valve				●	●	●	
Piston pump				●	●	●	
Vane pump					●	●	●
Pressure relief valve					●	●	●
Solenoid-operated directional control valve					●	●	●
ISO 4406:1999 CODE	14/12/9	15/13/10	16/14/11	17/15/12	18/16/13	19/17/14	20/18/15
Recommended filter mesh size (absolute)	3 µm		6 µm		10 µm		> 10 µm

8.4 FILTER MESH SIZE, ß VALUE AND SEPARATION RATE

Apart from their differentiation by function (e.g. pressure filter, return filter, suction filter), hydraulic filters are also classified according to the filter material and the filter mesh size (µm). Depending on the application, filters with mesh sizes between 3 µm and 250 µm are employed.

Further important parameters for the performance of a filter are the β value and the separation rate.

The β value (ISO 16889) is the measure of the filter separation rate and indicates the ratio of particles upline (Nv) and downline of the filter (Nh).

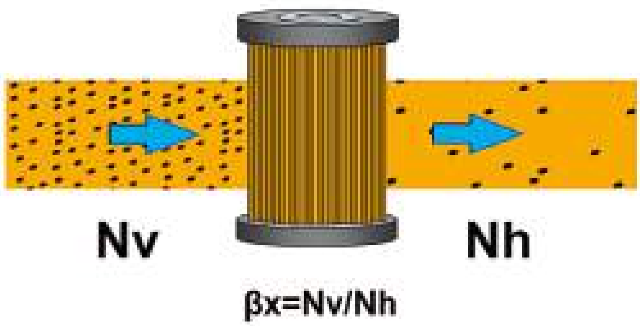
$$\beta x = Nv/Nh$$

β10 > 200 therefore means that of 1000 particles with a size of 10 µm, only five particles pass through the filter. 995 particles are retained. Filters with fibreglass media must achieve a β value of min. 200 in order to meet present-day demands on hydraulic filtration.

The separation rate (retention rate) thus has the following direct relationship with the β value:

$$\varepsilon = (\beta x - 1) / \beta x$$

A value of β10 >200 thus corresponds to a separation rate of 99.5%.



8.5 ADSORBER FILTERS

8.5.1 FUNCTIONAL PRINCIPLE

In numerous applications, e.g. in hydraulic systems or gearboxes, water is one of the main causes of damage and high costs. Water hereby enters the systems as humidity from the ambient air due to temperature fluctuations or active removal of the hydraulic oil. The use of adsorber filters can help to bind the humidity in the intaken air and so reduce the contamination of the hydraulic oil. That means longer service lives, less damage and ultimately lower costs.

On the basis of the thermal process engineering, the adsorption, the water in the air is retained in the pores of the adsorbent (desiccant). There is there no change in volume and only the weight increases. The maximum water adsorption capacity is approx. 35% w/w. During the adsorption process, the intaken air is dried, while the dry waste air allow a cyclic regeneration of the adsorbent. A precondition for a high efficiency is the use of activated charcoal to separate the oil mist and an optional valve system to prevent loading during standstill times.

8.5.2 COLOUR SATURATION

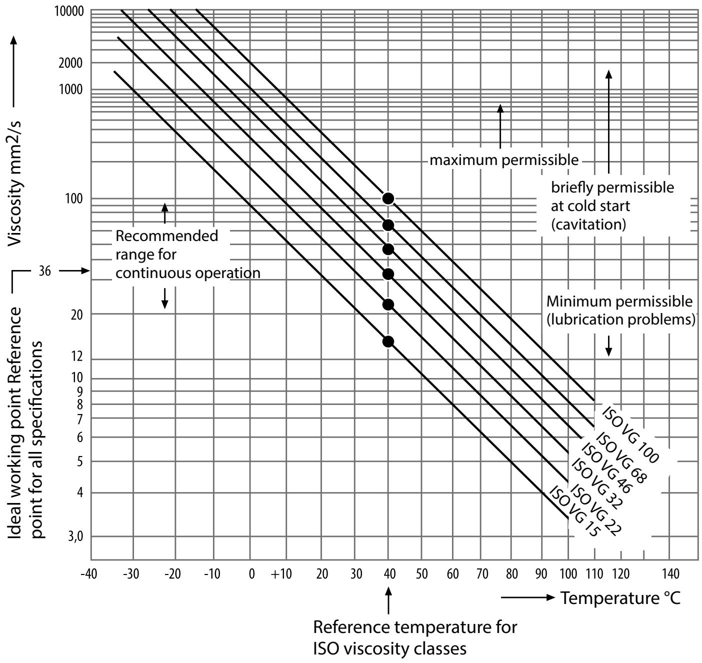
The saturation and the then necessary replacement of the adsorbent is indicated by a change in colour from orange to green. Silica gel (silicon oxide SiO2) with heavy metal-free pH indicators (organic pigments) is used in the adsorber filters. These are substances whose colour depends on the pH value of the solution.

Silica gel and the pH indicators used are classified as non-hazardous substances according to the legislation of the European Union (EC Directive No. 1272/2008). It is not subject to mandatory labelling according to EC Guidelines (67/548/EEC and 1999/45/EC) and the corresponding national laws. The adsorbents used are therefore not health or environment-endangering substances.

8.6 DEMANDS ON HYDRAULIC FLUIDS AND THEIR SELECTION

The following main characteristics must be observed when selecting the hydraulic fluid:

- Viscosity, viscosity index, viscosity class VG (viscosity at 40°C), pour point



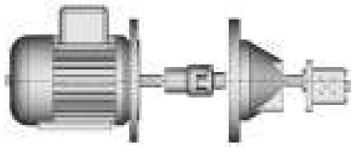
NOTE:
The information given in the catalogue on the individual devices (specifications) is binding

For a given application, the characteristics of the hydraulic fluid have to be reconciled with the operating conditions of the system and its components. A hydraulic fluid has a low viscosity when it is thin-bodied and a high viscosity when it is thick-bodied.

The viscosity changes with the temperature. The viscosity drops with increasing temperature. The viscosity rises with decreasing temperature. Mixing of unsuitable or different hydraulic fluids is not permitted and can lead to the total failure of the hydraulic system.

9. SELECTION TABLE OF MOTOR/PUMP COMBINATIONS FOR GEAR PUMPS

The selection table shows possible combinations of electric motors of sizes 71 to 180 (mounting B3B5) and gear pumps of sizes BG0 to BG3 (European standard) with the corresponding pump mounts and couplings.



For particularly high torques, combinations with steel coupling should be used!

Gear pump size BG 0: Hole pattern 66 / Centering dia. 22.0 / Cylindrical shaft dia. 7.0
Gear pump size BG 1: Hole pattern 71.9 x 52.4 / Centering dia. 25.4 / Conical shaft 1:8
Gear pump size BG 2: Hole pattern 96.2 x 71.5 / Centering dia. 36.5 / Conical shaft 1:8
Gear pump size BG 3: Hole pattern 128 x 98 / Centering dia. 50.8 / Conical shaft 1:8

Electric motor (Article number)	Power (kW)	Gear pump (Master designation from this catalogue)	Size	Pump mounts (Article number)	Coupling (Article number)
HK 71 A4 B35 2-4A	0.25	HK 0P ABBA	BG 0	HK PT RV 160 70 468	HK A1914 714 184 AL
HK 71 B4 B35 2-4A	0.37	HK 0P ABBA	BG 0	HK PT RV 160 70 468	HK A1914 714 184 AL
HK 80 A4 B35 2-4A	0.55	HK 0P ABBA	BG 0	HK PT RV 200 80 468	HK A1919 714 184 AL
HK 80 B4 B35 2-4IE2	0.75	HK 0P ABBA	BG 0	HK PT RV 200 80 468	HK A1919 714 184 AL
HK 71 A4 B35 2-4A	0.25	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 160 80 448 ZFV	HK A1914 N1 AL
HK 71 B4 B35 2-4A	0.37	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 160 80 448 ZFV	HK A1914 N1 AL
HK 80 A4 B35 2-4A	0.55	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 200 80 448	HK A1919 N1 AL
HK 132 M4 B35 4-6IE2	0.75	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 200 80 448	HK A1919 N1 AL
HK 90 S4 B35 2-4IE2	1.10	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 200 90 448	HK A1924 24 N1 AL
HK 90 L4 B35 2-4IE2	1.50	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 200 90 448	HK A1924 24 N1 AL
HK 100 LA4 B35 2-4IE2	2.20	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 250 110 448	HK A2432 28 60 N1 AL
HK 100 LB4 B35 2-4IE2	3.00	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 250 110 448	HK A2432 28 60 N1 AL
HK 112 M4 B35 4-6IE2	4.00	HK 1P FIIA, HK 1P FBBA	BG 1	HK PT RV 250 110 448	HK A2432 28 60 N1 AL
HK 80 A4 B35 2-4A	0.55	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 200 96 446 ZFV	HK A2419 N2A AL
HK 80 B4 B35 2-4IE2	0.75	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 200 96 446 ZFV	HK A2419 N2A AL
HK 90 S4 B35 2-4IE2	1.10	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 200 96 446 ZFV	HK A2424 N2A AL
HK 90 L4 B35 2-4IE2	1.50	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 200 96 446 ZFV	HK A2424 N2A AL
HK 100 LA4 B35 2-4IE2	2.20	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 250 110 446	HK A2432 28 N2A AL
HK 100 LB4 B35 2-4IE2	3.00	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 250 110 446	HK A2432 28 N2A AL
HK 112 M4 B35 4-6IE2	4.00	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 250 110 446	HK A2432 28 N2A AL
HK 132 SB4 B35 4-6IE2	5.50	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 300 130 446	HK A2838 38 60 N2A AL
HK 132 M4 B35 4-6IE2	7.50	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 300 130 446	HK A2838 38 60 N2A AL
HK 132 SB4 B35 4-6IE2	5.50	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PL3000102	HK R28 38 N2A
HK 132 M4 B35 4-6IE2	7.50	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PL3000102	HK R28 38 N2A
HK 160 M4 B35 4-6IE2	11.00	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 350 173 446	HK A3845 42 N2A AL
HK 160 L4 B35 4-6IE2	15.00	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PT RV 350 173 446	HK A3845 42 N2A AL
HK 160 M4 B35 4-6IE2	11.00	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PL3500105	HK R38 42 N2A
HK 160 L4 B35 4-6IE2	15.00	HK 2P EOOA/EPOA/EQPA, HK 2P EBBA/ECBA, HK CBTF	BG 2	HK PL3500105	HK R38 42 N2A
HK 100 LA4 B35 2-4IE2	2.20	HK X3P ABAA/ACBA, HK CBD1 F5	BG 3	HK PT RV 250 115 465	HK A2432 28 N3 AL
HK 100 LB4 B35 2-4IE2	3.00	HK X3P ABAA/ACBA, HK CBD1 F5	BG 3	HK PT RV 250 115 465	HK A2432 28 N3 AL
HK 112 M4 B35 4-6IE2	4.00	HK X3P ABAA/ACBA, HK CBD1 F5	BG 3	HK PT RV 250 115 465	HK A2432 28 N3 AL
HK 132 SB4 B35 4-6IE2	5.50	HK X3P ABAA/ACBA, HK CBD1 F5	BG 3	HK PT RV 300 144 465	HK A2838 38 60 N3 AL

10. INFORMATION ON MACHINERY DIRECTIVE 2006/42/EC REGARDING COMPONENTS AND ASSEMBLIES FROM HANSA-FLEX AG

The Machinery Directive 2006/42/EC demands from the machine manufacturer the identification of the necessary safety functions with 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 circuit or safety temperature controller. These safety components are components which are not necessary for the actual function of the machine or which can be replaced by parts that are normally used for the function of the machine. Only then are hydraulic components to be regarded as safety components and have to bear the CE mark. If these special safety components are brought onto the market, the MTBF values (mean time between failures) for calculation of the performance level (PL) are shown in our documentation.

Components and assemblies from the HANSA-FLEX AG product range are generally not subject to this guideline. Where this is not the case, the corresponding documentation is supplied.

Since the Machinery Directive 2006/42/EC came into force, manufacturer's declarations are no longer issued for components and assemblies. For components requiring CE marking, an EC Declaration of Conformity is issued.