Basic Training
Hydraulics
&
Electrics

WIRTGEN GROUP

VÖGELE

Training schedule

Day 1: Hydraulics (08:00 – 16:00 Hrs)

Day 2: Electrics (08:00 – 16:00 Hrs)

Table of Contents - Hydraulics

Table of Contents - Electrics

Basic Principles
Hydraulics

H.1.0 The history of hydraulics:

Hydraulics (from the Greek ***hydro*** = water and ***aulos*** = pipe or flute) is the science of the **flow behaviour** of fluids.
In particular, it involves the flow processes in open channels (canals, rivers) and lakes, as well as pipelines, pumps and ground water.
In the field of mechanical engineering, the technical components of drives and drivelines that function with fluids are referred to as hydraulic.

Joseph Bramah, England, is regarded as the founder of technical hydraulics. In 1795, he developed a hydromechanical machine operated with pressurized water that functioned according to the hydrostatic law of Blaise Pascal. In 1851, Sir W. Armstrong developed the weight accumulator, a reservoir that allowed the generation of large volume flows. In 1882, the London Hydraulic Power Company put a central pressurized water supply for multiple hydraulic systems into operation. The first power steering system was developed by Harry Vickers around 1925.

H.2.0 Hydraulics deals primarily with the following aspects:

- **Properties of fluids:**
  - Density
  - Viscosity
  - Elasticity
  - Specific heat capacity
  - Surface tension (capillary action)
  - Solubility of gases, air content of water
- **Hydrostatics:**
  - Pressure
  - Uplift
- **Theoretical description of the flow processes**
  - Kinematics and dynamics
  - Continuity condition, mass behaviour
  - Principle of linear momentum
  - Equation of motion (Euler‘s equation of motion)
  - Bernoulli‘s equation of energy (simple formulas for calculating outflow)
  - Hagen-Poiseuille law
  - Laminar flow
  - Turbulent flow
- **Real flows**
  - Flows in pipelines
  - Flows in open channels, such as rivers, lakes, canals
  - Flows in ground water

H.3.0 Units of measurement in hydraulics

The SI unit of pressure is the Pascal with the standard symbol *Pa.* One Pascal corresponds to a pressure of one Newton (N) per square meter (m^2):

$$1\ \text{Pa} = 1\ \text{N/m2} = 1\ \text{kg/m}\ \text{s}^2$$

The unit of pressure most predominantly used for hydraulics is the *Bar*.
One *Bar* corresponds to 100,000 *Pa*, 1,000 *hPa* or 100 *kPa.*

In engineering, the unit N/mm^2 is used both for pressures and for mechanical tension.
In this context, 1 $N/mm^2 = 1MPa$
Other units of pressure that can be found but which are no longer permissible are:

-**1 *Torr* = approx. 133.3 *Pa***

-**1 meter water column (*mWc*) = 9.80665 *kPa***

-**1 technical atmosphere (*at*) = 98066.5 *Pa***

-**1 physical atmosphere (*atm*) = 101.325 *kPa***

- 1 *psi* = 6894.757293168 *Pa*

H.4.0 Legend of abbreviations

H.4.1 Lines

P = Pressure line (from the English **P**ower)

R = **R**eturn line

S = **S**uction line

T = **T**ank line

L = **L**eakage oil line

H.4.2 Valves

DBV = Pressure control valve (**D**ruck**b**egrenzungs**v**entil)

DRV = Pressure reducing valve (**D**ruck**r**eduzier**v**entil)

RSV = Non return valve (**R**ück**s**chlag**v**entil)

SRV = Flow control valve (**S**trom**r**egel**v**entil)

PM = **P**roportional **m**agnet

WV = Directional control valve (**W**ege**v**entil)

H.4.3 Other components

Q = Pump (standardized symbol)

M = **M**otor

F = **F**ilter

MT = Flow divider (**M**engen**t**eiler)

Z = Cylinder (**Z**ylinder)

ST = Control block (**St**euerblock)

SA = Collector (**Sa**mmler)

DS = Pressure switch (**D**ruck**s**chalter)

PVG = Transfer gearbox (**P**umpen**v**erteiler**g**etriebe)

HÖK = Hydraulic oil cooler (**H**ydraulik**ö**l**k**ühler)

H.5.0 Circuit symbols and circuits

H.5.1 Explanation

A circuit diagram is the plan of a hydraulic system. The components are presented by means of standardized symbols.
These diagrams are part of the requisite documentation of every system and are particularly important for the creation and maintenance of a system.
The list of circuit symbols contains a comprehensive array of symbols used in hydraulics.

Circuit diagrams may be drawn up individually, in line with company specifications or in accordance with standards (DIN ISO 1219).
They can represent components, such as operating and control circuits, the steps of the operating sequence, the circuit components with their designations and the associated lines and connections. The spatial arrangement of the components is not usually taken into consideration, or it is presented in a separate overview plan.

A symbol exclusively depicts the function of a component / device. It says nothing about the construction or point of installation of the hydraulic components.
Symbols are presented in one colour, normally idle, without current and in their initial position.

H.5.0 Circuit symbols and circuits

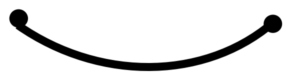
H.5.2 Circuit symbols – Part 1

Vent line

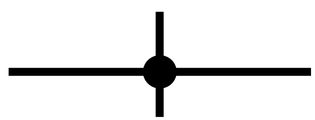
Control line

Leakage oil line

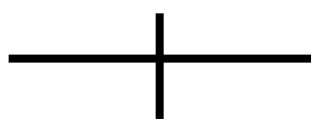
Flexible line



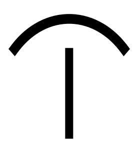
Line connection



Line junction

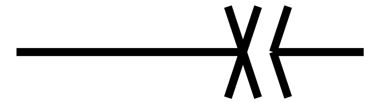


Bleed point



Pressure connection with plugs

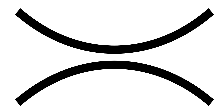
Pressure connection with access line



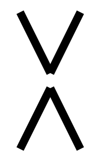
Mechanical connection (shaft, level, bar)

Spring

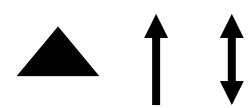
Throttle



Orifice

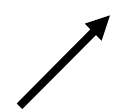


Flow direction



Rotatability

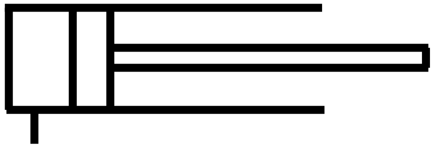
Adjustability



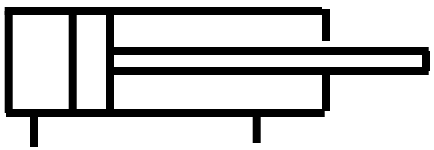
H.5.0 Circuit symbols and circuits

H.5.2 Circuit symbols – Part 2

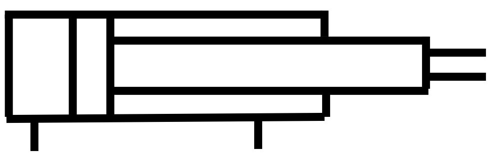
Single-acting cylinder



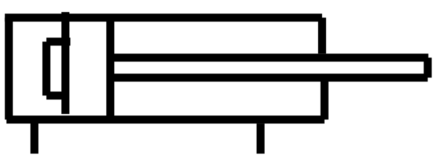
Double-acting cylinder



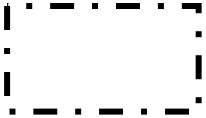
Differential cylinder (double-acting)



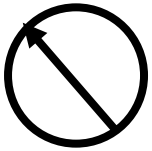
Cylinder with damping (double-acting)



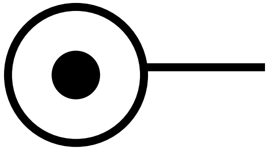
Border of assemblies / blocks



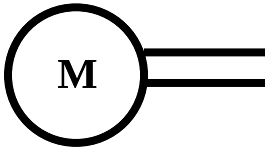
Manometer



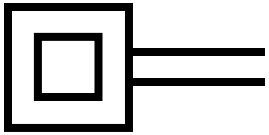
Pressure source



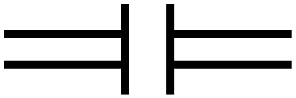
Electric motor



Combustion engine

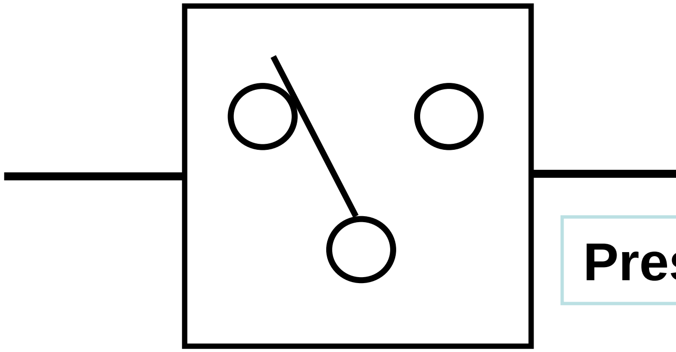


Coupling

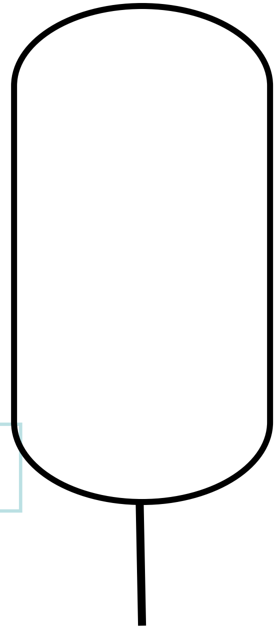


H.5.0 Circuit symbols and circuits

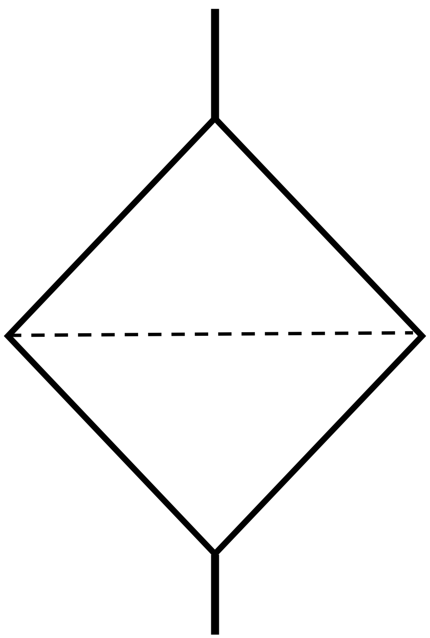
H.5.2 Circuit symbols – Part 3



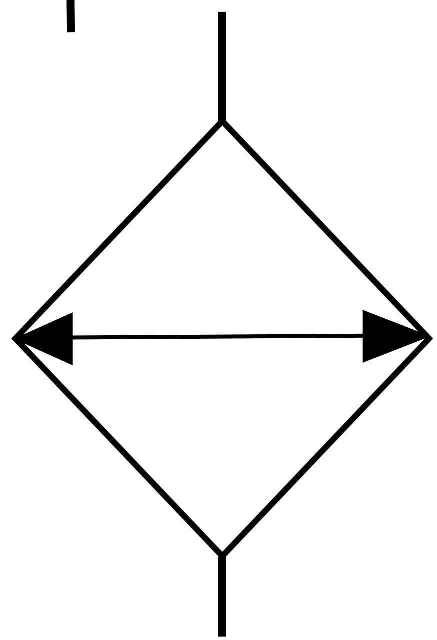
Pressure switch



Hydraulic reservoir



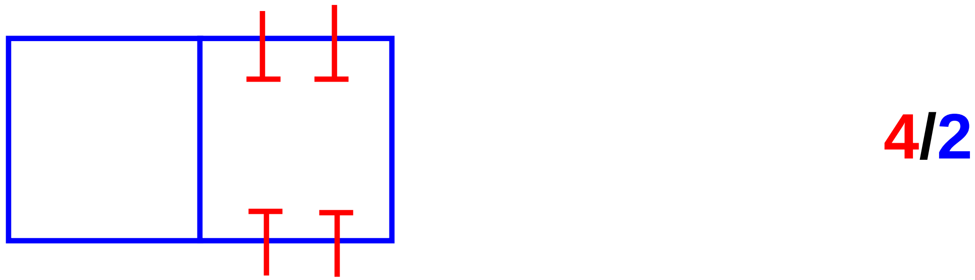
Filter

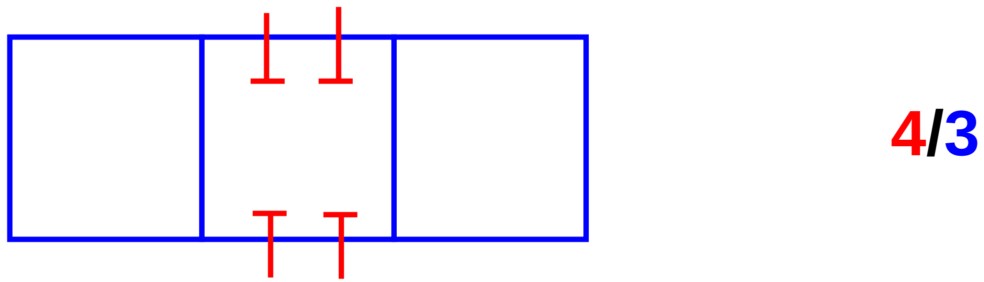


Cooler

H.5.0 Circuit symbols and circuits

H.5.3 Directional control valves – Part 1

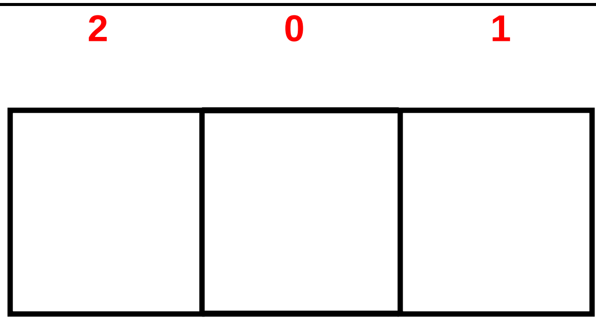




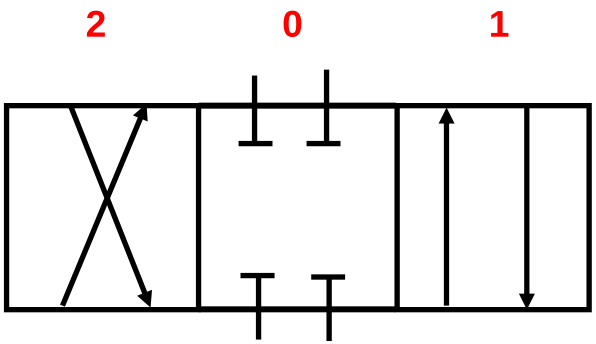
Directional control valves are designated according to the number of connections and switching positions. The number of connections comes first, followed by the number of switching positions.

H.5.0 Circuit symbols and circuits

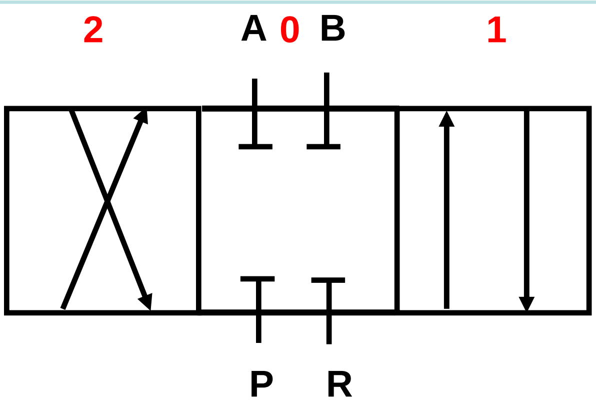
H.5.3 Directional control valves – Part 2



Directional control valves are represented by individual rectangles.
The number of fields equates to the number of switching positions, which are designated with the figures (**0** / **1** / **2**).

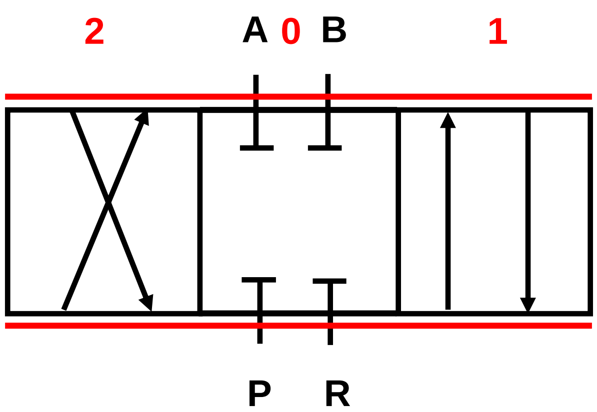


The position of the respective lines indicates how the connections are connected.
Small dashes on the connections indicate shut-offs.



Connections are designated with capital letters.

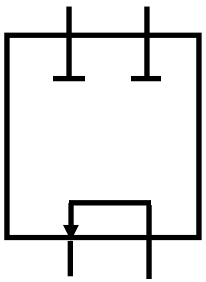
A,B,C	= Vent lines	R,S	= Vent (runback)
P	= Feeder (pressure line)	X,Y,Z	= Control line



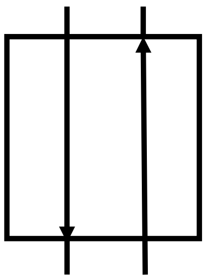
If a valve is switched proportionally, this is indicated by lines above and below the switching positions.

H.5.0 Circuit symbols and circuits

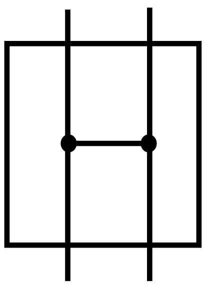
H.5.3.1 Switching positions:



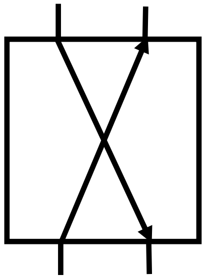
Circulating position



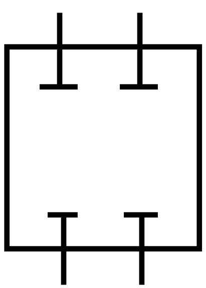
Forward flow position



Floating position



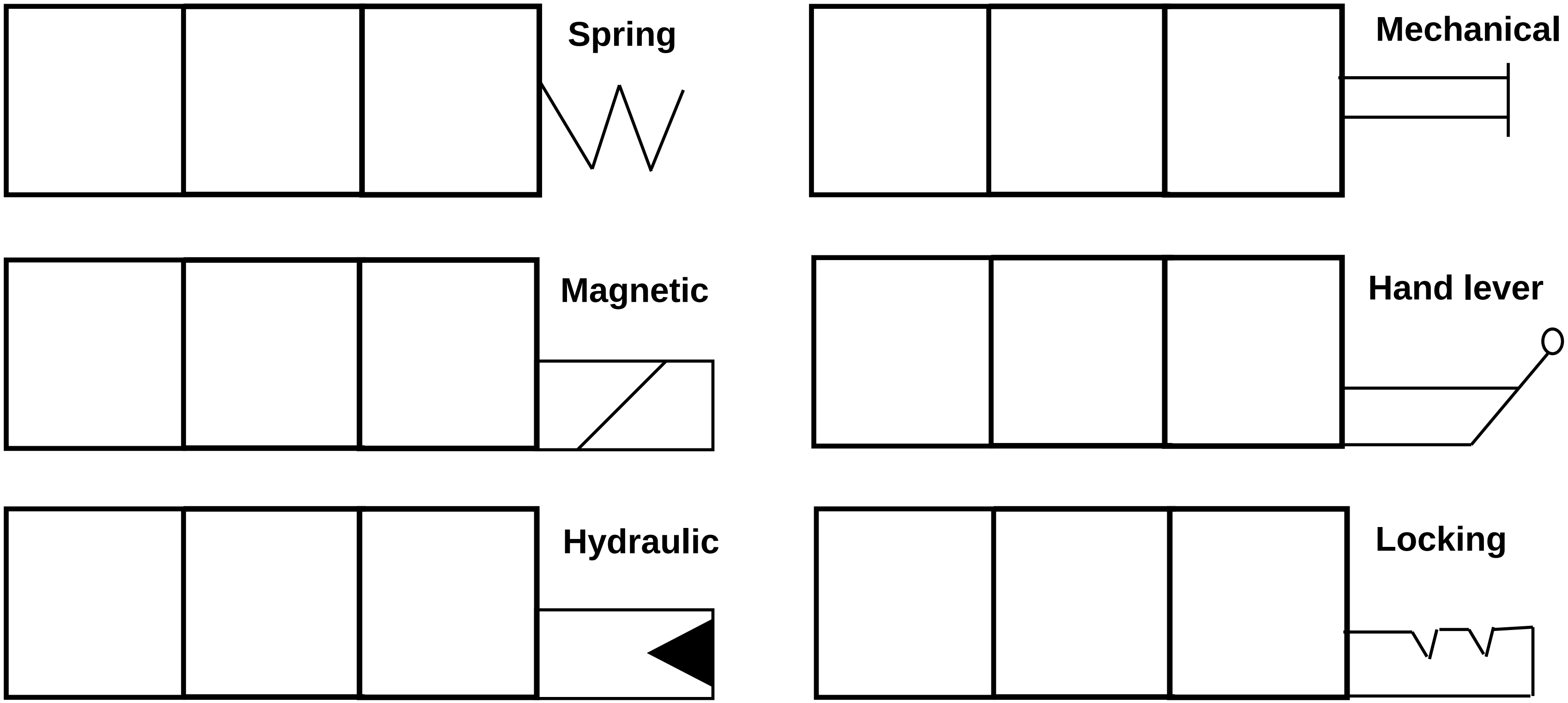
Reverse flow position



Shut-off position

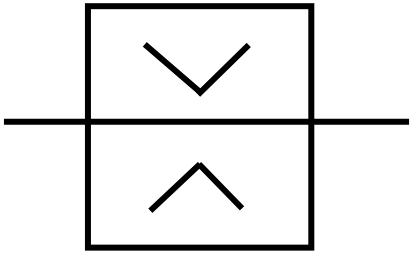
H.5.3 Circuit symbols and circuits

H.5.3.2. Types of operation

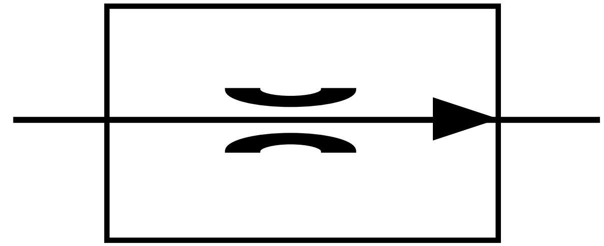


H.5.0 Circuit symbols and circuits

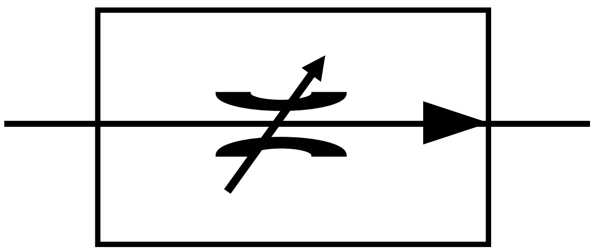
H.5.4 Flow control valves (SRV):



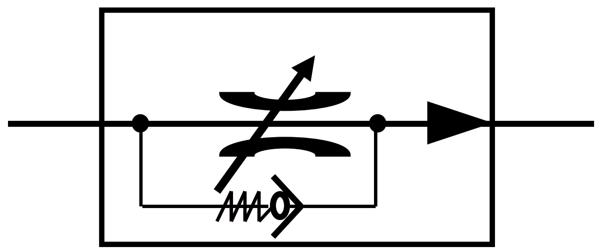
Flow control valve with orifice



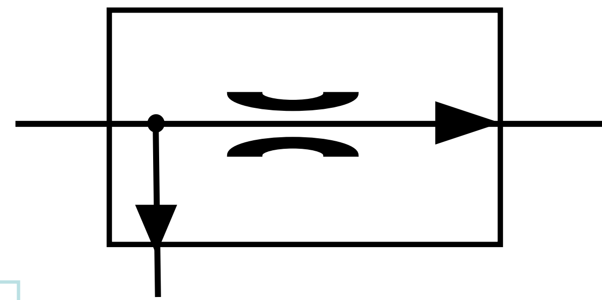
Flow control valve (SRV), fixed (for one flow direction only)



Flow control valve (SRV), adjustable (for one flow direction only)



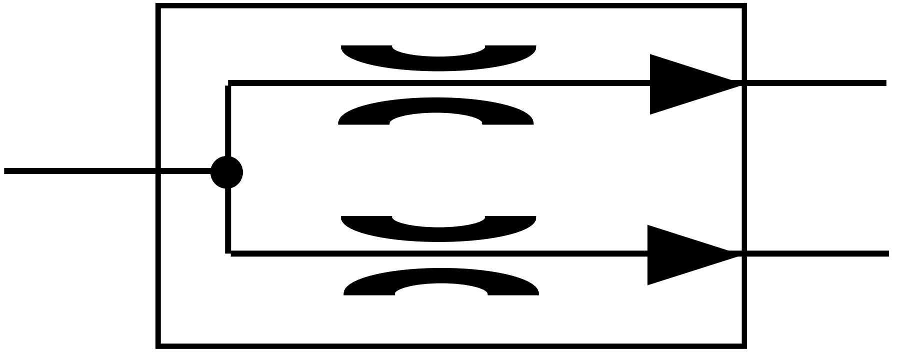
Flow control valve (SRV), adjustable (for one flow direction only) With non-return valve (RSV)



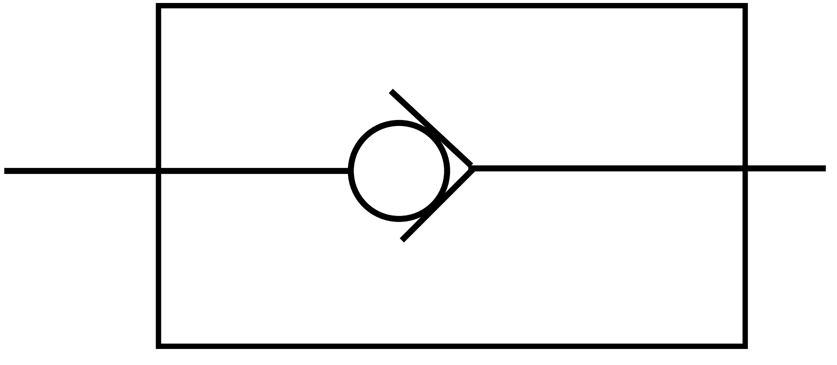
3-way flow control valve

H.5.0 Circuit symbols and circuits

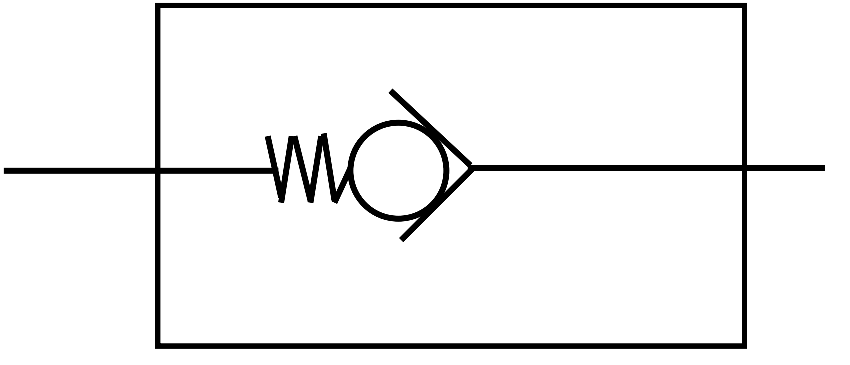
H.5.5 Shut-off valves



Flow divider (MT)



Non-return valve (RSV), without closing spring



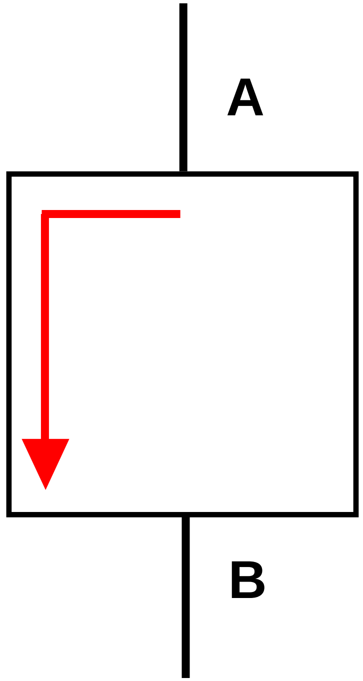
Non-return valve (RSV), with closing spring

H.5.0 Circuit symbols and circuits

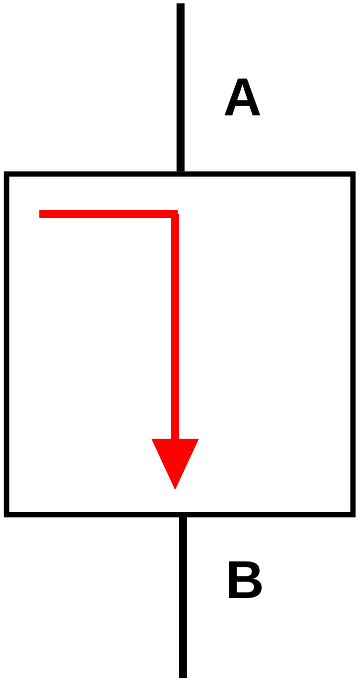
H.5.6 Pressure control valve (DBV):

H.5.6.1 Explanation and zero position

If the pressure in a hydraulic system rises to a level that is undesirable and which the system cannot tolerate, the weakest point of the system will be destroyed. Pressure control valves - in short DBV – feed the oil not accepted by the consumer at the highest permissible pressure back to the tank.



Closed zero position

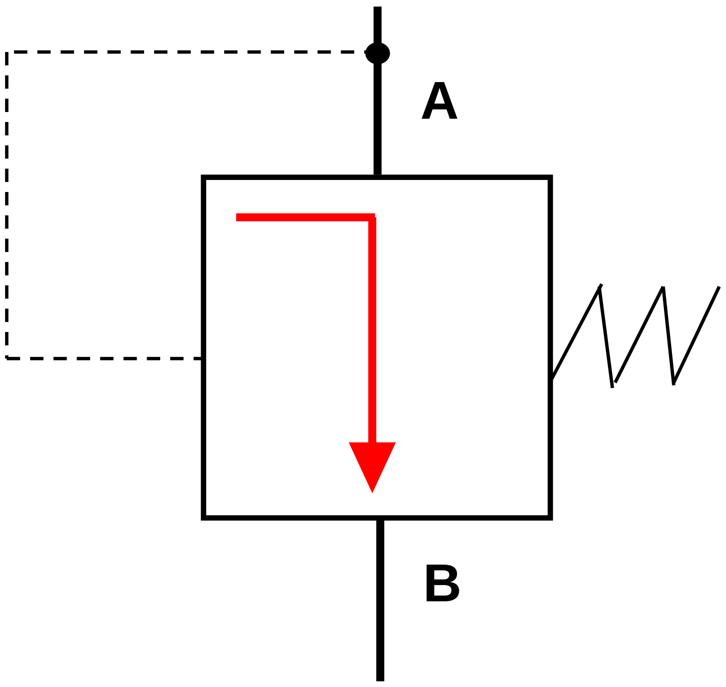


Open zero position

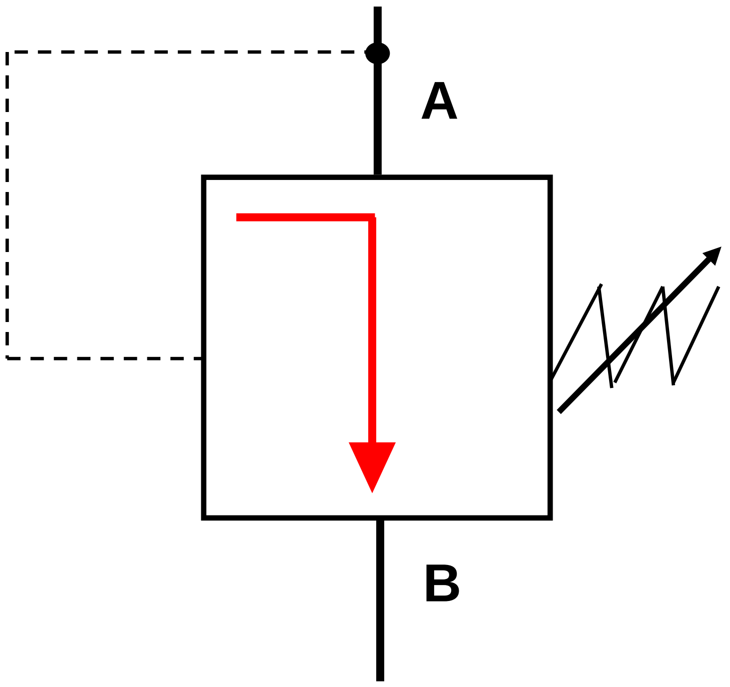
H.5.0 Circuit symbols and circuits

H.5.6 Pressure control valve (DBV):

H.5.6.2 Adjustability



Pressure control valve DBV, fixed position

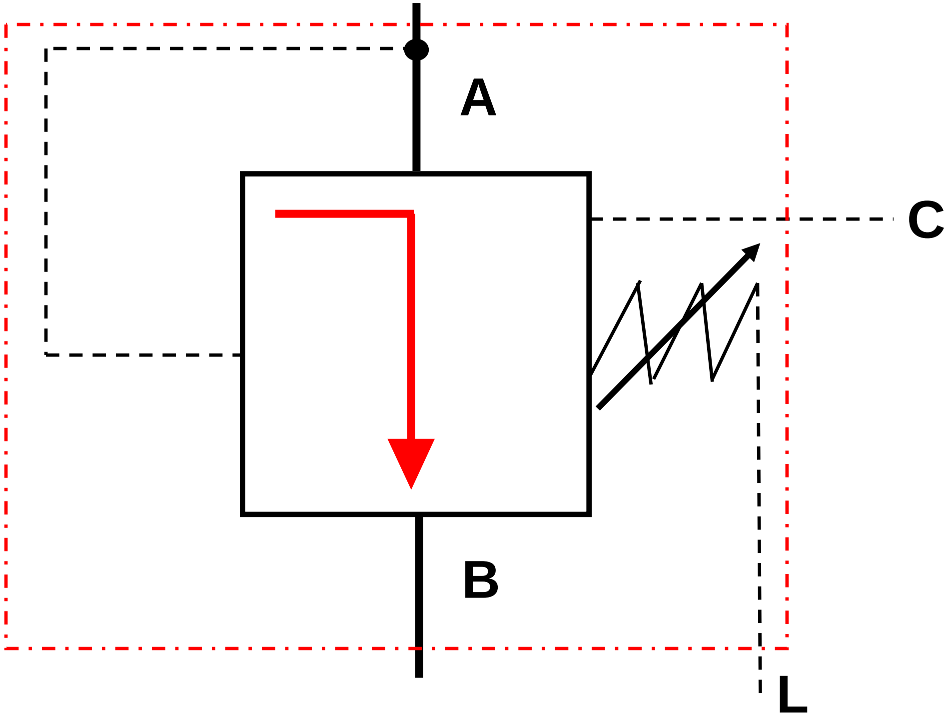


Pressure control valve DBV, adjustable

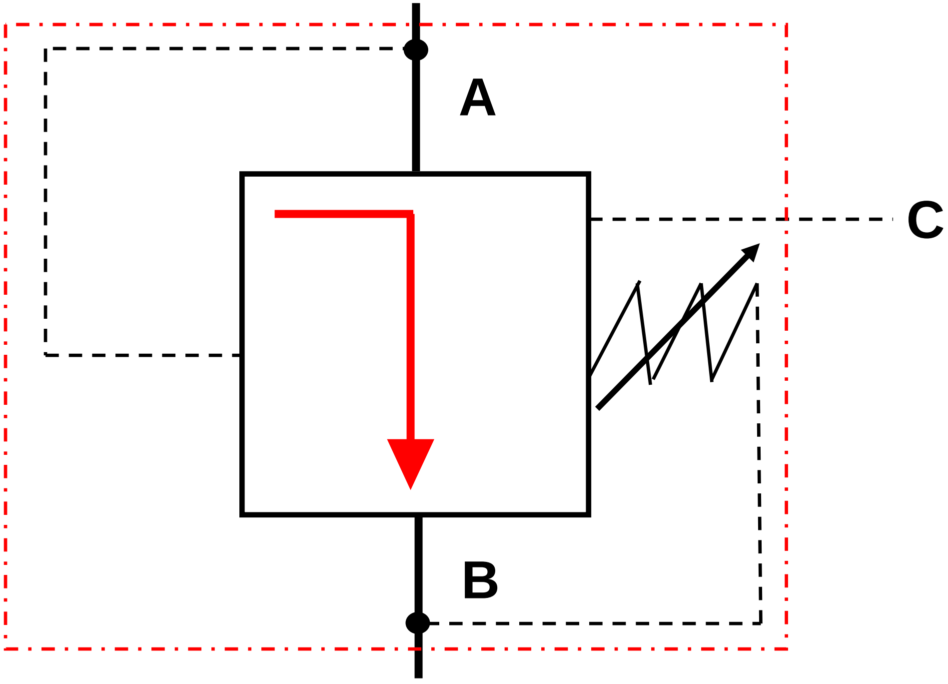
H.5.0 Circuit symbols and circuits

H.5.6 Pressure control valve (DBV):

H.5.6.3 Activation



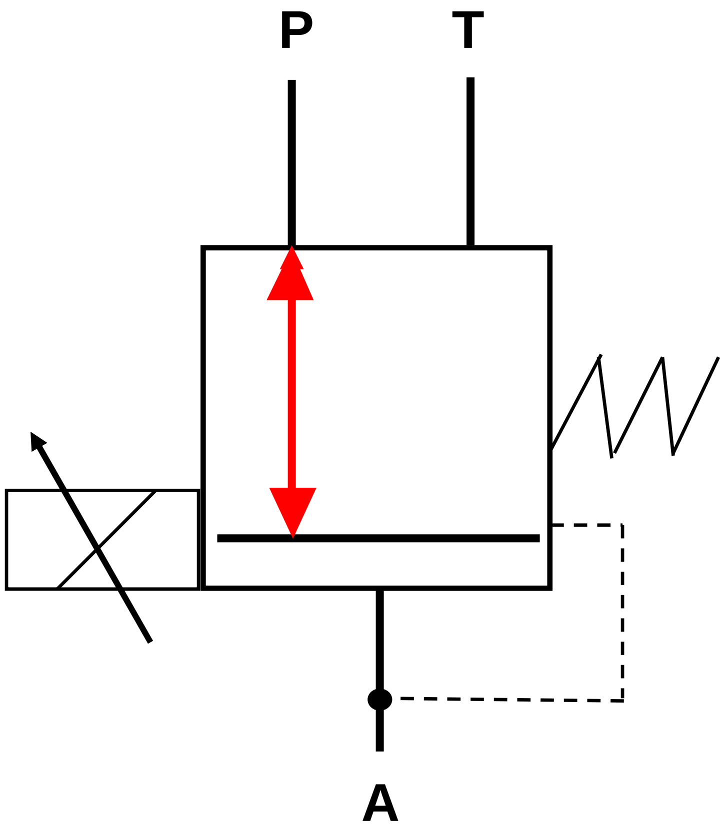
Pressure control valve DBV with additional remote activation connection and **external** control outlet.



Pressure control valve DBV with additional remote activation connection and **internal** control outlet.

H.5.0 Circuit symbols and circuits

H.5.7 Pressure reducing valve (DRV):



H.6.0 Circuit diagrams

H.6.1 Types of circuit diagram

At VÖGELE, we distinguish between two types of circuit diagram.

On the one hand, we have the „Hydraulic Function Diagram“ (**“H**ydraulischer **F**unktions**p**lan” **HFP**).

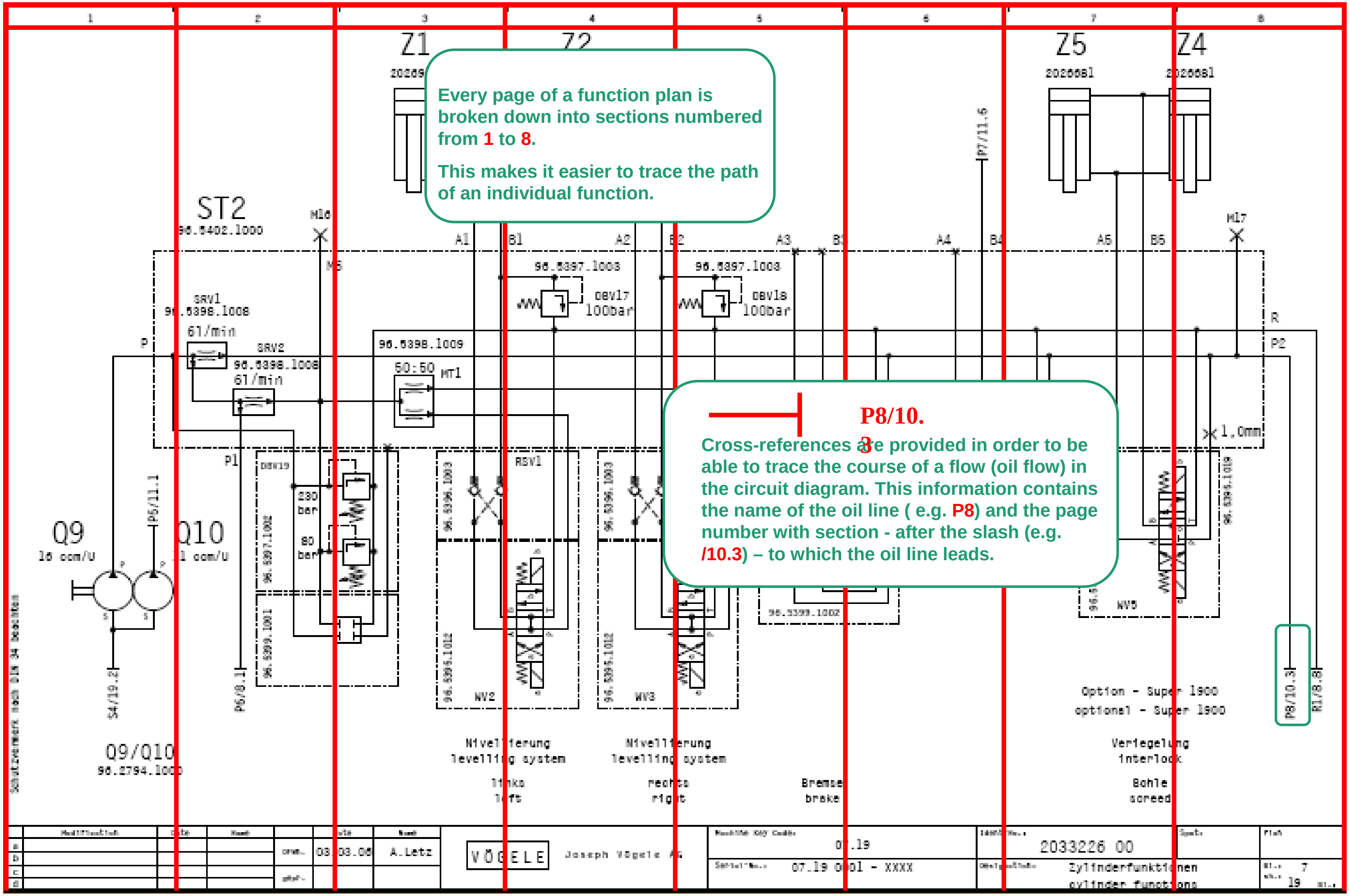
And on the other hand, we have the „Hydraulic Piping Diagram“ (“**H**ydraulischer **V**erschlauchungs**p**lan” **HVP**).

As the name already implies, the **HFP** illustrates the hydraulic functions, while the **HVP**, in contrast, illustrates individual components, such as pumps, hoses or consumers (motors or cylinders) and how they are interconnected.

The parts numbers of the individual components are always entered in both diagrams.

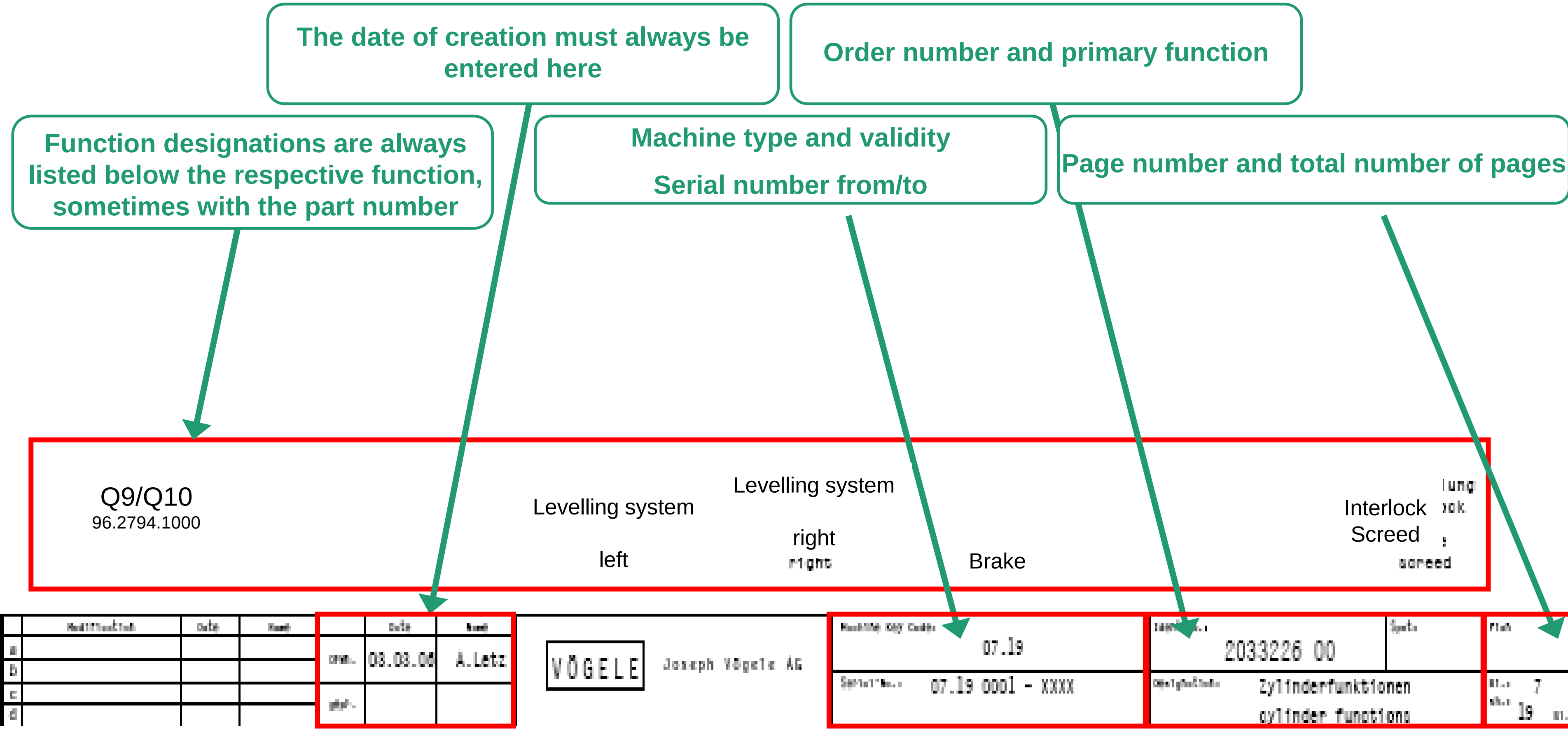
H.6.0 Circuit diagrams

H.6.2 Layout of a hydraulic function diagram (HFP) - Part 1



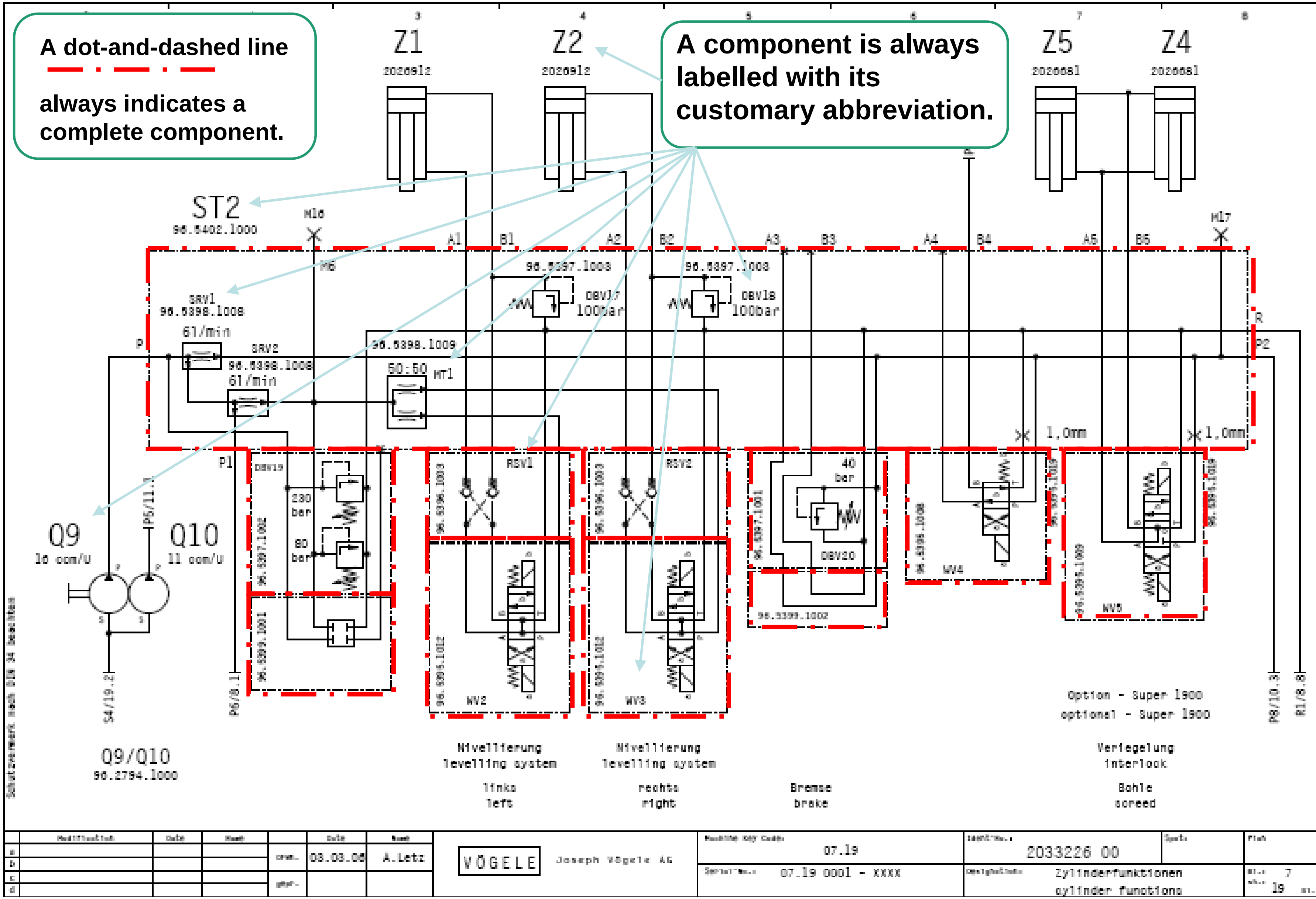
H.6.0 Circuit diagrams

H.6.2 Layout of a hydraulic function diagram (HFP) - Part 2



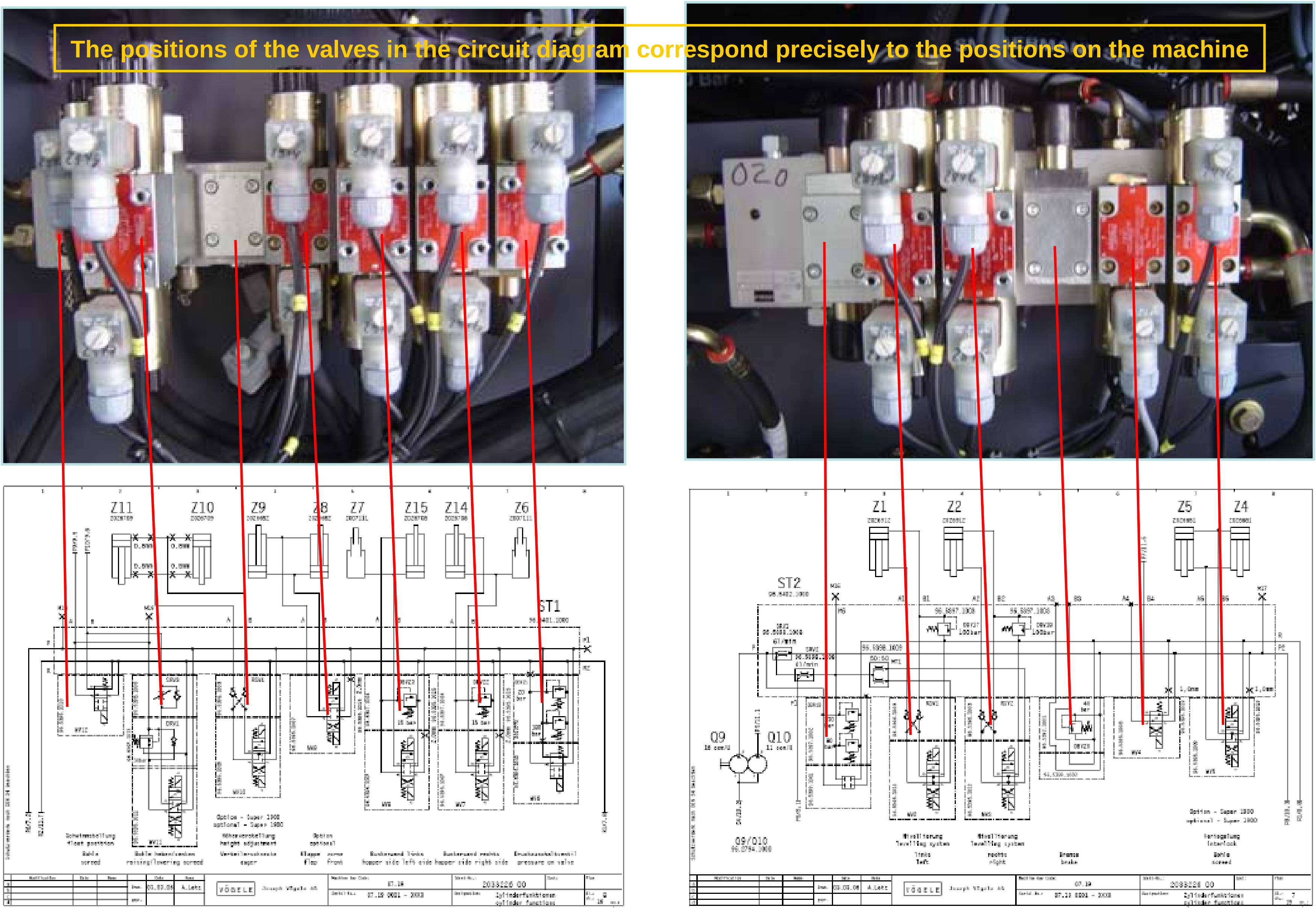
H.6.0 Circuit diagrams

H.6.2 Layout of a hydraulic function diagram (HFP) - Part 3



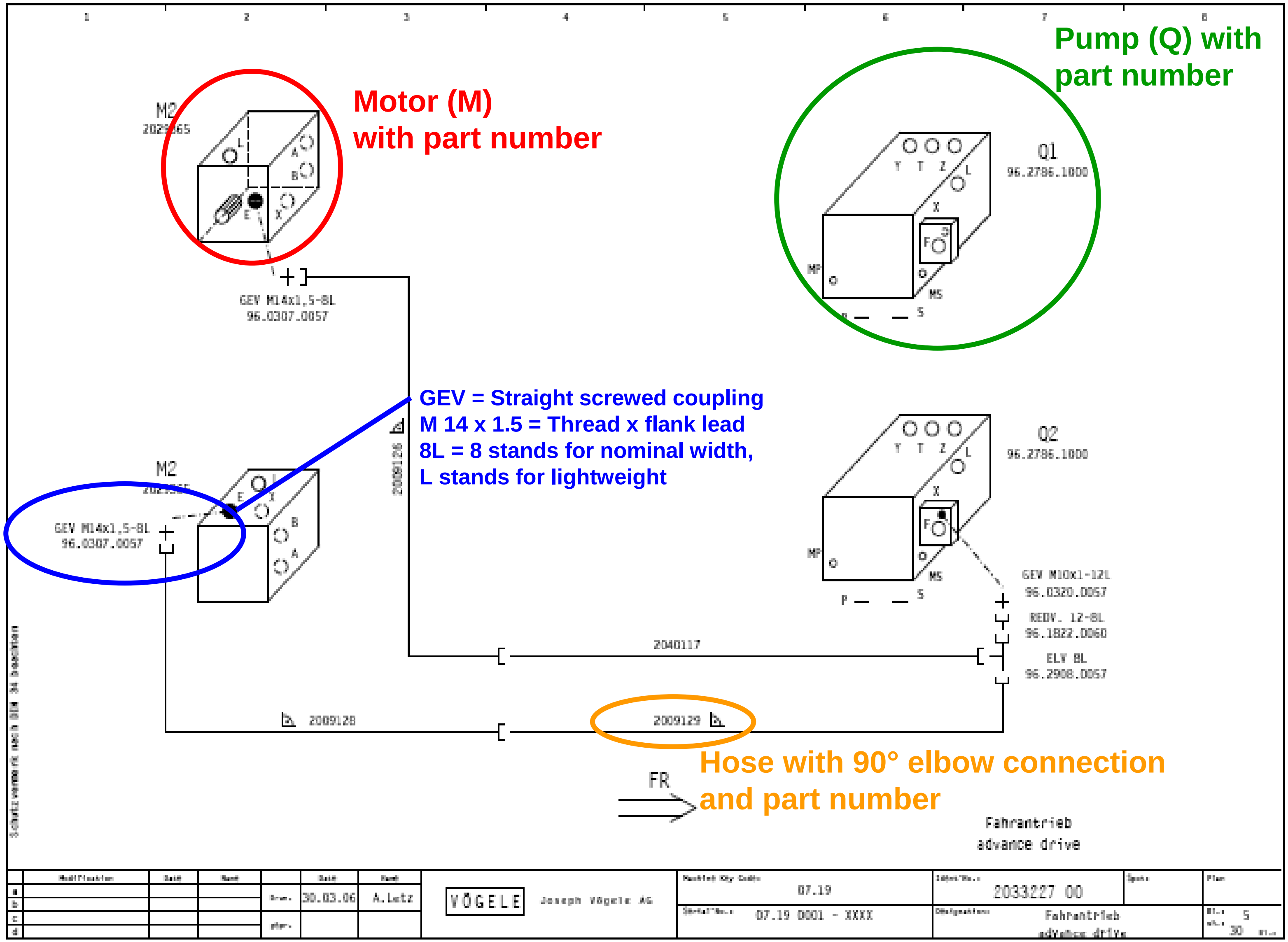
H.6.0 Circuit diagrams

H.6.2 Layout of a hydraulic function diagram (HFP) - Part 4



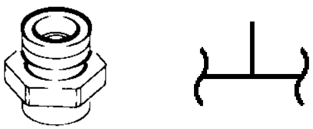
H.6.0 Circuit diagrams

H.6.3 Hydraulic piping diagram (HVP)

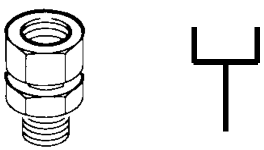


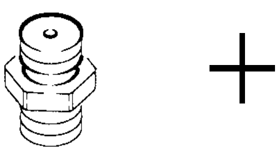
H.6.0 Circuit diagrams

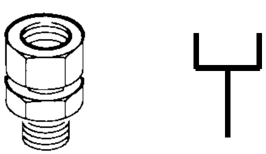
H.6.4 Symbols and abbreviations for HVPs - Part 1

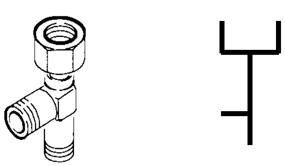

Welded fitting (ASV)

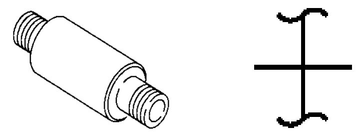

Inlay baffle (BL)

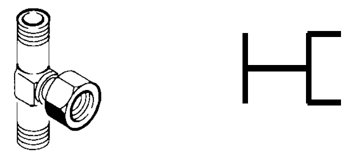

Spacer adapter (DA)

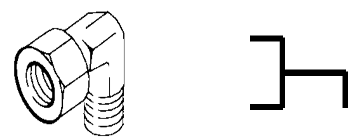

Restrictor fitting (DV)


Straight screw-in fitting with sealing cap (EGE)

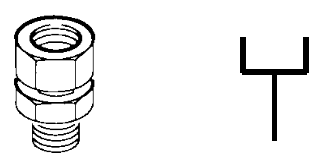

Adjustable – L – fitting (ELV)

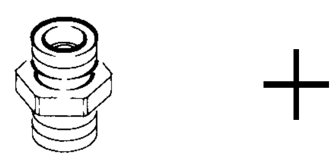

Welded bulkhead fitting (ESV)


Adjustable – T – fitting (ETV)


Adjustable elbow fitting (EWV)


Flat nut (FLM)


Straight screw-on fitting (GAI)

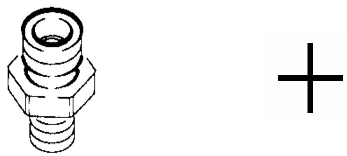

Straight screw-in fitting (GEV)

H.6.0 Circuit diagrams

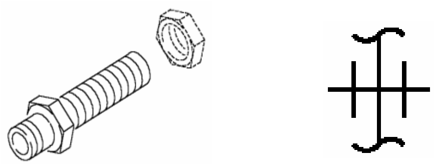
H.6.4 Symbols and abbreviations for HVPs - Part 2

Straight flanged fitting
L - Series (GFL)

Straight flanged fitting
S – Series (GFS)



Straight reducing fitting (GRV)



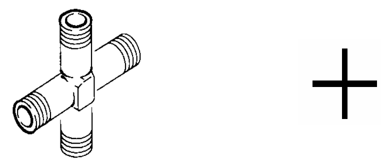
Straight bulkhead fitting (GSV)

Straight fitting (GV)

Straight intermediate fitting (GZV)

Hollow bolt (HS)

Tapered reducer fitting (KOR)



Cross fitting (KV)

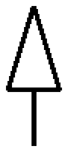
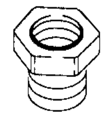
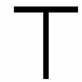
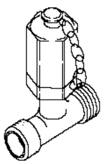
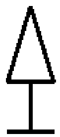
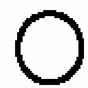
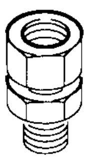
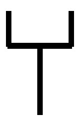
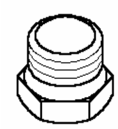
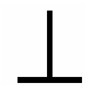
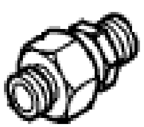
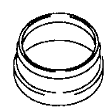
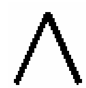
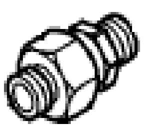
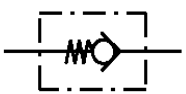
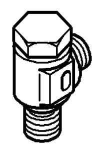
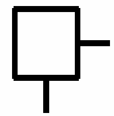
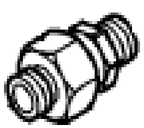
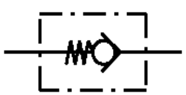
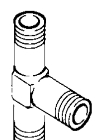
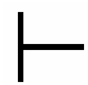
Manometer screw-on fitting (MAV)

Manometer fitting (MAVE)

Screw-on measurement connection
(Minim. DKO)

H.6.0 Circuit diagrams

H.6.4 Symbols and abbreviations for HVPs - Part 3

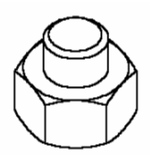
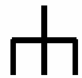
		Screw-in measurement connection (Minim. GEV)			Screw-in reducer fitting (RI)
		Straight measurement connection (Minim. GV)			Ring eye (RIG)
		Reducer fitting (REDV)			Pipe connection fitting ROV)
		Non-return valve (RHD)			Olive (SR)
		Non-return valve (RHV)			Swivel fitting (SWV)
		Non-return valve (RHZ)			T – fitting (TV)

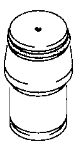
H.6.0 Circuit diagrams

H.6.4 Symbols and abbreviations for HVPs - Part 4

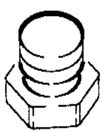
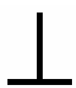


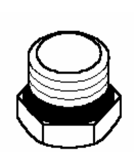
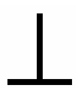
Sleeve nut (ÜM)

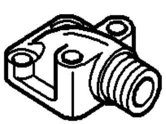


Blanking plug, including sleeve nut (VKA)



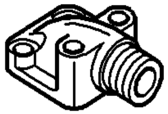
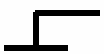
Blanking plug (VS)

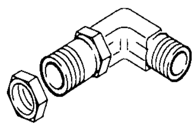
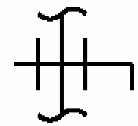


Blanking bolt (VSS) (sealing edge)

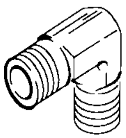
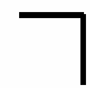


Blanking bolt (VSTI) (Eolastic – seal)



Elbow flanged fitting L – Series (WFL)



Elbow flanged fitting S – Series (WFS)



Elbow bulkhead fitting (WSV)

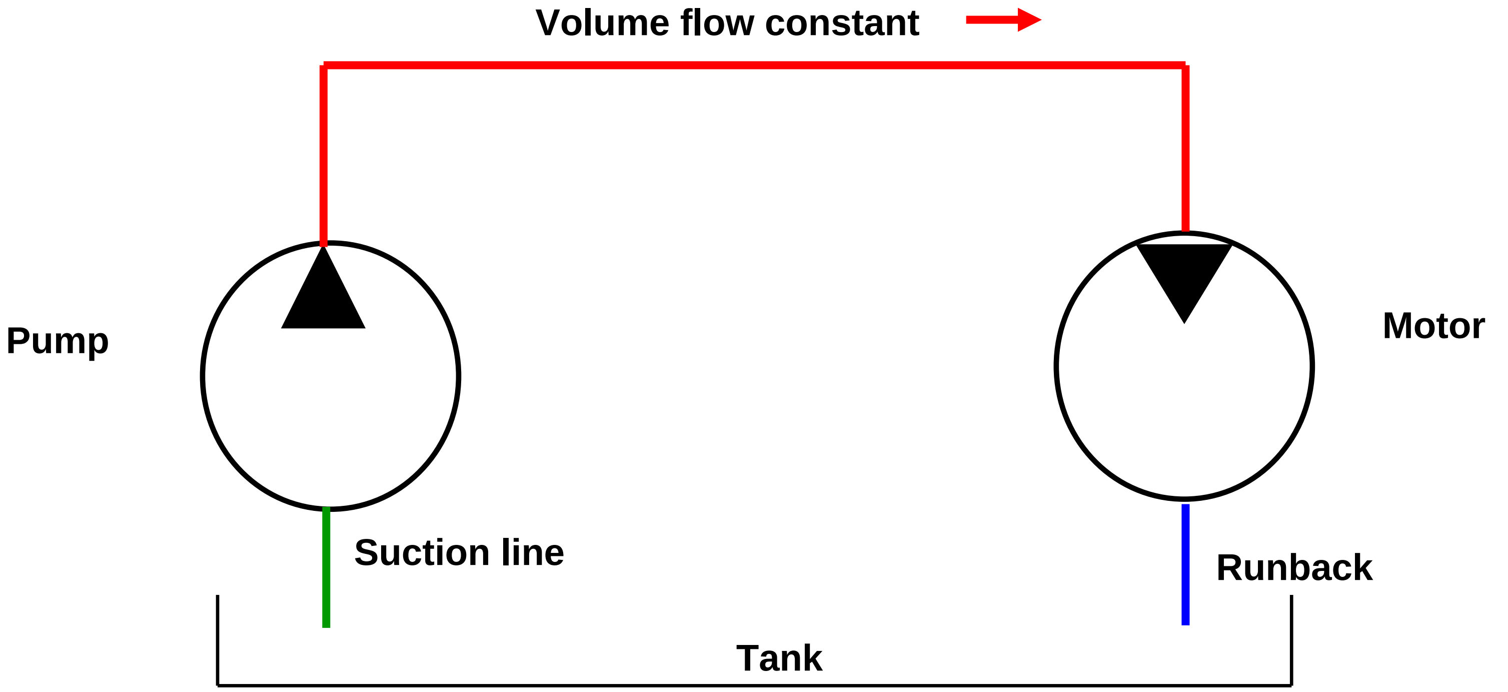


Elbow fitting (DCV)

H.7.0 Open circuit

The hydraulic pump sucks hydraulic fluid (hydraulic oil) out of an unpressurized container (hydraulic tank) and feeds the hydraulic fluid into a hydraulic system. The pressurized hydraulic fluid can then be fed via lines, hoses and valves to „actuators“ (hydraulic cylinders, hydraulic motors) where the actual work is carried out.

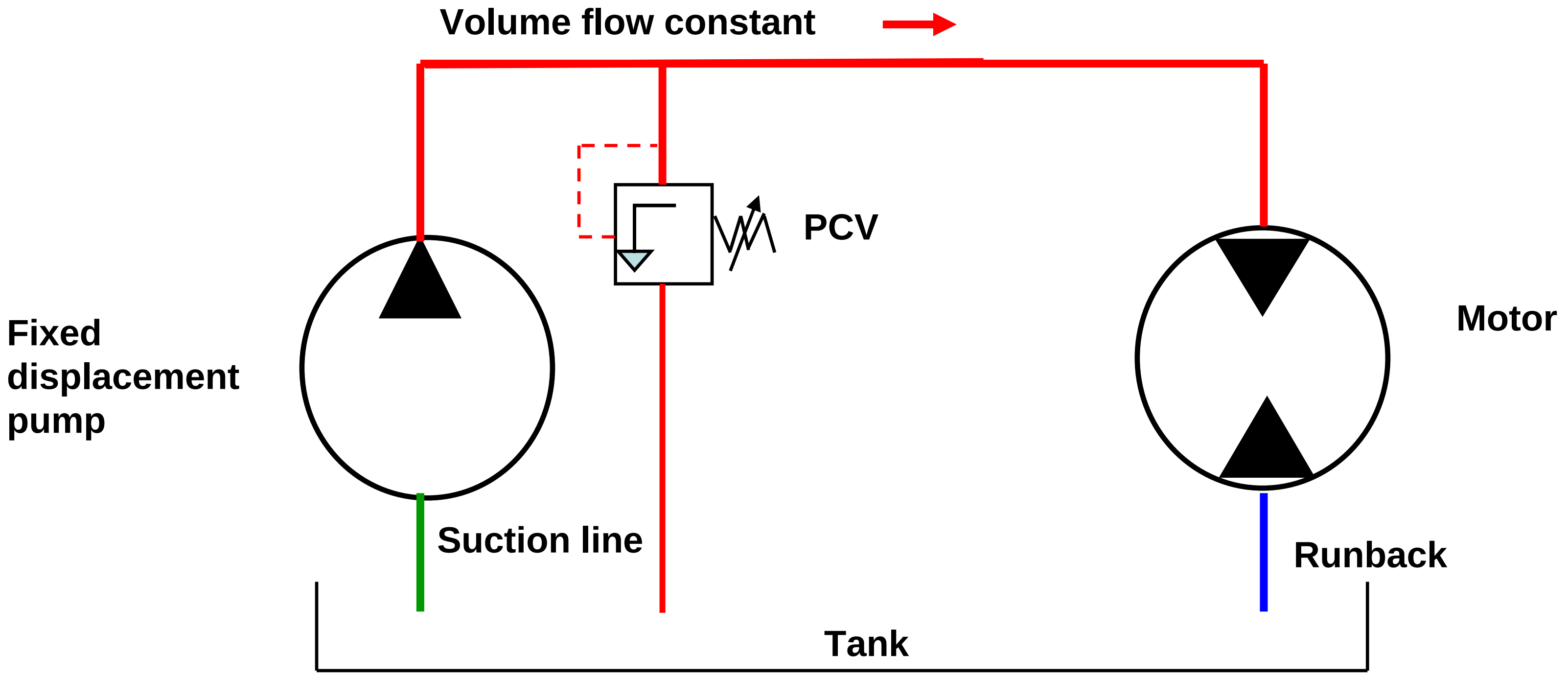
Axial piston machines are self-priming and are therefore pressurized on the suction-side in certain individual cases (<2 bar).

The open circuit represents the standard for many industrial and mobile applications, from machine tools and press drive systems, all the way to winch and mobile gearboxes.



H.7.0 Open circuit

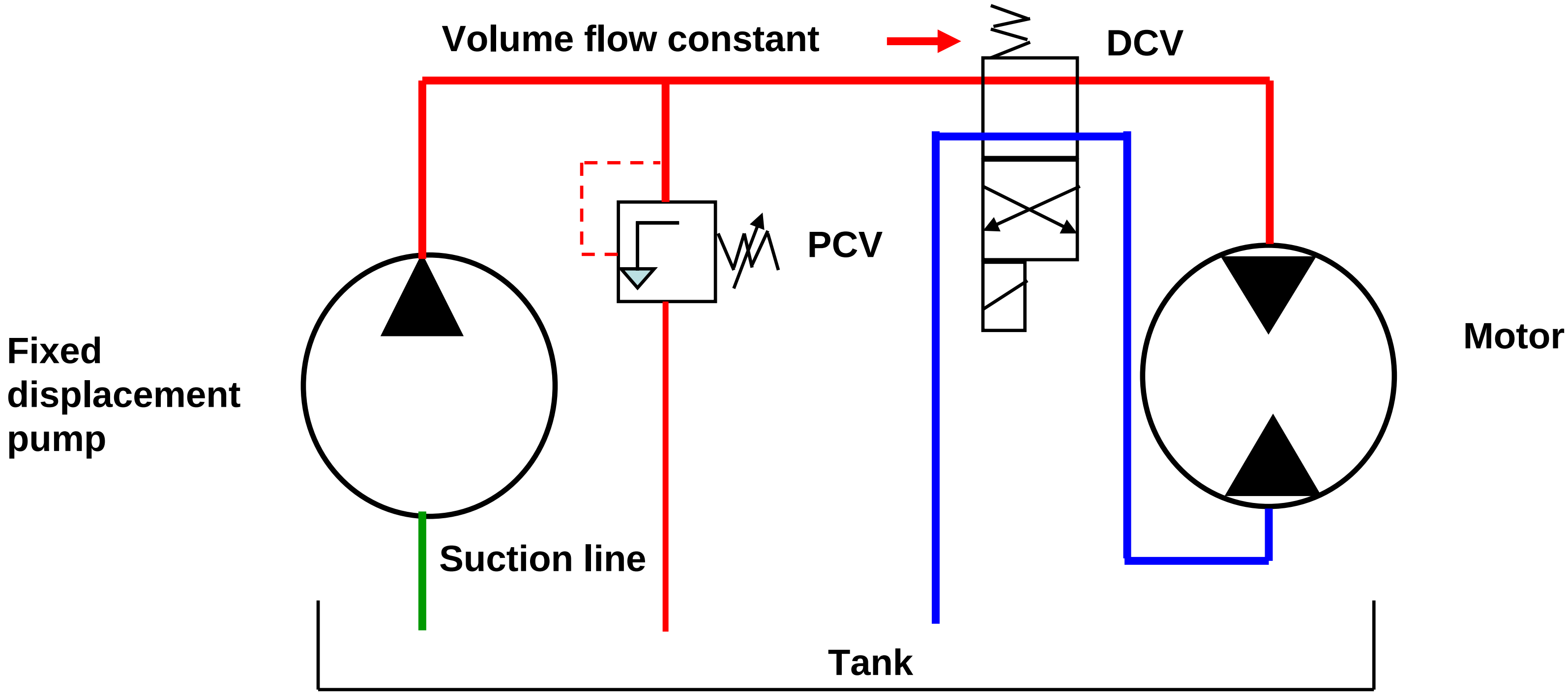
H.7.1 Overload protection



The pressure control valve (PCV) protects the system against overloading.

H.7.0 Open circuit

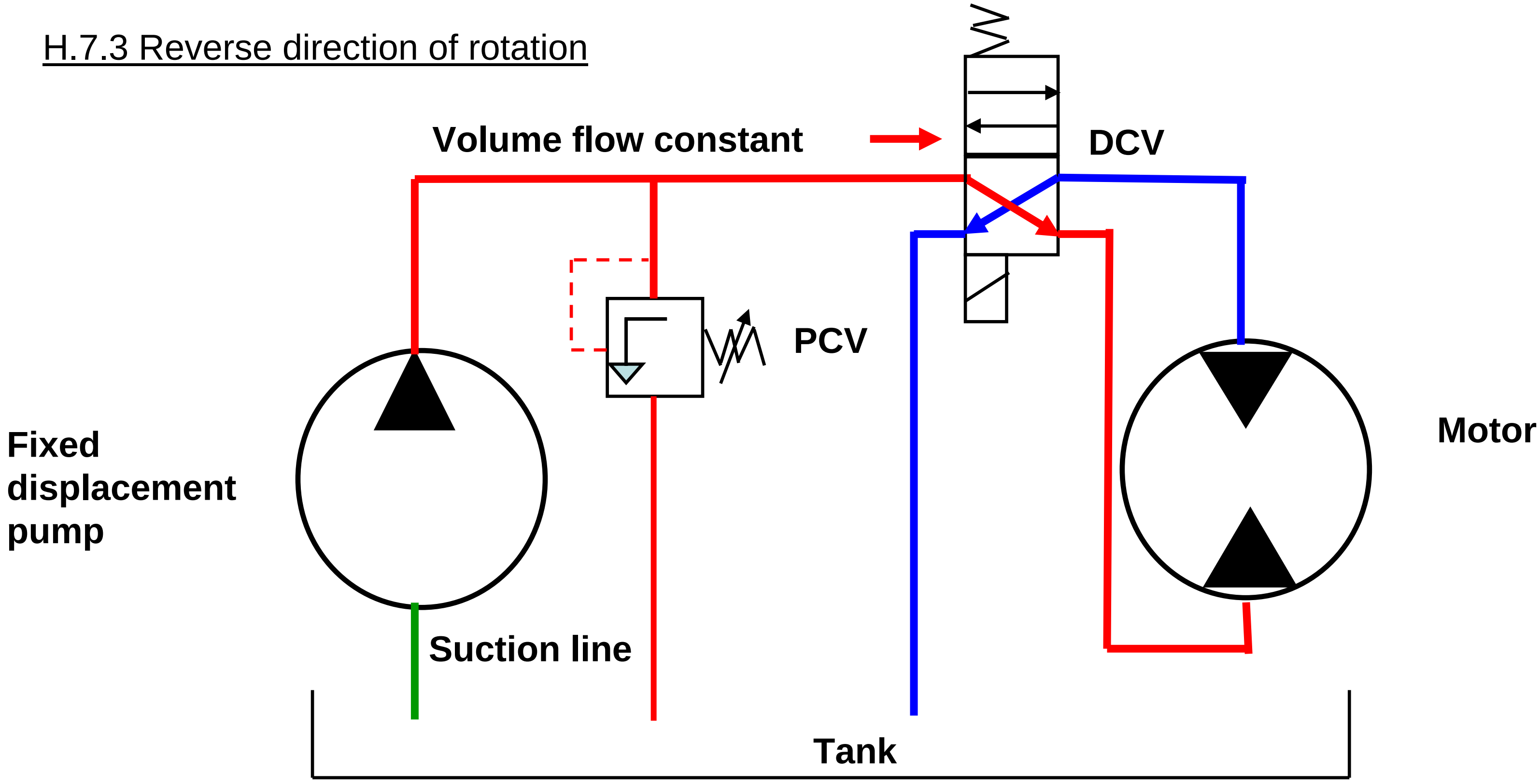
H.7.2 Directional control valve



A directional control valve (DCV) can also be installed in order to change the direction of rotation of the motor.

H.7.0 Open circuit

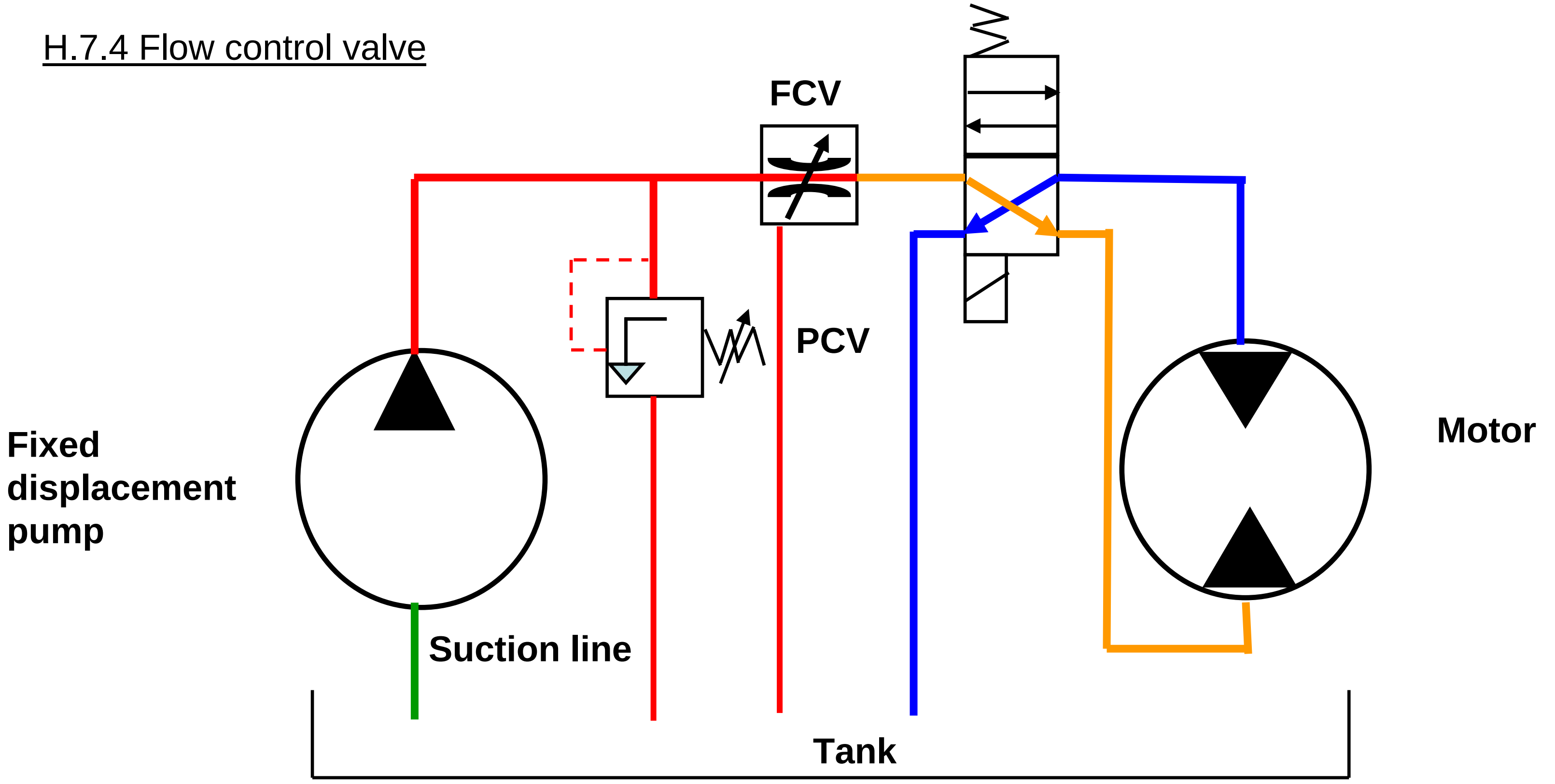
H.7.3 Reverse direction of rotation



The directional control valve makes it possible to reverse the direction of rotation or travel at the consumer.

H.7.0 Open circuit

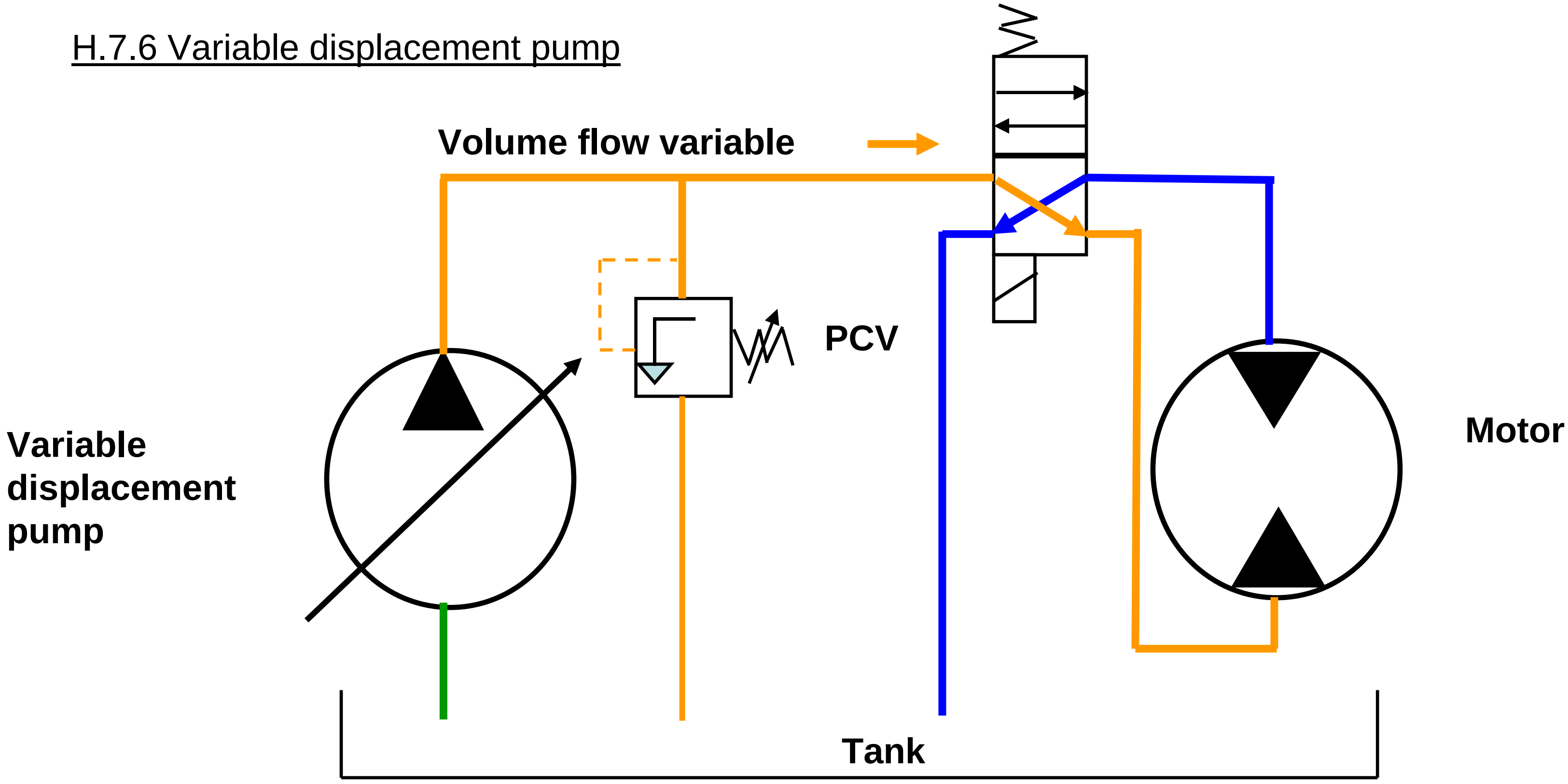
H.7.4 Flow control valve



The use of a flow control valve (FCV) renders the motor speed variable.

H.7.0 Open circuit

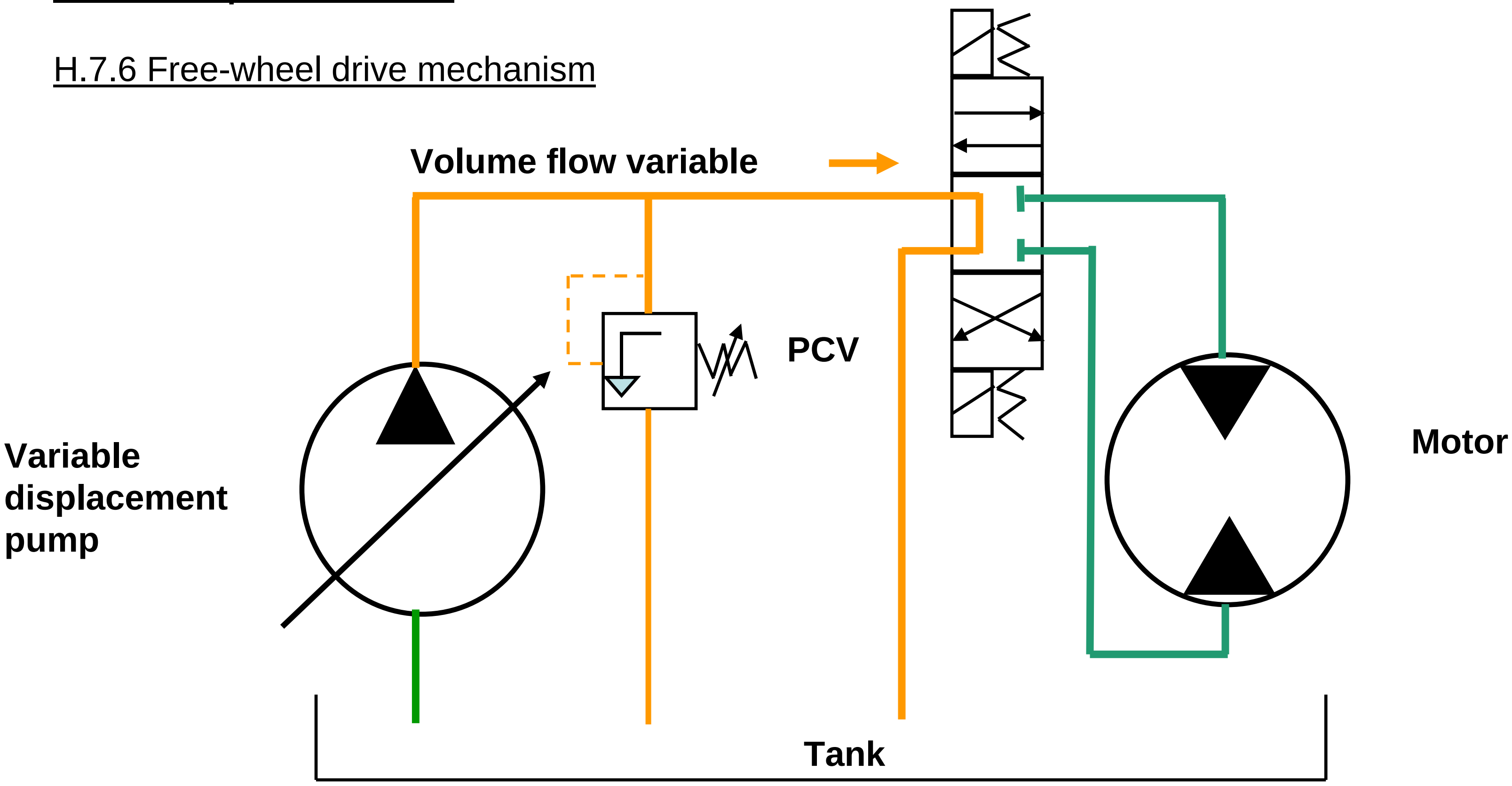
H.7.6 Variable displacement pump



A variable displacement pump replaces
a fixed displacement pump and flow control valve.

H.7.0 Open circuit

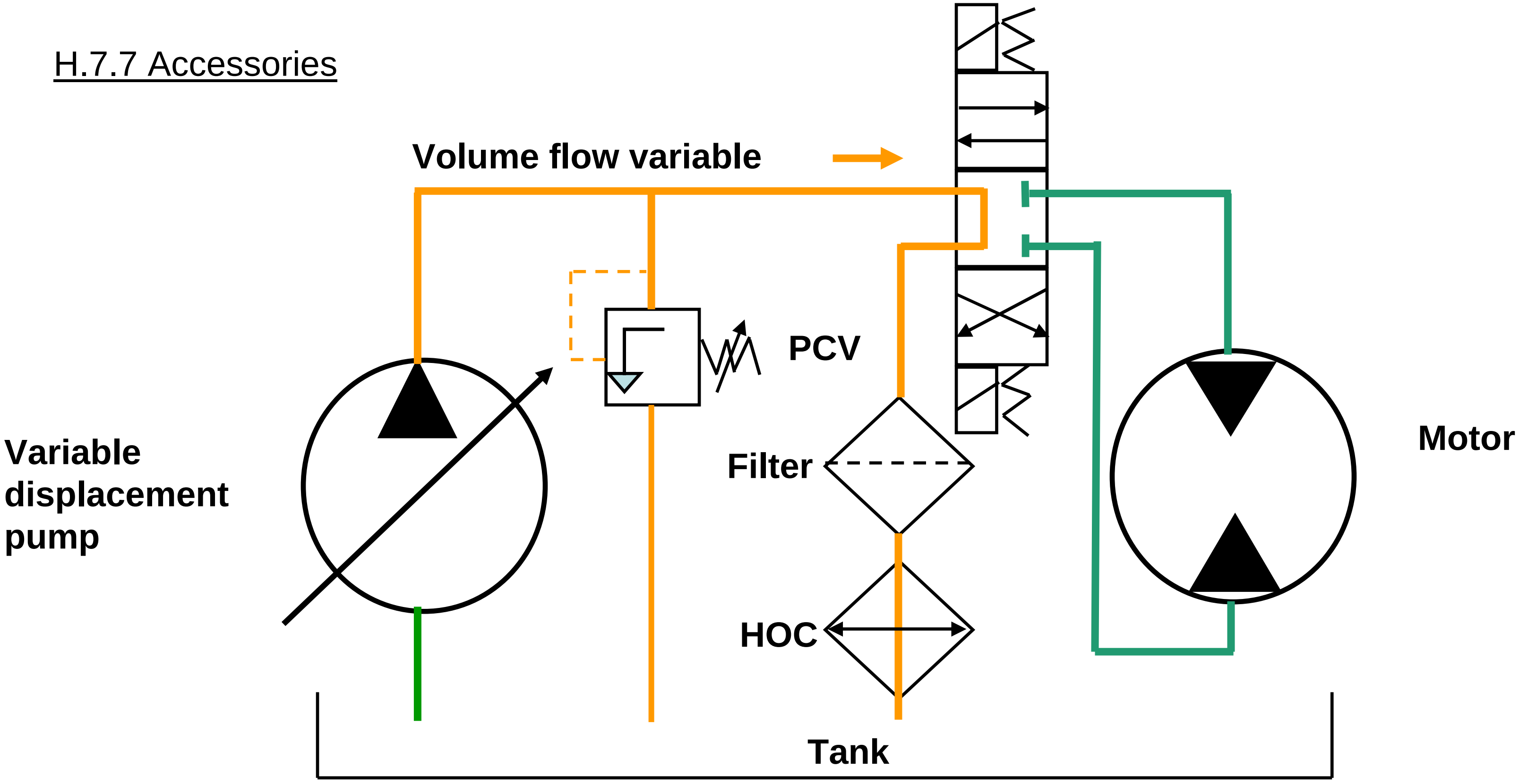
H.7.6 Free-wheel drive mechanism



The use of additional directional control valve functions result in a free-wheel drive mechanism of the consumer.

H.7.0 Open circuit

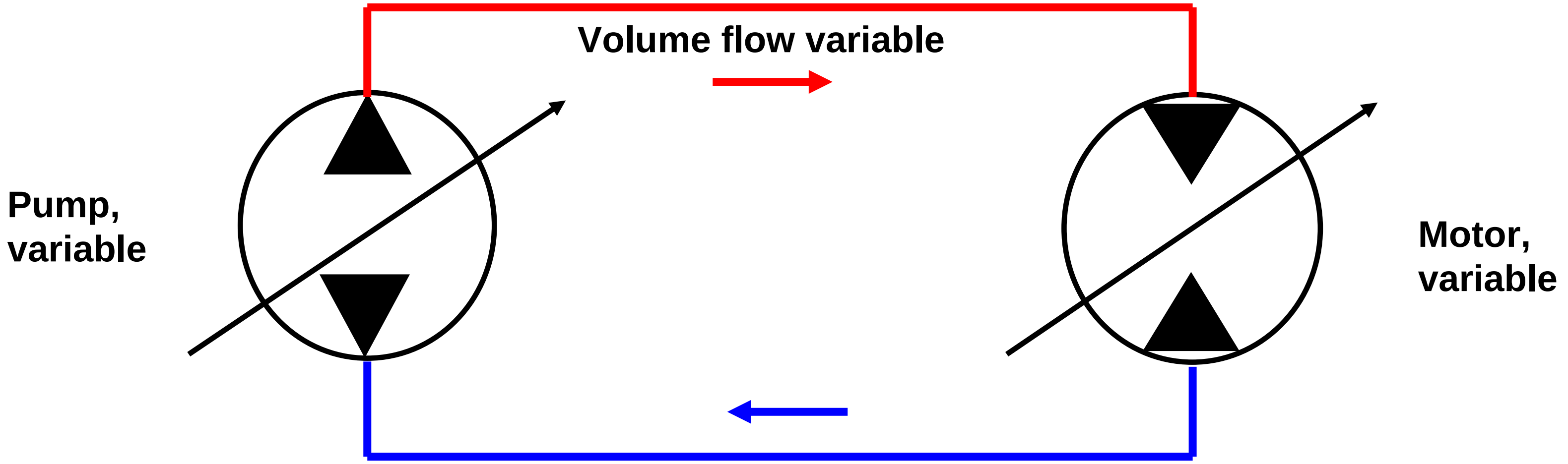
H.7.7 Accessories



The circuit can be supplemented through accessories, such as filters and coolers, etc.

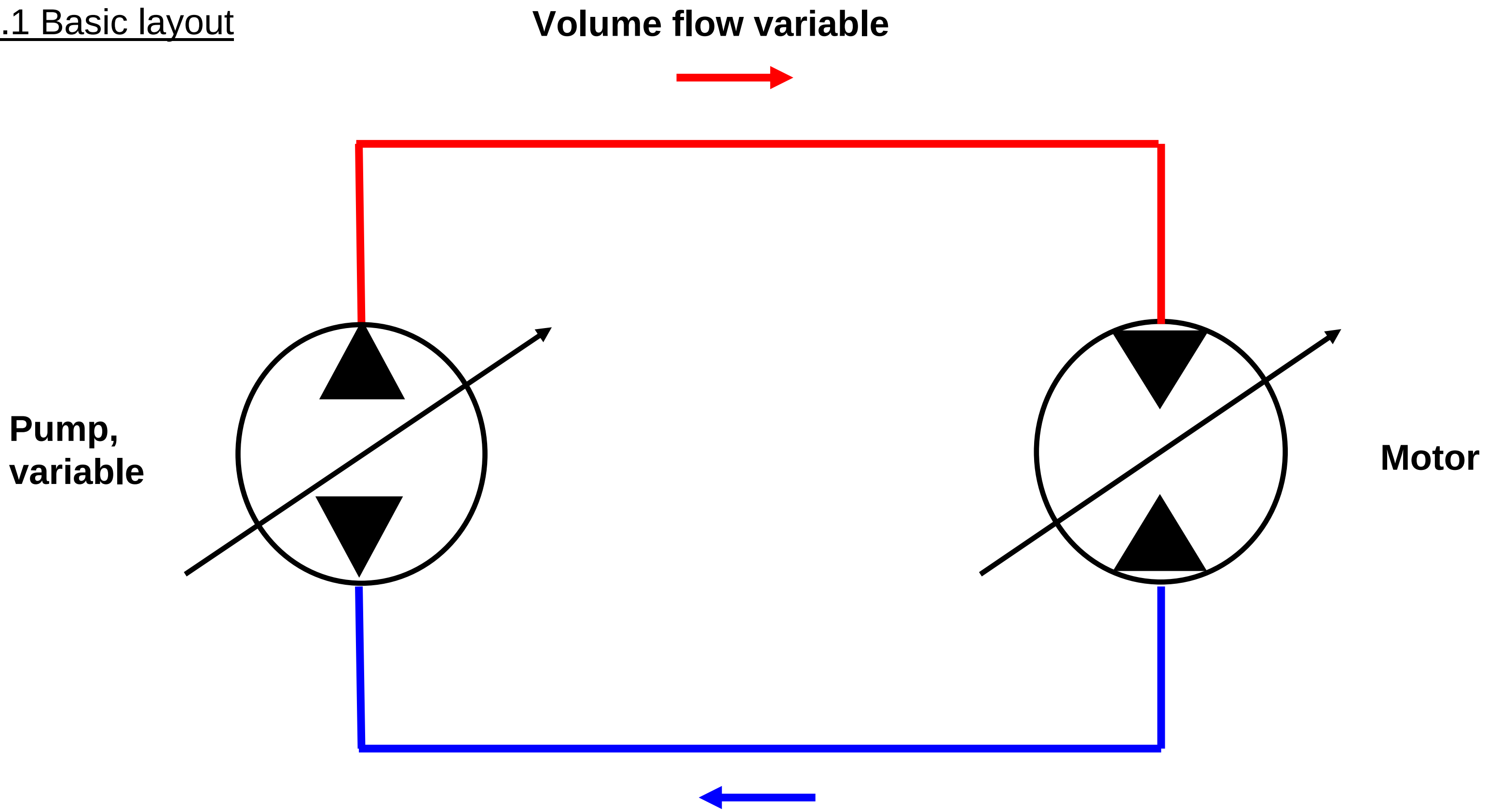
H.8.0 Closed circuit

The hydraulic pump is fed with hydraulic fluid returning directly from the actuator (hydraulic motor).
The hydraulic fluid is under low pressure of roughly 10 to 30 bar and is raised to a higher pressure level (high pressure) by the hydraulic pump before being fed back to the actuator again.
The advantages of this process are high speeds and filtering at a low pressure of just 10 to 20% of the volume of the primary pump.
The circuit has high pressure and low pressure sides, which change with the direction of load.
The high pressure side is protected by pressure control valves, which relieve the pressure towards the low pressure side.
The medium remains in the circuit.
Only the leakage at the hydraulic pump and hydraulic motor (depending on operating data) has to be replaced.
This is realized by a (usually) directly flange-connected auxiliary pump that permanently feeds a sufficient fluid volume (feed volume) from a tank to the low pressure side via a non-return valve.
The unneeded volume flow of the feed pump working in the open circuit is returned to the tank via a feed pressure control valve.



H.8.0 Closed circuit

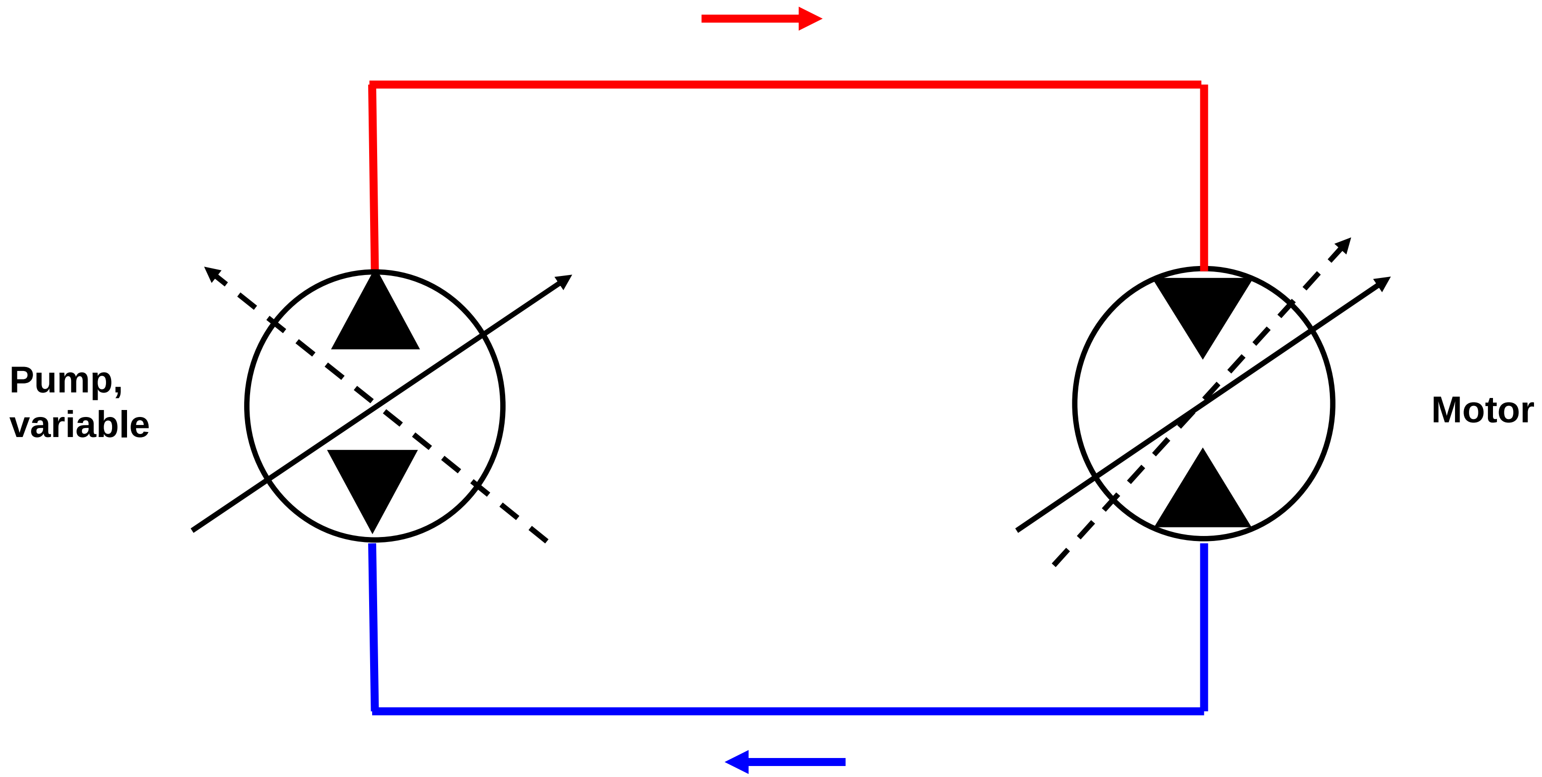
H.8.1 Basic layout



Basic layout with variable displacement pump and variable displacement motor.

H.8.0 Closed circuit

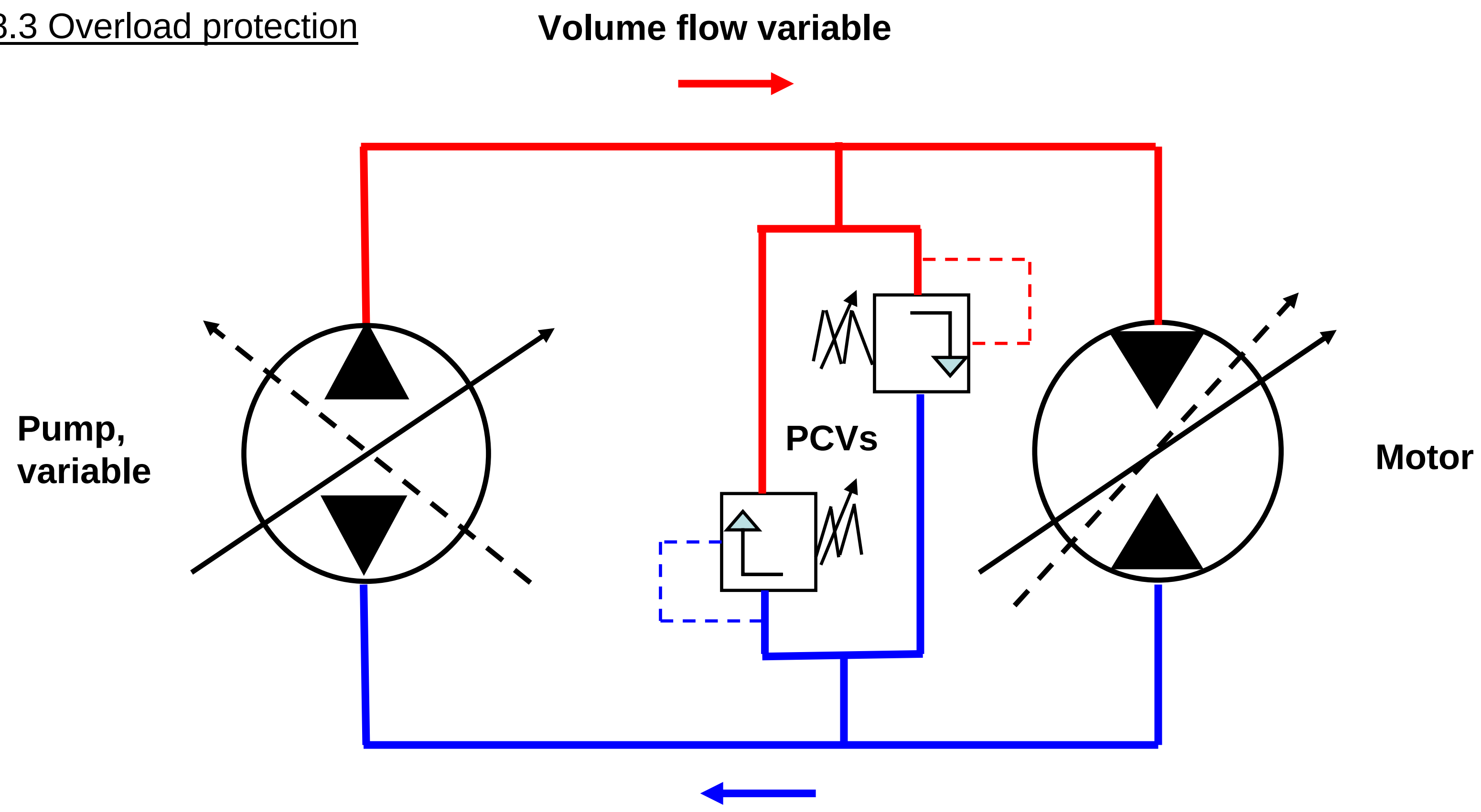
H.8.2 Changing direction of rotation **Volume flow variable**



The drive direction of rotation of the pump is unidirectional, while that of the motor is bidirectional. The pivoting angle of the pump is infinitely adjustable via the zero position, i.e. the volume flow direction can be reversed.
The motor pivots unidirectionally and is likewise infinitely adjustable.

H.8.0 Closed circuit

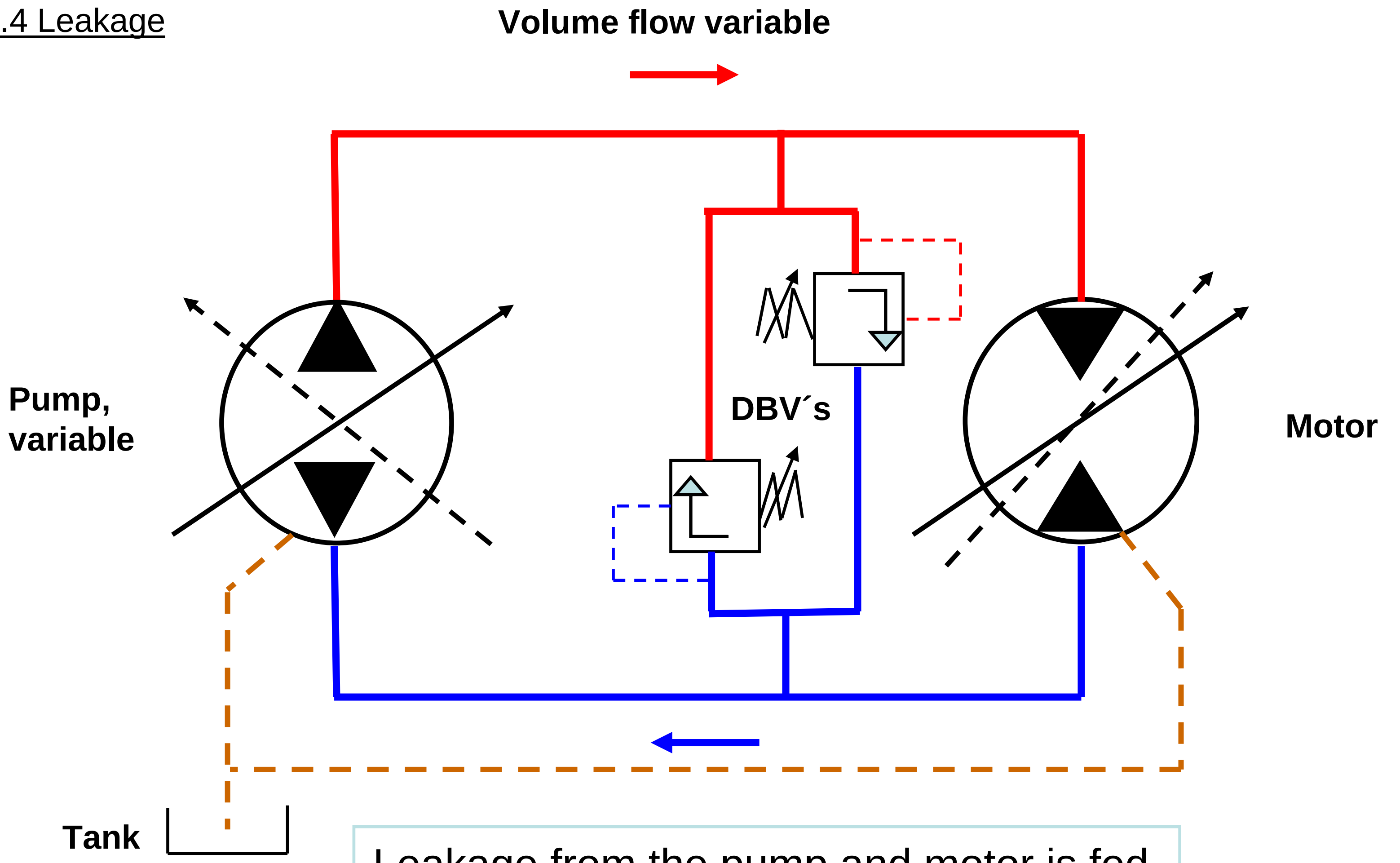
H.8.3 Overload protection



The maximum permissible pressure is ensured by means of pressure control valves (PCV). A pressure control valve (PCV) is used for each pressure side.

H.8.0 Closed circuit

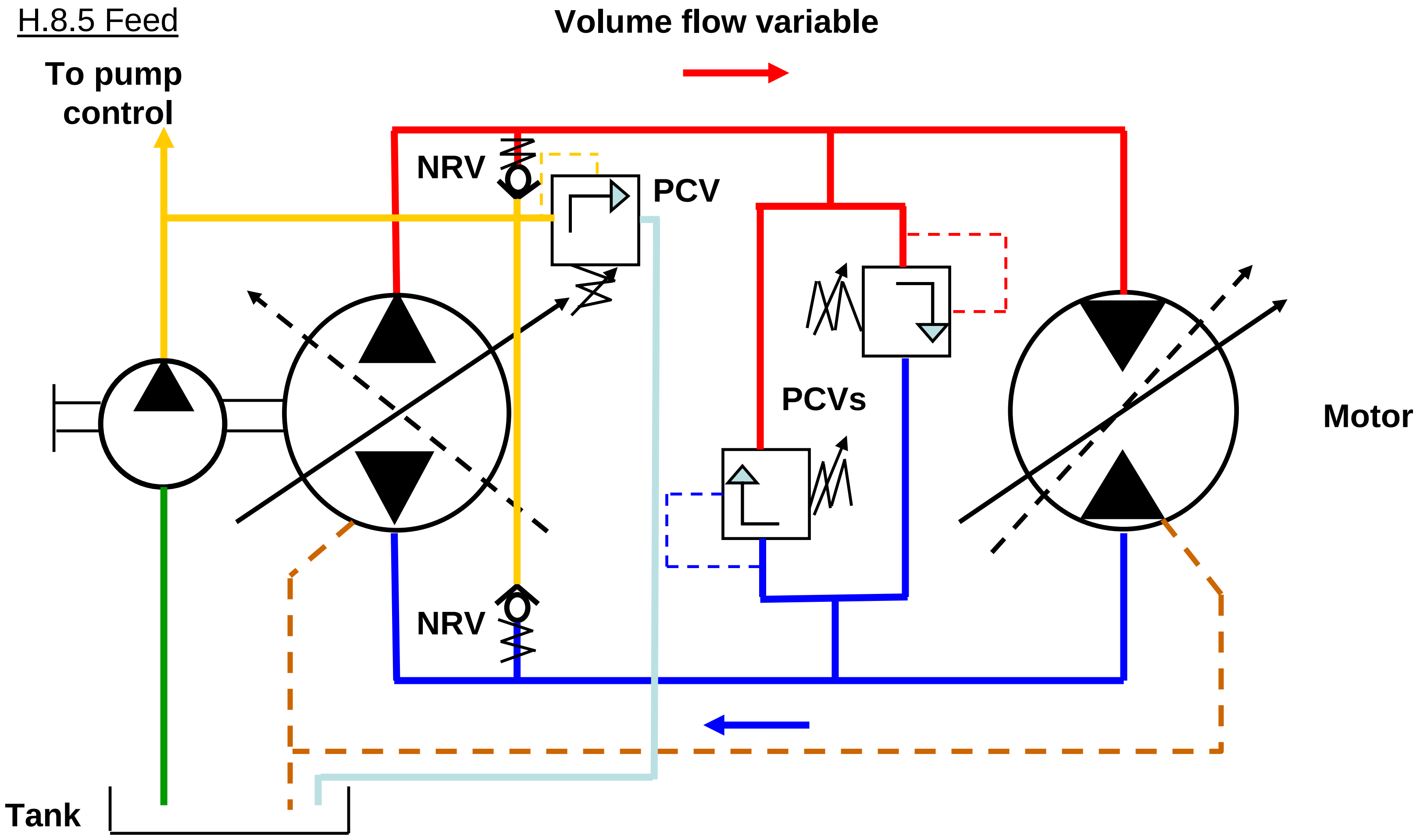
H.8.4 Leakage



Leakage from the pump and motor is fed into the tank and must be replaced.

H.8.0 Closed circuit

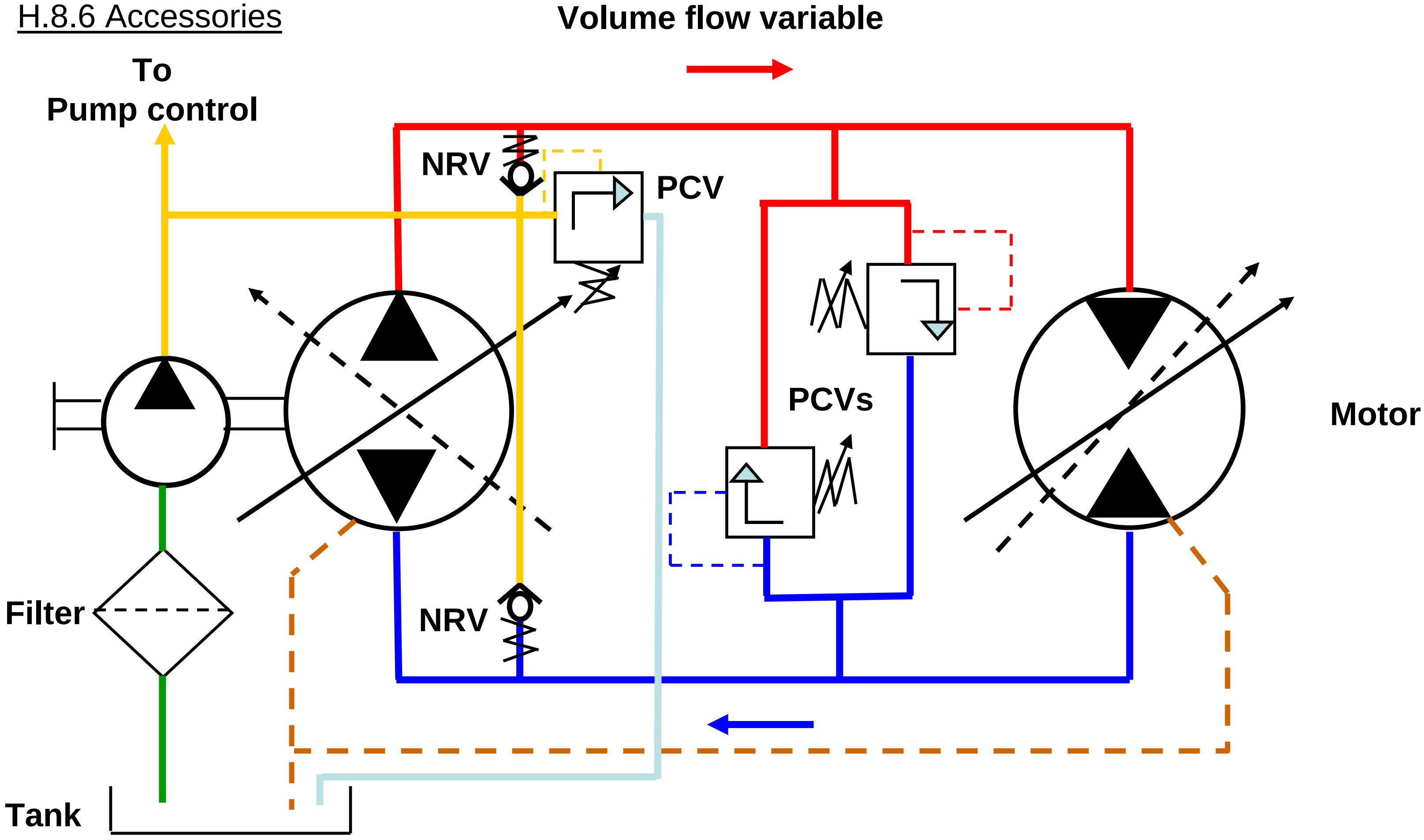
H.8.5 Feed



An auxiliary pump for replacing the leakage and controlling the variable pump,
non-return valves (NRV) for the feed. Protection is provided by a feed pressure control valve.

H.8.0 Closed circuit

H.8.6 Accessories



The hydraulic system can be supplemented through the use of accessories, such as filters.

H.9.0 Hydraulic pumps

The hydraulic pump is a fluid engineering component that converts mechanical energy (rotational speed x torque) into hydraulic energy (pressure x volume flow).

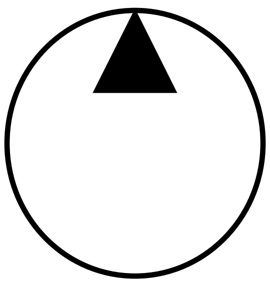
H.9.1 Designs

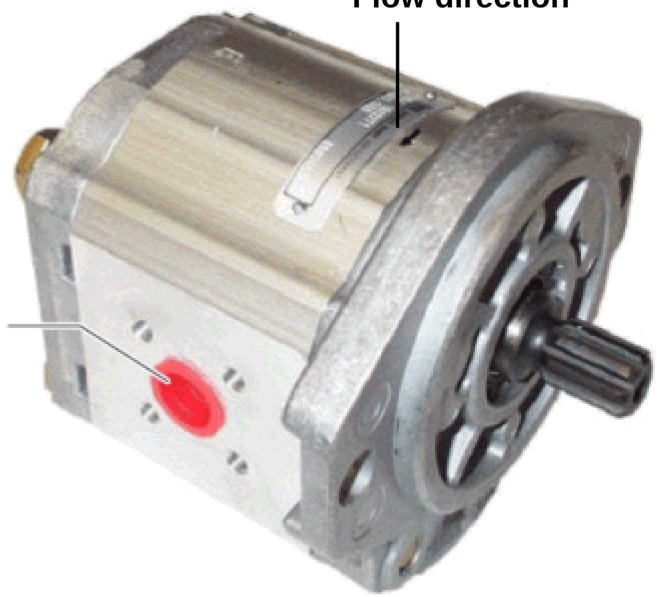
Distinctions are made between numerous designs:

- Geared pump (geared internally or externally)
- Rotary screw pump
- Gerotor pump
- Axial piston pump (inclined axle or inclined disk)
- Reciprocating pump (often used for high-pressure applications)
- Radial piston pump (series or star eccentric)
- Rotary vane pump

H.9.0 Hydraulic pumps

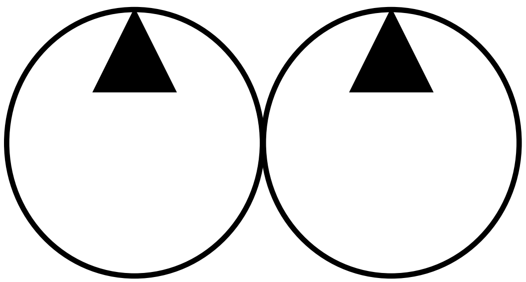
H.9.2 Fixed displacement pump (geared pump) - Part 1

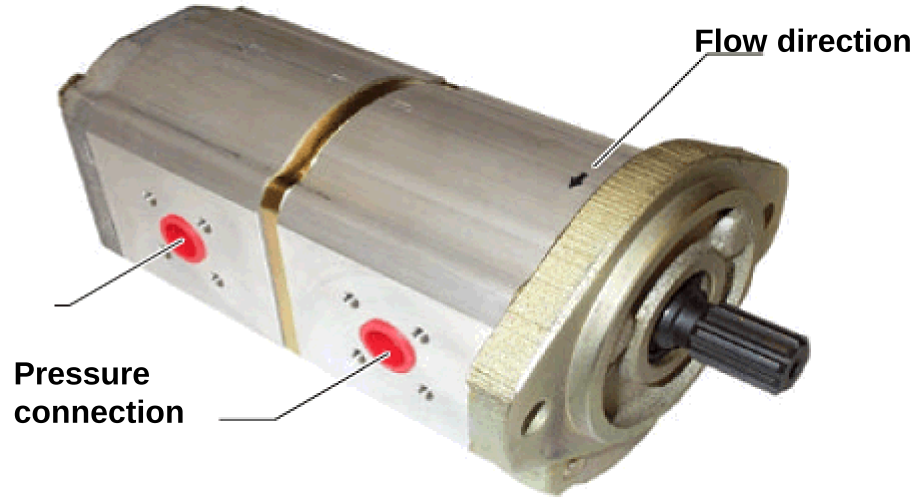


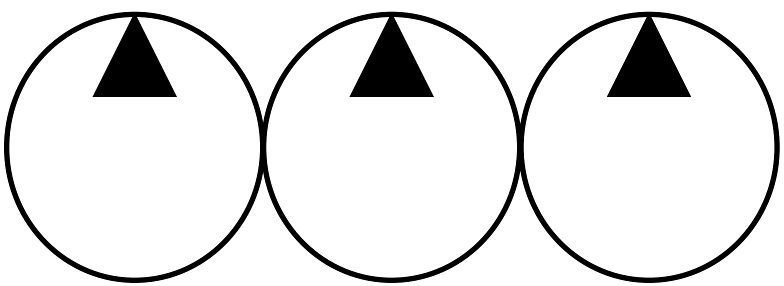


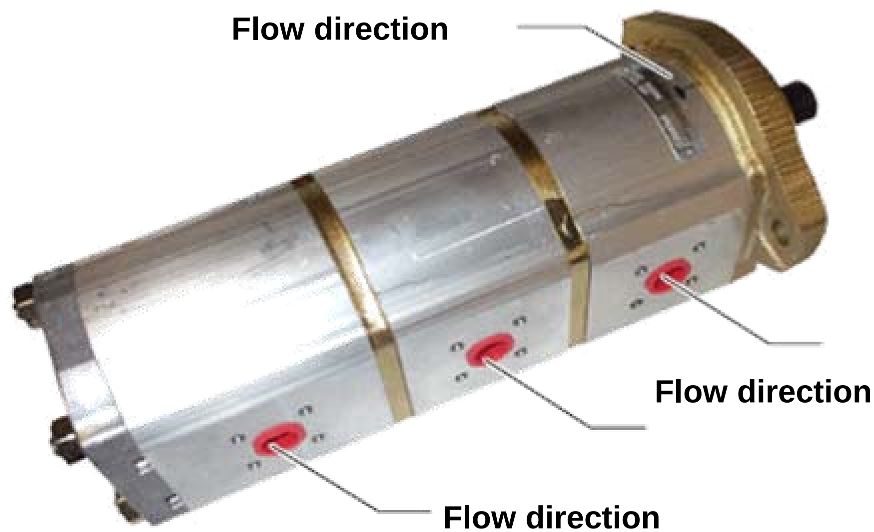
H.9.0 Hydraulic pumps

H.9.2 Fixed displacement pump (geared pump) - Part 2





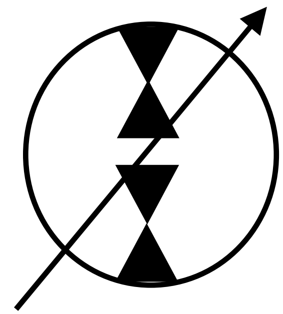


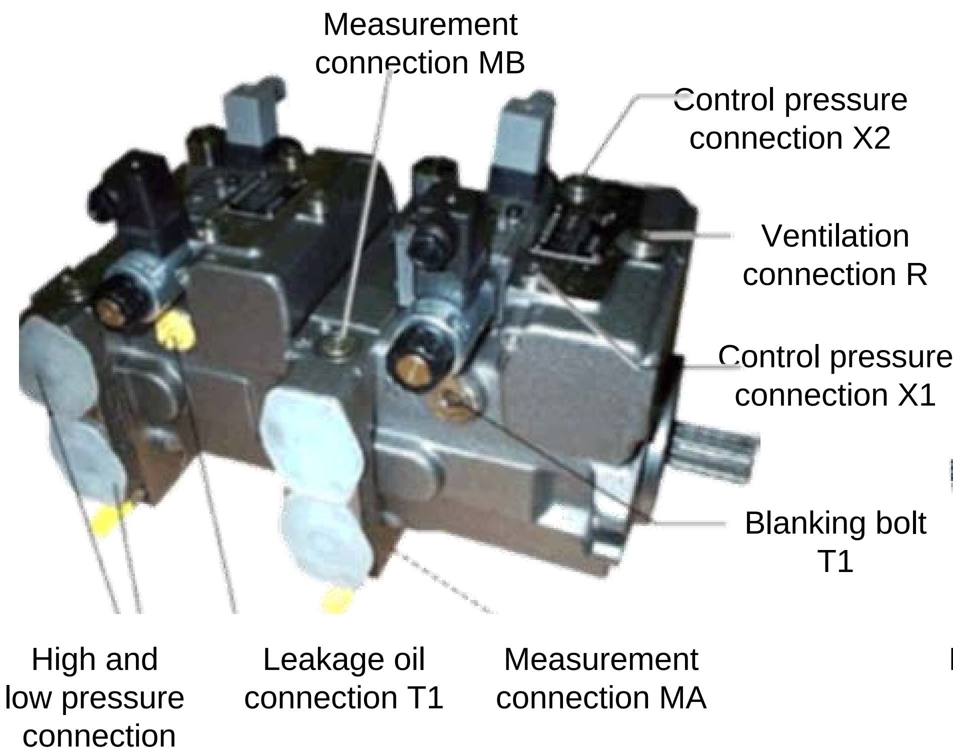


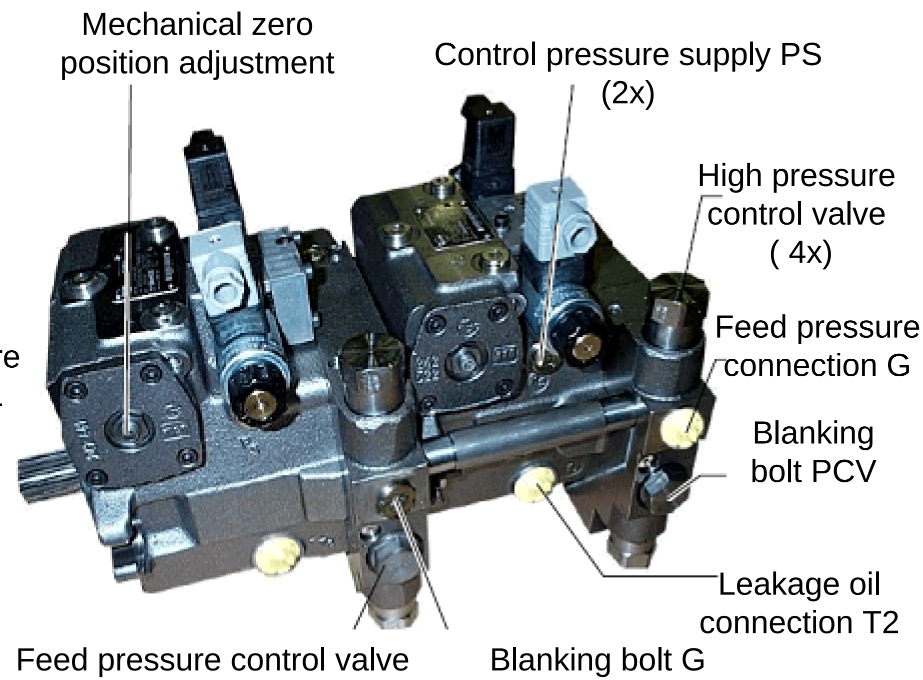
H.9.0 Hydraulic pumps

H.9.3 Variable displacement pump (axial piston variable displacement pump)

H.9.3.1 Conveyor - Auger





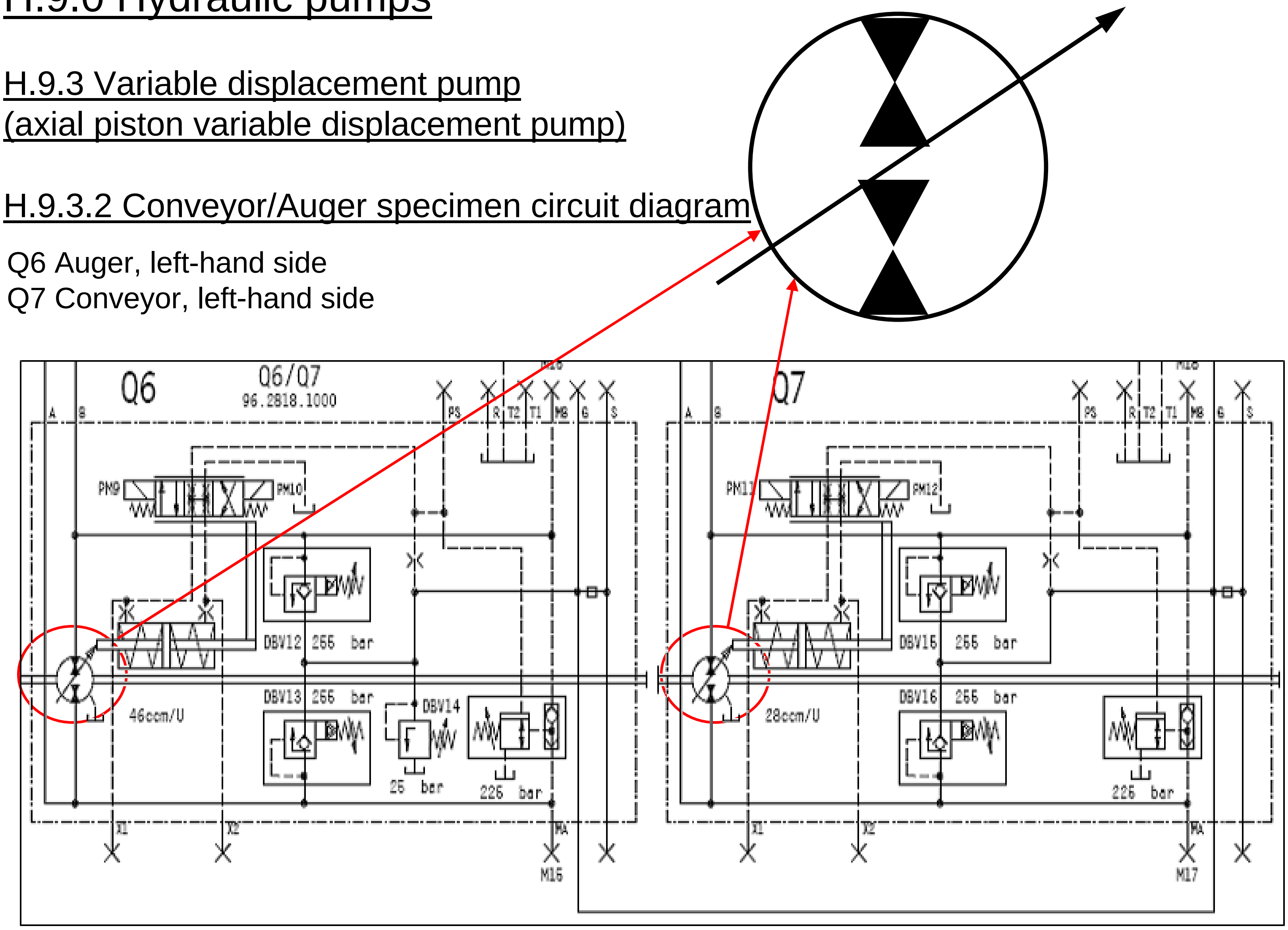


H.9.0 Hydraulic pumps

H.9.3 Variable displacement pump (axial piston variable displacement pump)

H.9.3.2 Conveyor/Auger specimen circuit diagram

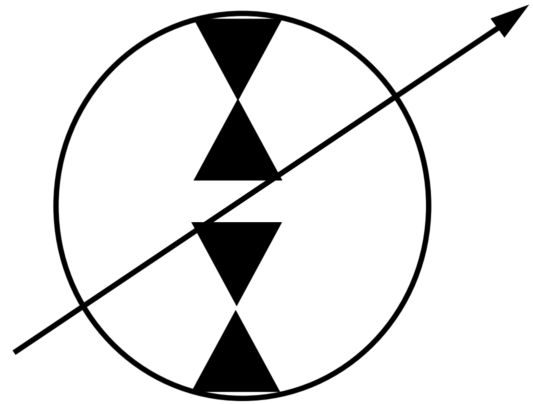
Q6 Auger, left-hand side
Q7 Conveyor, left-hand side

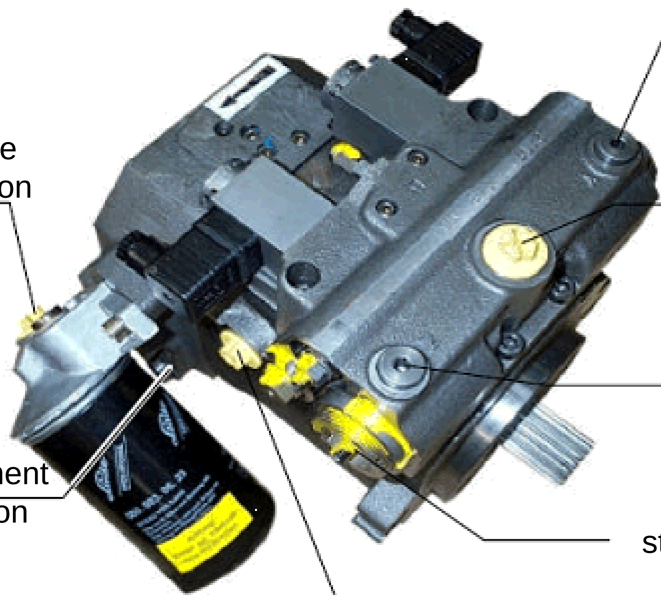


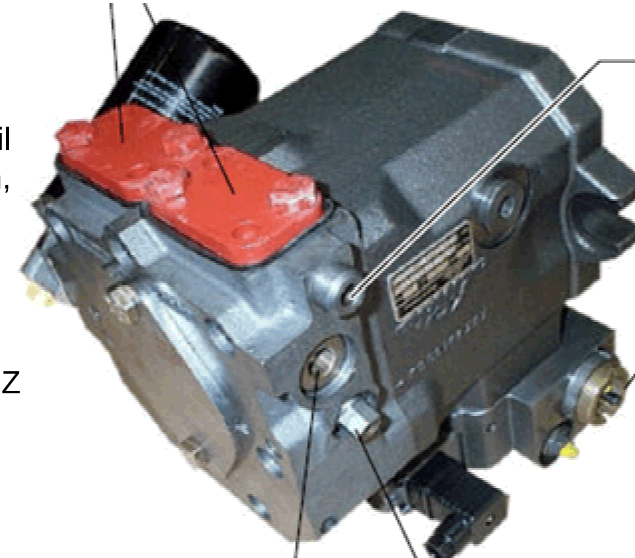
H.9.0 Hydraulic pumps

H.9.3 Variable displacement pump (axial piston variable displacement pump)

H.9.3.3 Traction drive



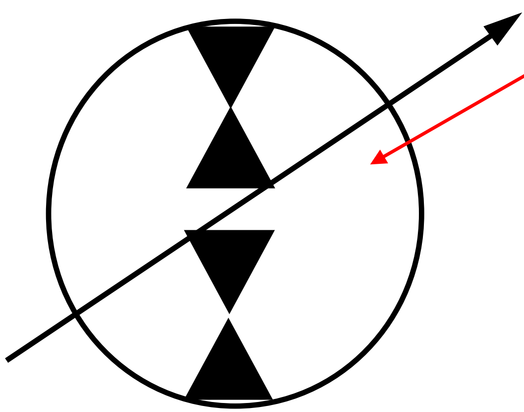


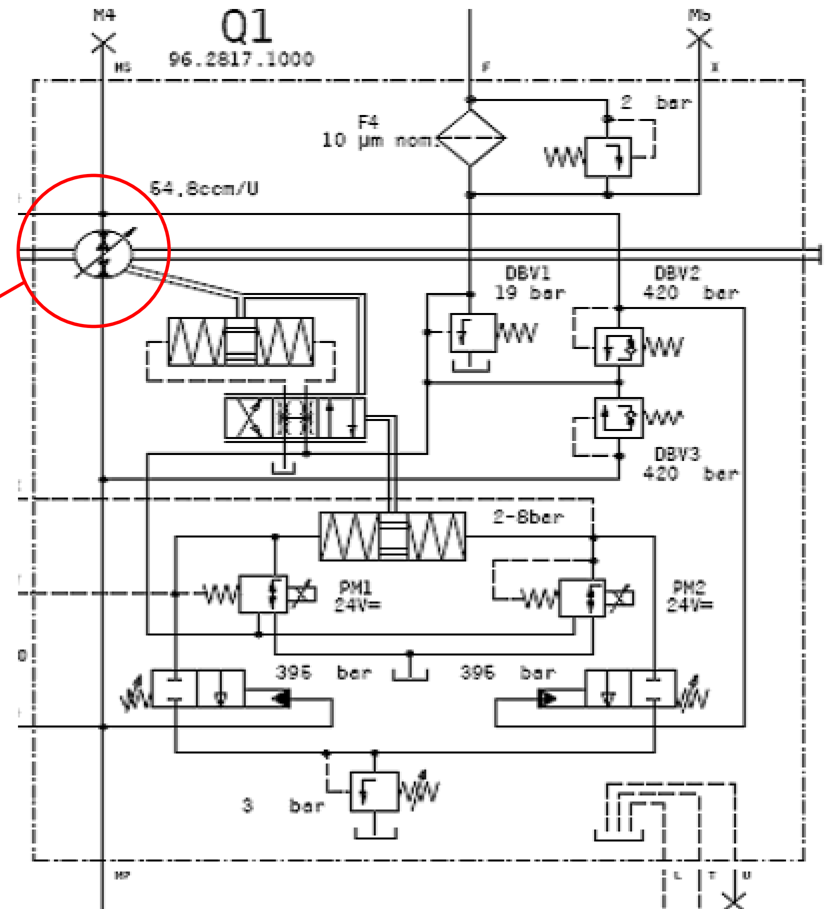


H.9.0 Hydraulic pumps

H.9.3 Variable displacement pump (axial piston variable displacement pump)

H.9.3.4 Traction drive specimen circuit diagram





Q1 Traction dive pump, right-hand side

H.10.0 Hydraulic motors

Hydraulic motors - also known as hydromotors - have the task of converting hydraulic energy (pressure + fluid flow) into Mechanical energy. A host of different designs exist to this end that can be roughly categorized as fixed displacement motors or variable displacement motors as a function of their method of operation. They are frequently constructed in the same way as hydraulic pumps.
The scope of applications is decisive for the dimensions and performance of a hydromotor. The size of a motor (pump) is specified as the nominal size.

The torque generated by a hydromotor is independent of the rotational speed. While the torque is determined by the load pressure and displacement volume, the rotational speed depends on the provided volume flow and displacement volume.

H.10.1 Designs

- Geared pump
- Radial piston pump
- Axial piston motor
- Rotary vane motor
- Rotary screw motor

H.10.2 Categorisation of hydraulic motors

Hydraulic motors are assigned to the following categories as a function of their range of rotational speed:

- *High speed*

  Geared motors are classed as high-speed motors on account of their high degree of slip (leakage oil).
  They are built as fixed displacement motors with one or two directions of rotation.
    - Operating pressure approx. 100 bar
    - Rotational speed range 500 – 3.000 rpm

- *Medium speed*

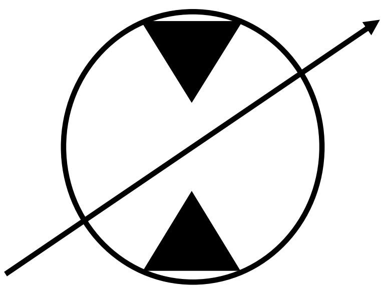
  Rotary vane motors display lower levels of leakage oil loss than geared motors. The attainable lower rotational speed range is approx. 50 – 100 rpm. The operating pressure can vary between 100 and 150 bar. One or two directions of rotation are possible.

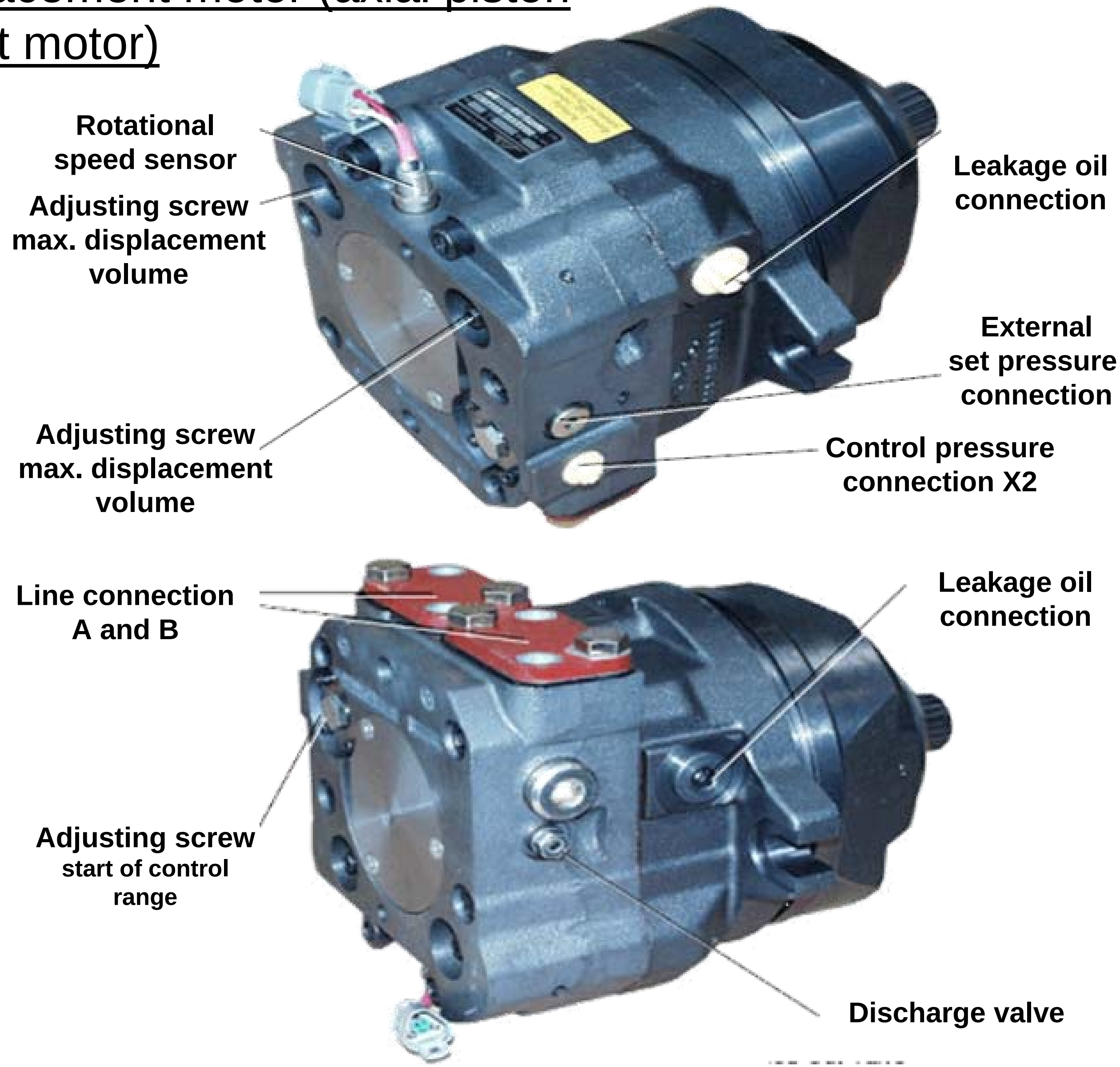
- *Low speed*

  Piston motors can be regarded as typical low-speed motors. They are used wherever high torque has to be transmitted at relatively low rotational speed. A distinction is made between axial and radial motors.
  The rotational speed range of a piston motor can be as low as 1 rpm.
  Piston motors have one or two directions of rotation.

Fundamental rule:	High torque	-	Low rotational speed
	High rotational speed	-	Low torque

H.10.3 Variable displacement motor (axial piston variable displacement motor)





H.11.0 Viscosity classes

SAE classification

The **SAE** viscosity classes were specified by the „**S**ociety of **A**utomotive **E**ngineers“ in order to facilitate consumers in choosing the right oil. The classes **SAE** xx and **SAE** xx**W** (**W**inter) were specified. In this context, the smaller numbers stand for low viscosity oils and the larger numbers for more viscous oils.
The system could no longer be applied after the introduction of multi-viscosity oils and was consequently expanded.
The format now reads SAE xxW-yy.
This syntax means that the properties of the respective oil at 0°F (approx. -18°C) correspond to those of a single-viscosity oil with the viscosity class SAE xxW, and at 120°F (approx. 99°C) to an SAE yy oil.
In order to achieve these properties, multi-viscosity oils contain polymers that change their spatial structure as a function of the temperature.
A cheap standard mineral oil usually has a viscosity of SAE 20W-40 or 15W-40.
High-quality synthetic oils nowadays reach viscosities of 0W-40, 5W-50 or 10W-60.
In principle, every oil can be used that exceeds the specified viscosity range.
For instance, if a 20W-40 oil is specified, the motor would also run with a 10W-40 or 20W-50 oil without suffering any damage.

The viscosity describes only one property of an oil and contains absolutely no information on quality, although it is important to maintain the correct oil pressure.

An excessively high oil pressure can damage seals, while an excessively low oil pressure can damage the bearings.

H.12.0 Oils used at VÖGELE

Motor oil:	SAE 10W-40 API-CH4 ACEAE5
Gearbox oil: (standard gearbox)	SAE 80W-90 API-GL5 MIL-L-2105 C/D with EP additives SAE 90 API-GL5 MIL-L-2105 B with EP additives
Special gearbox oil: (high thermal requirement)	SAE 75W-90 API-GL4/GL5 MIL-L-2105 E MT-1 with EP additives
Hydraulic oil: (outdoor temps. -10°C to +40°C)	HLP hydraulic oil in accordance with DIN 51524-2 with EP additives ISO – VG – 46
Organic hydraulic oil: (outdoor temps. -10°C to +40°C)	Organic hydraulic oil VDMA 24568 Type HEES (saturated synthetic ester) ISO – VG – 46 Panolin HLP Synth. 46

H.13.0 Annex

H.13.1 Principles of hydraulics

Hydraulics is the technology of an alternative gearbox type to that of mechanical, electric or pneumatic gearboxes, i.e. it serves to transfer power, energy and torque from drive machines (pumps) to working machines (pistons or hydraulic motors), where the performance parameters are matched to the requirements of the working machine. In hydraulics, the energy is transferred by fluid, usually in the form of a special mineral oil, but also to an increasing degree in the form of ecologically compatible fluids, such as water, or special-purpose esters or glycols. The power transferred is yielded by two factors: pressure and fluid flow (volume flow).

The following distinctions must be made:

- Hydrodynamic drives operate with a pump and a drive turbine. The rotational speed and torque are converted via the kinetic energy of the fluid.

- Viscous couplings transfer energy through the viscous friction between rotating circular plates.

- Hydrostatic drives primarily convert the mechanical energy of the drive machine (electric motor; diesel) into hydraulic power via a pump. This power is in turn converted back into mechanical power in consumers. This takes place in hydraulic cylinders in a linear movement, or in hydromotors in a rotary movement. Hydrostatic drives are often the most energy efficient type of gearbox when infinite adjustment of the drive-side speed is necessary.

Feeding pressurized fluid into the cylinder sets the pistons and piston rods inside the cylinder into linear motion that is utilized for the working processes and to drive machines. Rotating drives can also be realized with fluid pressure, such as the hydraulic motor.

In principle, hydraulic systems are similar to pneumatic drives, in which compressed air is used to transfer energy and signal, but have different properties. Oil-operated hydraulic systems always require a closed circuit (supply and return), while the exhaust air of a pneumatic system is emitted into the environment, usually via a muffler. Only water-based hydraulic systems also require an open circuit. In contrast to pneumatics, hydraulics has the advantage that significantly greater forces can be transferred and extremely uniform and precise motion is possible, as the compression of the hydraulic fluid is so slight that it has virtually no negative impact in the case of technical applications.

H.13.0 Annex

H.13.2 Advantages

The great proliferation of hydraulics throughout numerous branches of industry is due to the following advantages:

- The versatile design, e.g. the flexible connection between drive and output and the optimum matching of the design to spatial requirements. Pipes and hoses serve to connect the motor and pump and their installation is extensively freely configurable. In the case of mechanical drives, on the other hand, a direct connection between the motor and gearbox and then the differential is necessary, e.g. via cardan shaft or a chain. Therefore, the position of the gearbox is extensively determined by the position of the motor.
- Infinitely adjustable speed of the drive within very large limits and simple reversal of the direction of movement.
- Generation of linear output motion with simple technical components with very high degrees of efficiency.
- Simple generation of very high force and torque levels.
- Safe and quick-acting overload protection through pressure control valves.
- High power density, i.e. comparatively small components for a high level of performance, particularly in comparison with electric motors.
- Realisation of parallel operating linear or rotary drive elements (hydraulic cylinders or hydraulic motors) with one primary part (pump) in a common system. This yields the effect of a differential without added expense.
- High degree of versatility in connecting the pumps, including valve technology, with the hydromotors or cylinders via pipelines or flexible hoses.
- Long service life as the fluid is self-lubricating and can serve as a coolant.
- Simple control concept for optimum utilisation of the drive motor with extreme variations in the performance requirements of the working machine.
- High degree of positioning accuracy.
- Uniform movements thanks to the low compressibility of the hydraulic fluid.
- Standardisation through the use of standardized components, connecting dimensions, installation spaces, etc.
- Simple display of the load via pressure gauges.
- Low inertial resistance of the hydromotors and cylinders.
- Start-up from idle at full load.
- Space and weight saving components (mass–performance ratio) that can transfer high force levels.
- Rapid*, sensitive, uniform and infinitely adjustable cylinder and motor speeds (*albeit slower than a pneumatic system).
- Simple troubleshooting (leakage is visible).
- Higher pressure, thus making higher force levels possible.
- Hydraulic oil minimizes friction between the components.
- Corrosion protection through hydraulic fluid (except for water).

H.13.0 Annex

H.13.4 Disadvantages

- The elasticity of the fluid that leads to compression under pressure is a disadvantage of hydraulic drives. Under certain circumstances, this can lead to pressure or motion oscillations. However, this problem only affects drives with stringent requirements on the uniformity of the speed under greatly varying loads, e.g. feed drives on machine tools. This effect has to be counterbalanced via a flexible coupling, which increases the costs.

- Stringent demands on filtering the hydraulic fluid.

- Development of heat and a consequent change in the viscosity of the hydraulic fluid.

- Valve switching noise.

- Danger of leakage.

- Low clearance between hydraulic components.

- Temperature dependency of hydraulic oils (viscosity and expenditure of energy increase with decreasing temperatures).

- Leakage oil loss.

- Components are heavier than pneumatic components.

- High degree of flow loss within the hydraulic fluids, which is converted into heat and can elevate the system temperature (energy loss).

- Tendency to oscillate as a result of pressure surges and the associated noise generation.

H.13.0 Annex

H.13.5 Applications

On account of their specific advantages and disadvantages, hydraulic drives are frequently used in mobile work machines, such as construction machines and agricultural machines. In these instances, loads are primarily raised and lowered (fork lift trucks, diggers, hoists and road pavers, etc.) through linearly articulated hydraulic cylinders.

Vehicles are often driven by rotating hydraulic gears or fluid convertors, e.g. with so-called inclined axle or inclined disk machines with which high outputs can be transferred. The special feature in this respect is that the hydraulic gears can more flexibly adjust the motion of a motor operating with an inflexible or fixed speed to the operating conditions, as in the case of diesel locomotives, in particular.

Some typical applications involving road pavers are:

- Linearly articulated hydraulic cylinders (raising/lowering the screed)
- Rotating hydraulic gears (undercarriage control)
- Valve actuation
- Clutch and brake activation (wheeled pavers)
- Hydrostatic traction drives
- Hydraulic steering (wheeled pavers)

H.13.0 Annex

H.13.5 Hydraulic fluid

Hydraulic fluid is a fluid that is used to transfer energy (volume flow, pressure) in hydraulic systems in fluid engineering.
The actual fluid composition differs depending on the application and requisite properties (particular demands on high or low temperature resistance, combustibility, lubricity).

H.13.5.1 Mineral oil based hydraulic fluid

The most commonly used hydraulic fluids are mineral oil based with appropriate additives.
They are also referred to as hydraulic oils. The requirements on these hydraulic oils are specified in *ISO 6743/4* with the designations *HL*, *HM* and *HV*. In Germany, the designations *HL*, *HLP* and *HVLP* are used in accordance with *DIN 51524*.

HL: with active substances to increase corrosion protection and ageing resistance (*HL* also in accordance with DIN 51524, Part 1)

HM: with active substances to increase corrosion protection and ageing resistance and to reduce wear due to scoring in mixed friction environments (also *HLP* in accordance with DIN 51524, Part 2)

HV: with active substances to increase corrosion protection and ageing resistance and to reduce wear due to scoring in mixed friction environments and to improve the viscosity and temperature behaviour (also *HVLP* in accordance with DIN 51524, Part 3)

H.13.0 Annex

H.13.5.2 Combustion resistant fluids

HFAE: Oil in water emulsion

Water content >80% and concentrate on mineral oil basis or on the basis of soluble polyglycols.
Concentrates on a mineral oil basis are susceptible to decomposition and microbes.
Suitable for use at temperatures between +5°C and +55°C, highly resistant to combustion.

HFAS: Synthetic concentrates dissolved in water

No danger of decomposition as they involve genuine solutions. Instead, they are significantly more susceptible to corrosion.

HFB: Water in oil emulsions

Water content >40% and mineral oil. Is rarely used. Highly resistant to combustion. Suitable for use at temperatures between +5°C and +60°C. Not approved for use in Germany on account of a lack of fire resistance properties.

HFC: Water glycols

Water content >35% and polymer solution. Highly resistant to combustion. Suitable for use at temperatures between -20°C and +60°C. Suitable for use at pressures of up to 250 bar.

HFD: Synthetic fluids

Display a higher density than mineral oils or water. May cause problems in the suction behaviour of pumps.
Also attack many sealant substances. Highly resistant to combustion. Suitable for use at temperatures between – 20°C and + 150°C.

H.13.0 Annex

H.13.5.3 Biodegradable

Manufactured on the basis of vegetable oils (e.g. rapeseed basis). Suitable for use in biologically critical environments (construction machines in water protection zones, slope machines in ski resorts, etc.)
These fluids are Pollutant Category 1 pollutants.

Code: ***HE*** = ***H***ydraulic ***E***nvironmental

Categorisation:

- HETG (triglyceride based = vegetable oils)
- HEES (synthetic ester based)
- HEPG (polyglycol based)
- HEPR (other base fluids, primarily poly-alpha-olefins)

H.13.5.4 Water

The use of water as a hydraulic fluid is unobjectionable in every respect. The formation of ice must be prevented and the upper temperature limits are dependent on the components used. The first technical use of hydraulics utilized water as the fluid. Water has a significantly lower output resistance and faster reaction times on account of its low viscosity and incompressibility. The following grades of water are used in modern water-based hydraulics.

Tap water (filtered), technical water (demineralized), sea or salt water (filtered)

Basic Principles Electrics

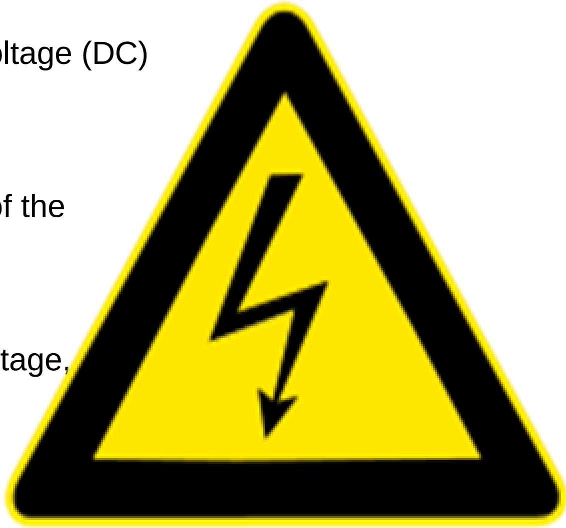
E.1.0 Hazards

The general rule is: 50 V alternating current voltage (AC) or 120 V direct current voltage (DC) are the maximum permissible limits for touch voltage.

Upwards of roughly 50 V AC voltage, the voltage is hazardous for humans as the transition barrier from the skin to the inner body is overcome and the conductivity of the human body increases.

However, it is not the voltage (U) that is responsible for a fatal electric shock, but rather the current intensity (I). And as the flowing current increases with the voltage, it can be said that **the higher the voltage, the greater the danger!!!**

Also remember that severe accidents can still occur even with „safe“ (low) voltages as a result of burns if metal jewellery (rings, necklaces) cause a short circuit.



International symbol
for
hazardous voltages.

E.2.0 Units of measurement in electrics

E.2.1 Electric current / Current intensity

As a rule, electric current is understood to mean the directed motion of charge carriers.

- The charge carriers may be both electrons and ions.

- An electric current can only flow when sufficient charge carriers are available and freely moveable.

- The current intensity (**I**) serves the numerical description of the electric current.

- The more electrons that flow through a conductor in one second, the higher the current intensity.

The symbol for current intensity is **I**.

Units of measurement: kA (kiloampere), A (ampere), mA (milliampere), µA (microampere), nA (nanoampere)

The **A**mpere (**A**) is the basic SI unit (SI = International System of Units).
The ampere is named after Andre Marie **A**mpere.

E.2.0 Units of measurement in electrics

E.2.2 Types of electricity

As a rule, a distinction is made between three different technical types of electricity:

Direct current (e.g. VÖGELE on-board network):

Direct **C**urrent (**DC**) is understood to mean an electric current that does not change its direction or strength over time, i.e. it remains constant over time.

Direct current can be gained from alternating current by means of alignment.

There are also direct sources of direct current, such as galvanic cells (batteries) or photovoltaic cells (solar cells).

Alternating current (e.g. VÖGELE heating system):

Alternating **C**urrent (**AC**) is characterized by a continuous, usually periodical change in the direction of current.

The periodical change is expressed as a frequency (Hz) that specifies how often the current direction changes per second.

Advantage: Alternating current can be easily transformed between different voltages.

Mains frequency: Usually 50 Hz, but 60 Hz in the USA and Japan, for instance.

A special form of alternating current is three-phase current (referred to colloquially as high-voltage current, rotary current or power current), which is widely used in public power grids for distributing electricity.

Mixed current:

A combination of alternating current and direct current is called mixed current.

The strength of the direct current portion, which is constant over time, is continuously and usually periodically changed by the application of an additional alternating current.

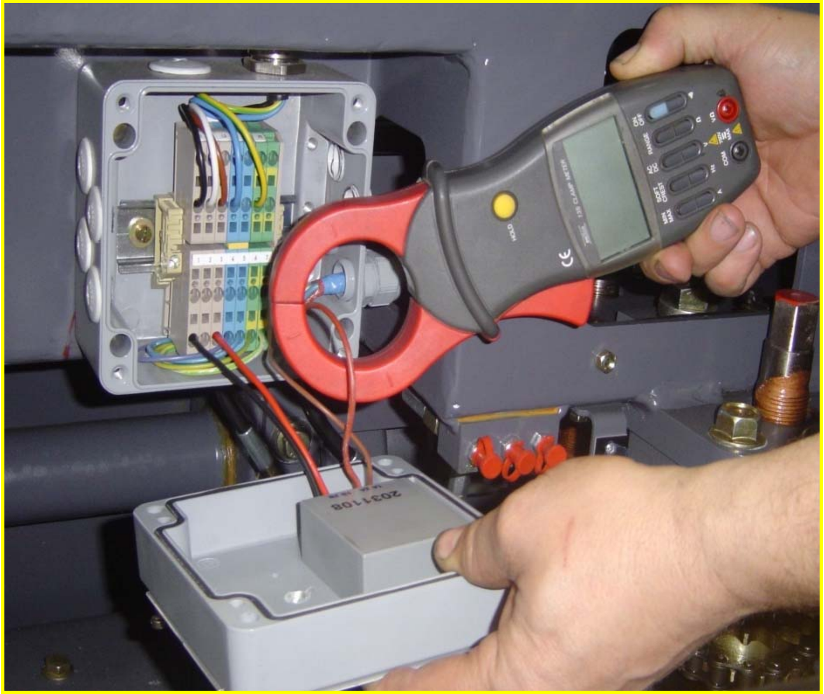
One example of the use of mixed current is in rectifiers.

E.2.0 Units of measurement in electrics

E.2.3 Measuring electric current

Electric current can be measured directly using an amperemeter.
To this end, the measuring instrument must be connected between the lines in series.
When measuring larger currents, an indirect electricity measuring instrument should be used for safety reasons, e.g. a clamp-on amperemeter.

Note the setting!!!

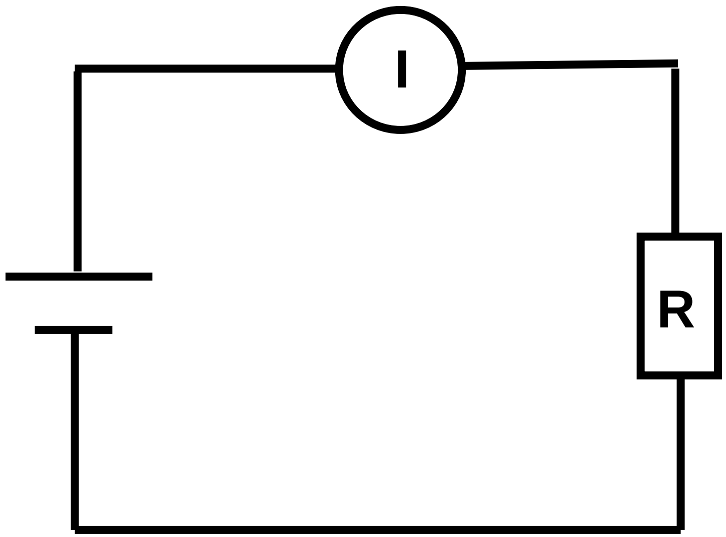


Current intensities of up to 2 ampere direct current can be measured with the amperemeter.
Anything above that, as well as alternating current, should only ever be measured using a clamp-on amperemeter!!!!

E.2.0 Units of measurement in electrics

E.2.4 Electricity measurement circuit diagram

Connect measuring instrument (amperemeter) in series



R (resistance) represents a consumer

Note the connections. Note the setting.

E.2.0 Units of measurement in electrics

E.2.5 Electrical voltage

Electrical voltage is a physical unit of measurement that specifies how much work or energy is necessary to move an object with a specific electric charge along an electric field. Voltage is thus the specific energy of the charge. It is a field variable that can fluctuate by many orders of magnitude.

The following statements can be made about electrical voltage :

- Electrical voltage is the pressure or force on free electrons.

- Electrical voltage is the originator of electric current.

- Electrical voltage is generated by the attempts of electrical charges to balance.

The symbol for voltage is **U**,
which stems from the Latin „**u**rgere“ (to push, to compel)

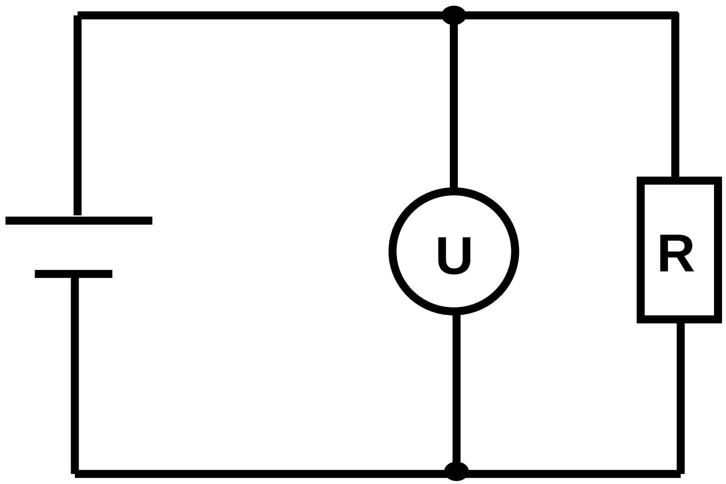
Units of measurement: MV (megavolt), kV (kilovolt), V (volt), mV (millivolt), µV (microvolt)

The **V**olt (**V**) is the basic SI unit (SI = International System of Units).
The volt is named after Alessandro **V**olta.

E.2.0 Units of measurement in electrics

E.2.6 Measuring electrical voltage

An electrical voltage is measured with a voltmeter.
Modern digital multimeters allow various measuring ranges to be set.
To measure the voltage, the measuring instrument is connected to the consumer in parallel.



R (resistance) represents a consumer

Connect measuring instrument (voltmeter) in parallel

Note the setting
- For AC = V~
- For DC = V-

Note the connections (no difference between AC and DC)

E.2.0 Units of measurement in electrics

E.2.7 Electrical resistance

Electrical resistance (symbol: **R**) is an electrical engineering term.
It is a measure of how much voltage is necessary for a specific current to flow through an electrical conductor. The electrical resistance is generally temperature dependent. The specific resistance of a conductor is equal to its resistance at a length of 1 m, a cross-section of 1 mm^2 and a temperature of 20°C.

The symbol for electrical resistance is **R.**
This stems form the English word „**r**esistance“ or „**r**esistor“.

Units of measurement: MOhm (megaohm), kOhm (kiloohm), Ohm, mOhm (milliohm)

The ohm (Ω) (large Omega symbol) is the basic SI unit (SI = International System of Units).

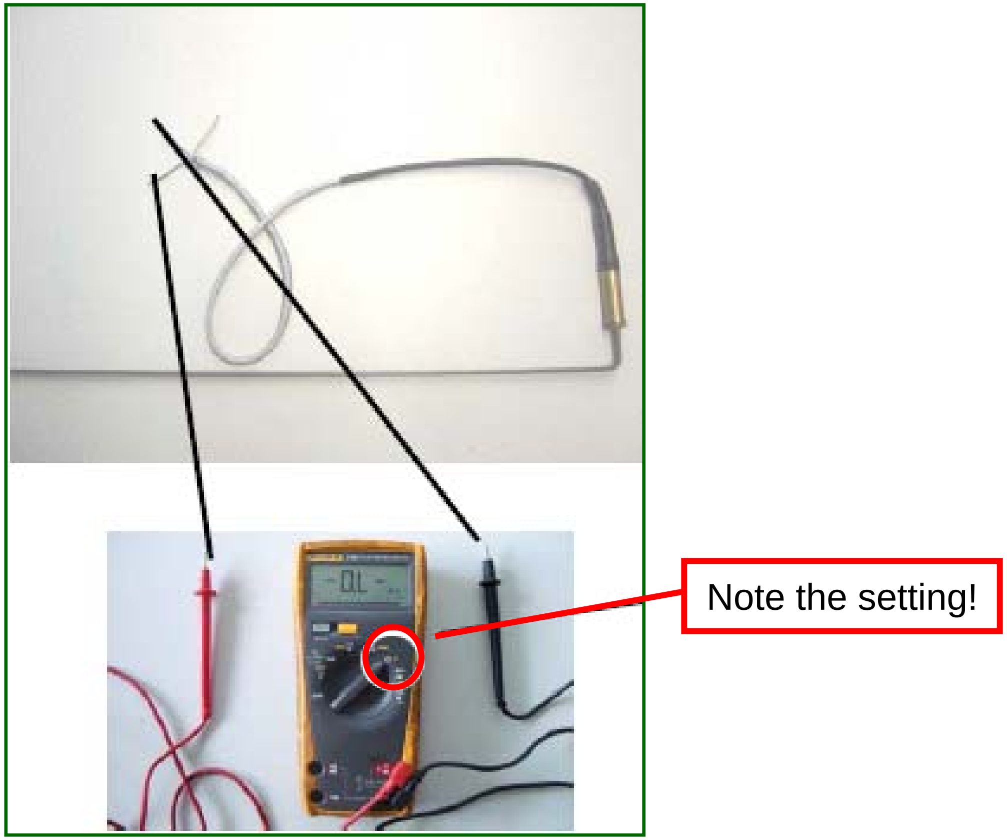
Every consumer, e.g. electric light bulb or heating rod, can be regarded as a resistor.

The system must be voltage-free to measure resistance!

E.2.0 Units of measurement in electrics

E.2.8 Measuring resistance

To measure resistance, the actual resistor, e.g. heating rod, must be disconnected from the circuit. The measurement is made between the live (L) and neutral (N) wires.



E.2.0 Units of measurement in electrics

E.2.9.1 Electrical power

Electrical power (**P**) is a type of power that is available when electrical work (electrical energy) is realized over a specific period of time.

Details regarding the effective electrical power necessary to power electric machines, such as heating rods, motors and lamps, are usually given in **W**atts (**W**).
The decisive factor is whether the type plate specifies the input power or the output power.
In the case of generators, for instance, the output power is specified, while the input power is specified for heating rods.

The following statements can be made about electrical power:

The power **P** is greater

- the higher the current **I**
- the higher the voltage **U**

The symbol for electrical power is **P**.

Unit of measurement: **W** (**W**att). This is also the basic SI unit (SI = International System of Units).

E.2.0 Units of measurement in electrics

E.2.9.2 Calculating electrical power

The following formulas can be used to calculate electrical power **P**.

$$P = U * I$$

$$P = R * I^2$$

The power **P** increases proportionally to the square of the current **I**.

$$P = \frac{U^2}{R}$$

The power **P** increases proportionally to the square of the voltage **U**.

E.3.0 Relationships between units of electricity

E.3.1 Ohm's Law

If a voltage (U) is applied to a resistor (R) in a closed electrical circuit, a specific current (I) will flow through that resistor (R).

The relationship of the values to one another can be determined by means of simple formulas.
The following formulas can be calculated to this end :

If a voltage (U) is applied to a resistor (R), a current (I) will flow through the resistor (R).

$$I = \frac{U}{R}$$

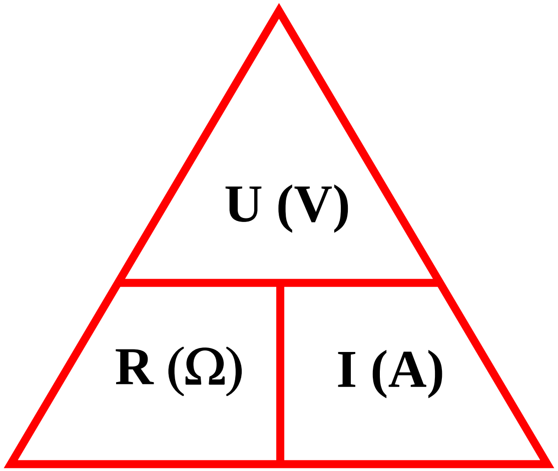
If a current (I) flows through a resistor (R), a voltage (U) has been applied to it.

$$R = \frac{U}{I}$$

If a current (I) should flow through a resistor (R), the voltage (U) must be calculated.

$$U = R * I$$

The magic triangle

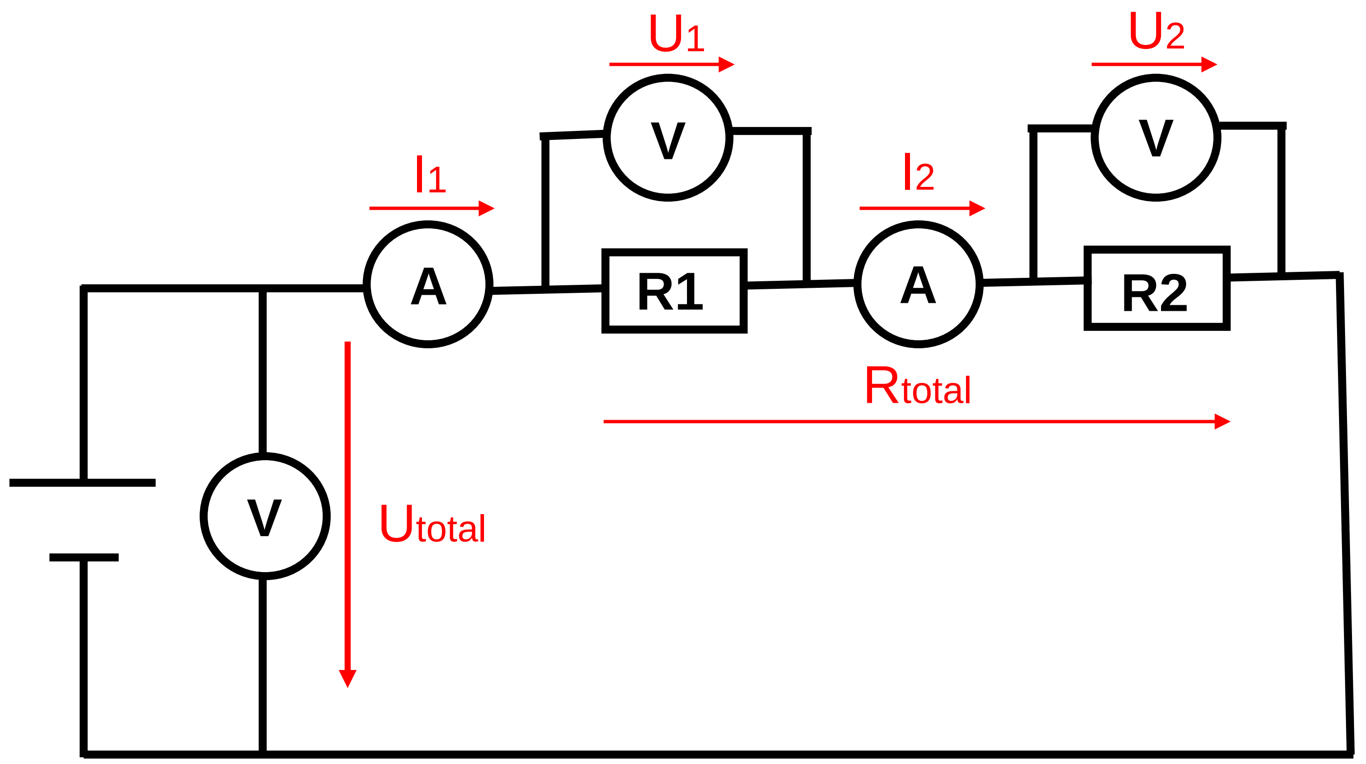


Simply cover the value to be calculated!!!!

E.4.0 Connecting resistors

E.4.1.1 Series connection

Resistors are connected in series when the same electrical current flows through all resistors. When discussing series connections, a distinction is made between the voltage at the voltage source and the voltage drop at the resistors.



E.4.0 Connecting resistors

E.4.1.2 Relationships in series connections

What statements can be made concerning series connections?

Current: The current is identical at all points of a series connection.

$$I_{total} = I_1 = I_2 = \ldots..$$

Voltage: The sum of the sub-voltages is equal to the total voltage.

$$U_{total} = U_1 + U_2 + \ldots..$$

Resistance: The sum of the sub-resistances is equal to the total resistance.

$$R_{total} = R_1 + R_2 + \ldots..$$

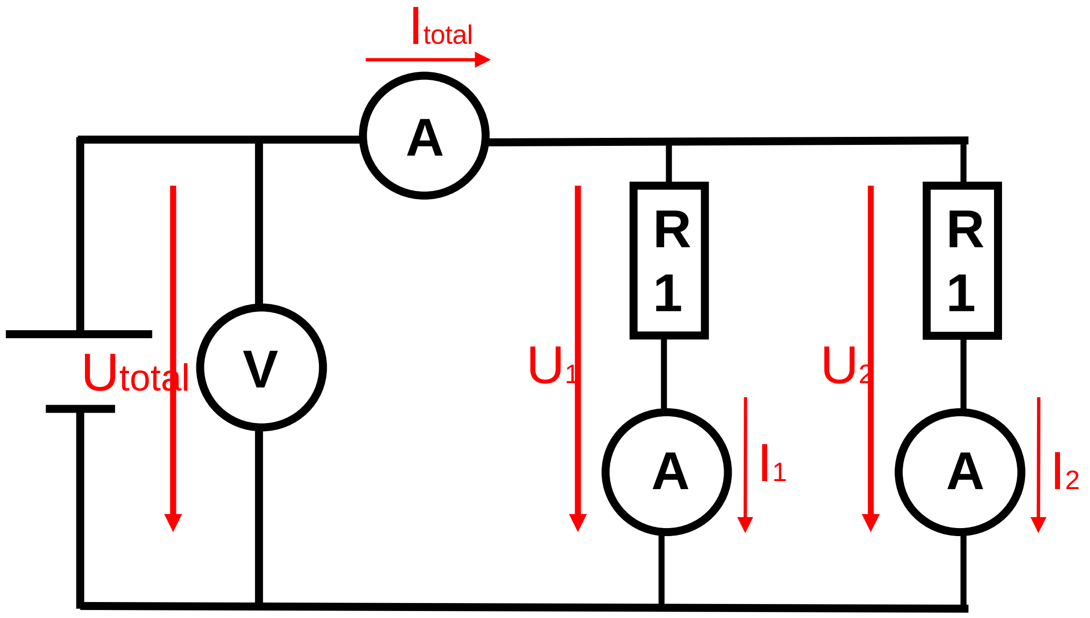
Relationships: The voltages behave like the associated resistances.

$$\frac{U_{total}}{R_{total}} = \frac{U_1}{R_1} = \frac{U_2}{R_2}$$

E.4.0 Connecting resistors

E.4.2.1 Parallel connection

Resistors are connected in parallel when the electrical currents are split by the resistors. Currents behave in the opposite manner to their resistance values. In other words, a lower current flows through a high-ohm resistor than through a low-ohm resistor.



E.4.0 Connecting resistors

E. 4.2.1. Relationships in parallel connections

What statements can be made concerning parallel connections?

Current: The total current is the sum of all sub-currents.

$$I_{total} = I_1 + I_2 + \ldots..$$

Voltage: The voltage on every resistor is identical .

$$U_{total} = U_1 = U_2 = \ldots..$$

Resistance: The total resistance is less than the lowest individual resistance.

$$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots..$$

E.5.0 Legend of abbreviations:

A = **A**ssembly, general (Digsy Compact)

B = Sensor (module / standardised character)

C = **C**apacitor

F = **F**use

G = Power supply (**G**enerator, battery)

H = Signalling system (**H**orn, light)

K = Relay, protection (standardised character)

M = **M**otor

Q = High-power current contactor (battery main switch)

R = **R**esistor, potentiometer

S = **S**witch

T = **T**ransformer

V = Diode (standardised character)

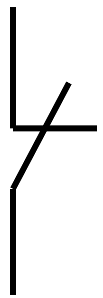
X = Terminal (standardised character)

Y = Solenoid (standardised character)

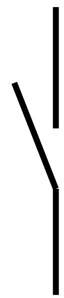
ϑ = Temperature-dependent resistor

E.6.0 Circuit symbols

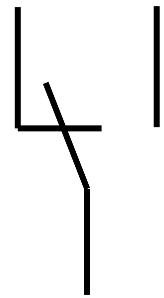
E.6.1 Switch and button symbols



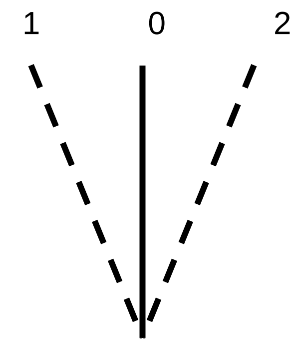
Normally closed contact



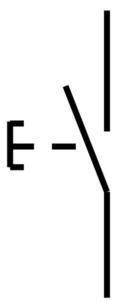
Normally open contact



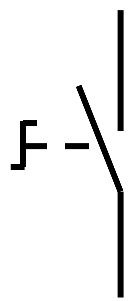
Two-way contact



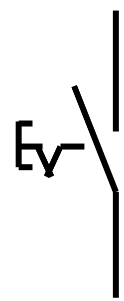
Switch with 3 positions (e.g. traction main switch) (0 = inoperative)



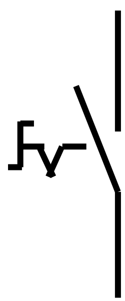
Push-button, momentary contact



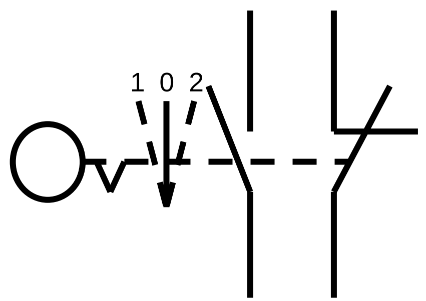
Rotary switch, momentary contact



Push-button, maintained contact



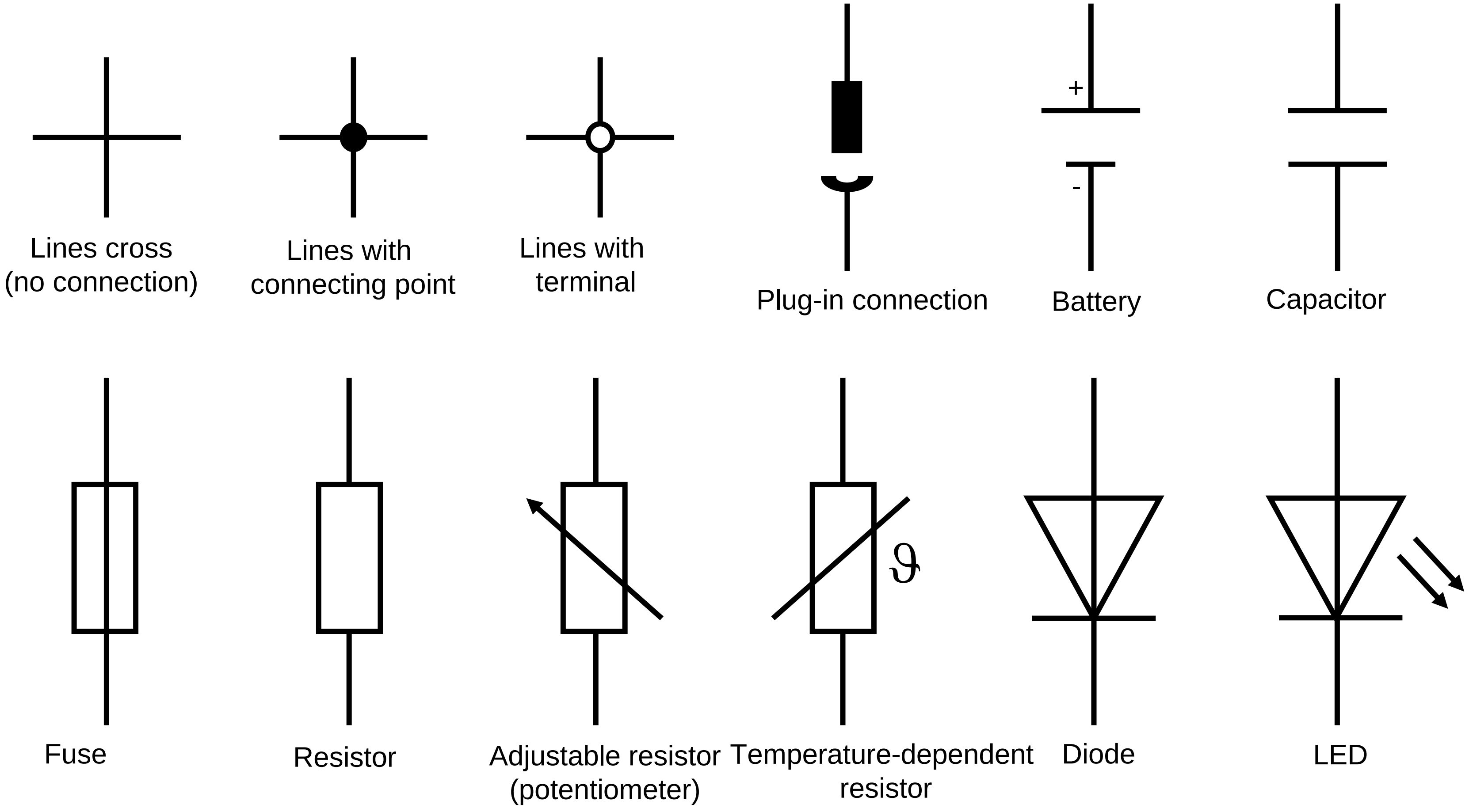
Rotary switch, maintained contact



The combinations are infinite.
The diagram above depicts a maintained contact key switch with normally open / normally closed contacts.

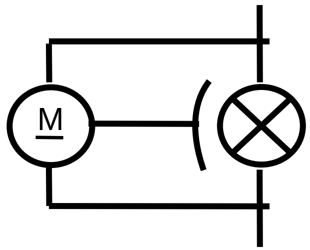
E.6.0 Circuit symbols

E.6.2 Symbols – Part 1

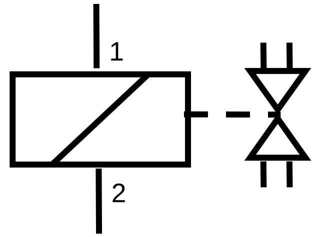


E.6.0 Circuit symbols

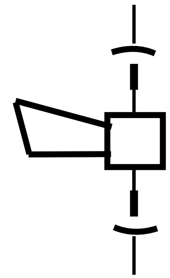
E.6.3 Symbols – Part 2



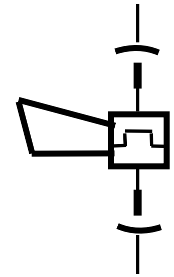
Rotating light



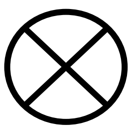
Solenoid valve



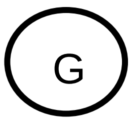
Horn



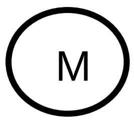
Reverse travel horn



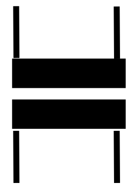
Signalling system (lamp)



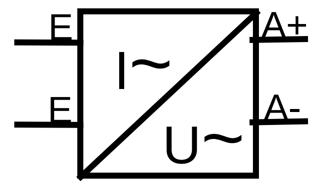
Generator



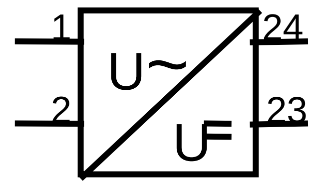
Motor



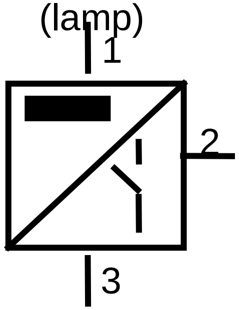
Transformer



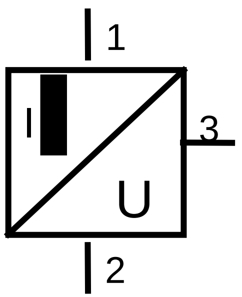
Converter module



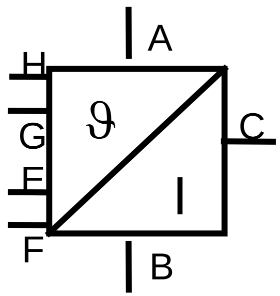
Screed module



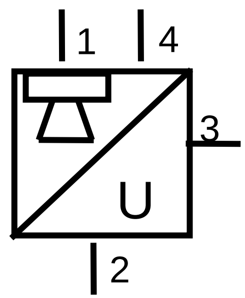
Sensor, initiator



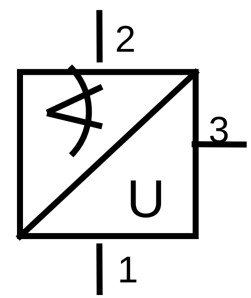
Sensor, levelling system



Temperature converter



Paddle sensor (old)

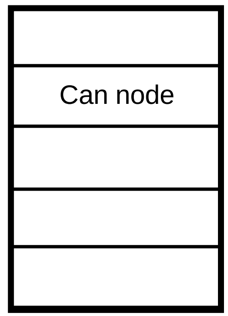


Paddle sensor (new)

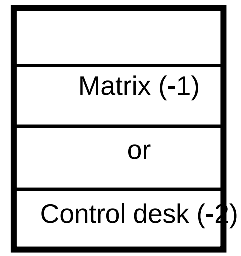
E.6.0 Circuit symbols

E.6.4.Symbols – Part 3

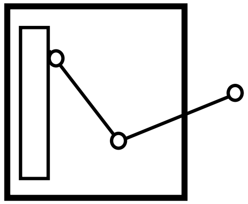
Input / Output
Digsy Compact



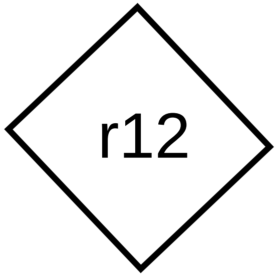
Output
Can nodes



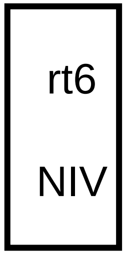
Input Matrix
or
Output control desk



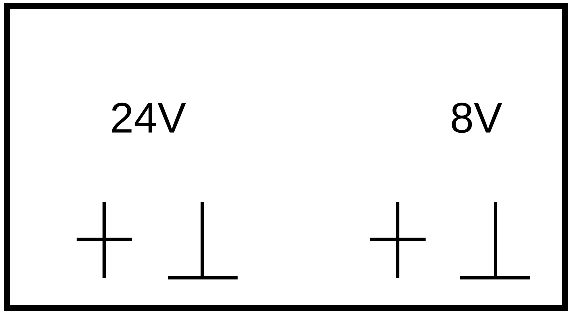
Tank sensor



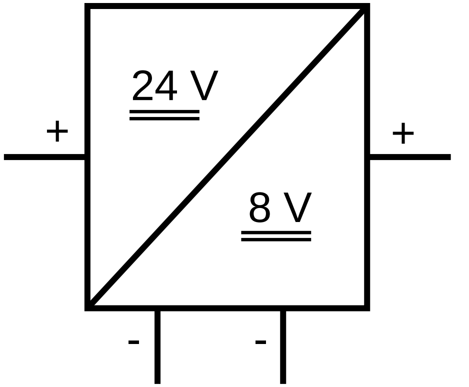
Electronics connection
r = **R**ed
b = **B**lue



Levelling system connection
r = **R**ed
b = **B**lue



Stabilising module
24 V – 8 V (old symbol)

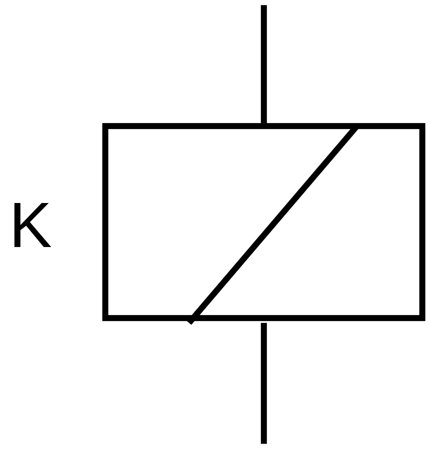


Stabilising module
24 V – 8 V (new symbol)

E.7.0 Relays

E.7.1 Design and function

Symbol (as a rule):

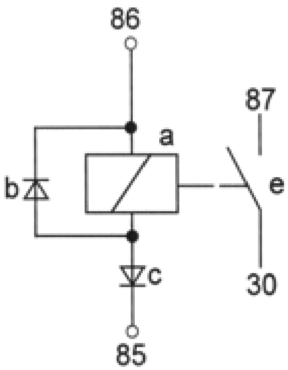


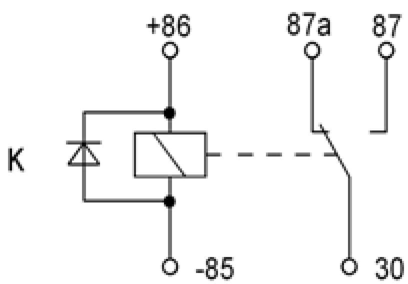
Design and function:

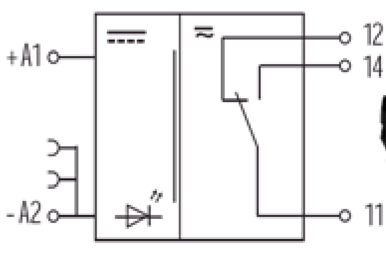
Relays are electromagnetic devices that operate with the force action of the electrical current through a solenoid. Relay contacts are actuated directly or by the armature.
Relays are always used as a function of the electrical current. Only the current flow (intensity) in the area of the load circuit (guided circuit) is of relevance to this end.
Relays are manufactured with differing contact combinations (e.g. normally closed contact, normally open contact and/or two-way contact).
Multiple variants are used at VÖGELE.

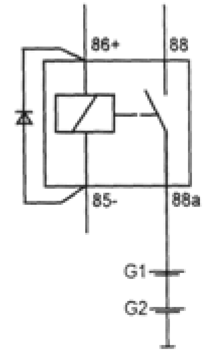
E.7.0 Relays

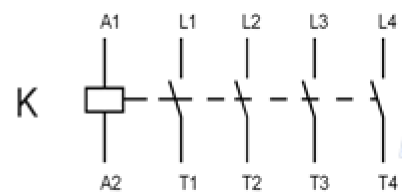
E.7.2 Relays used at VÖGELE

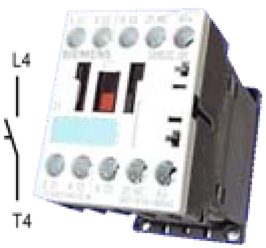


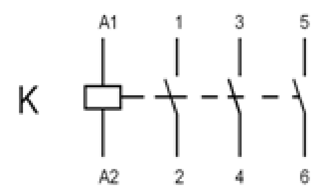








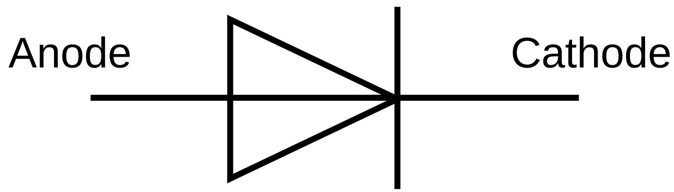




E.8.0 Diodes

E. 8.1 Design and function

Symbol



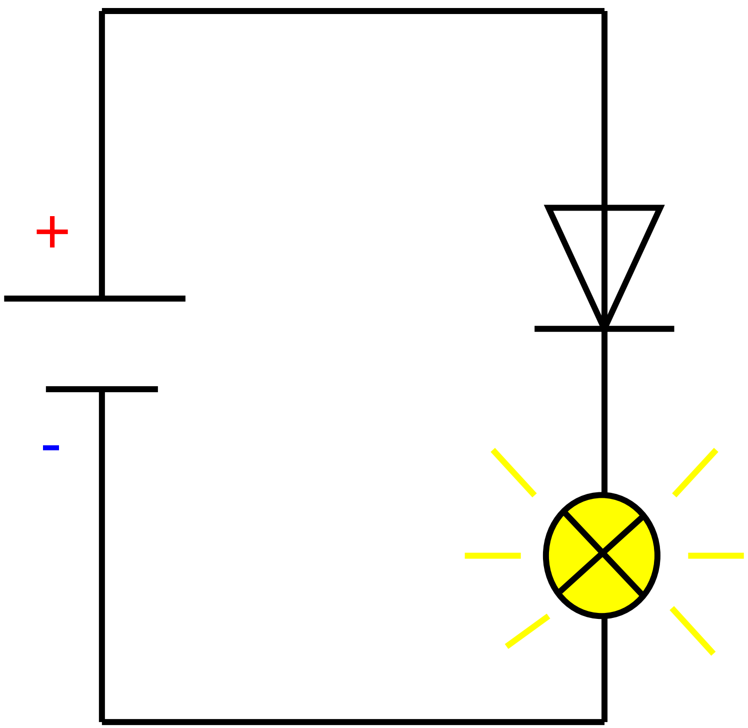
Design and function

A diode is a semiconductor device with two connections. These connections are referred to as the anode and the cathode. Such diodes frequently only allow the electrical current to flow in one direction. A diode circuit symbol is sometimes printed on the housing to indicate the corresponding direction.
In addition to the type designation, diodes usually also bear a ring to indicate the cathode side.

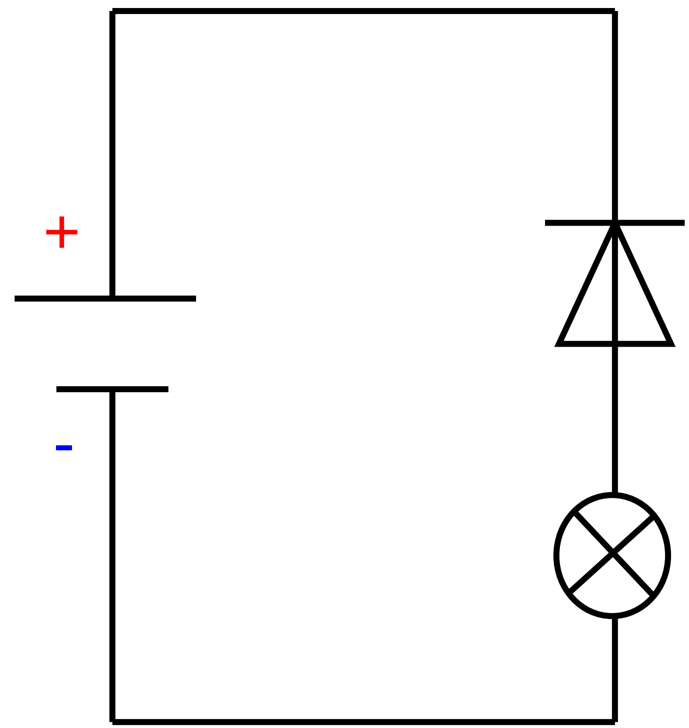
E.8.0 Diodes

E.8.2 Conducting direction and reverse direction

Diode in conducting direction



Diode in reverse direction



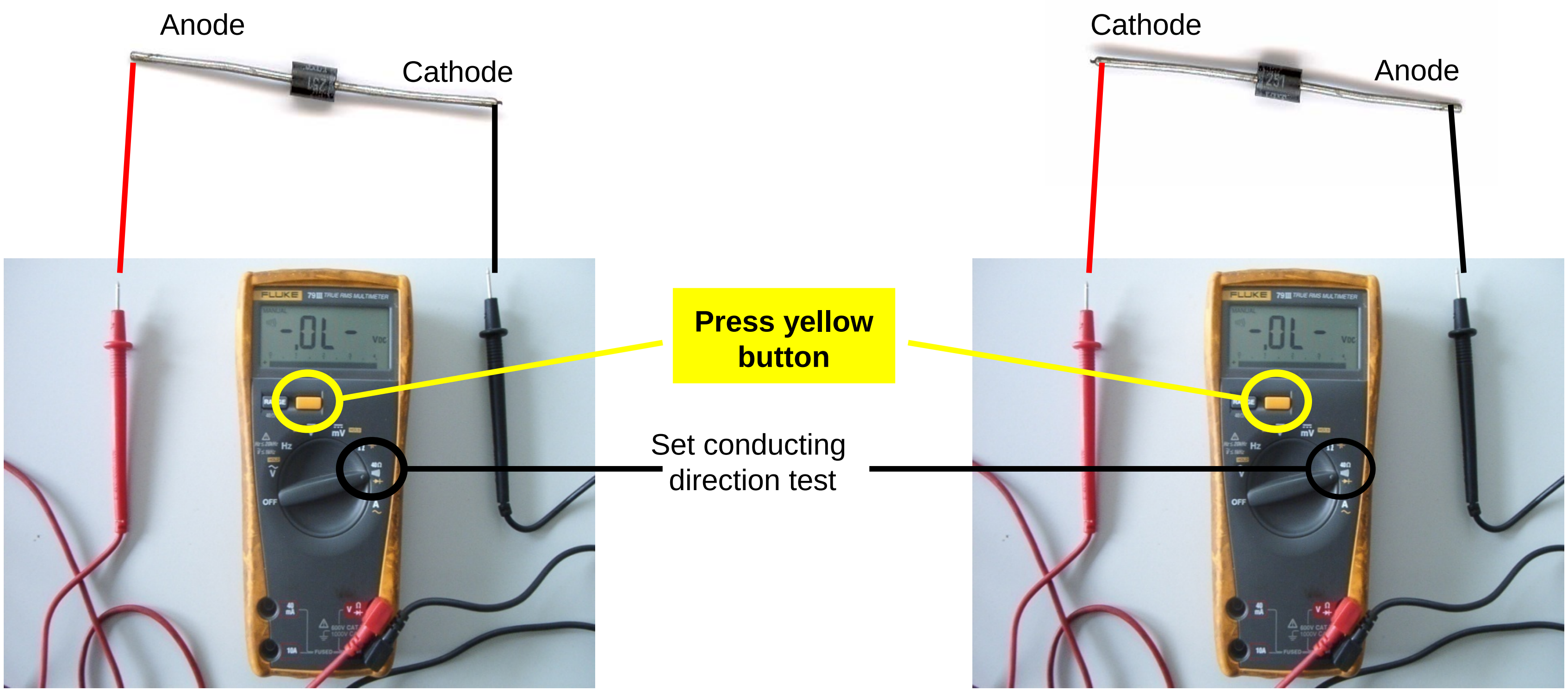
E.8.0 Diodes

E.8.3 Testing a diode

A diode must be uninstalled before it can be tested.
In order to test a diode, the measuring instrument must be set to conducting direction test.
Then press the yellow button. An acoustic signal sounds in the conducting direction.

Conducting direction

Reverse direction



A faulty diode would conduct in both directions!!!

E.9.0 Fuses

What is a fuse?

The weakest component in an electric circuit is always the first to be destroyed. The circuit is then broken. This component is usually the fuse. The task of a fuse is to protect electric devices and circuits. A fuse never serves to protect humans under ANY CIRCUMSTANCES. A fuse only protects against an overload (i.e. too much current flowing through the circuit) or a short circuit (low-ohm connection of two potentials). A fuse always has a nominal current. If this nominal current is exceeded, the fuse blows.

What does a fuse consist of?

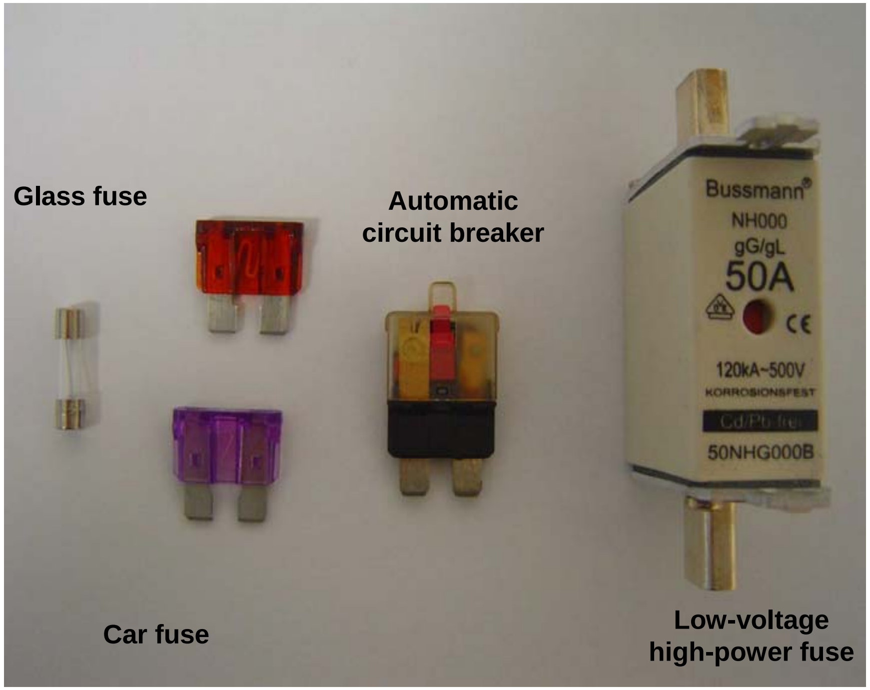
A fuse essentially consists of a stable housing and a wire that melts in the event of an overload or a short circuit.
The fuse thus ensures that the circuit is broken safely.

A fuse must never be repaired or bridged!!!!!

There are slow blow fuses (T) and fast blow fuses (F). Slow blow fuses blow later than fast blow fuses. The housing usually indicates whether the fuse is a slow blow fuse or a fast blow fuse.

We distinguish between 5 categories:

Super fast (FF), fast (F), medium fast (M), slow (T), super slow (TT)



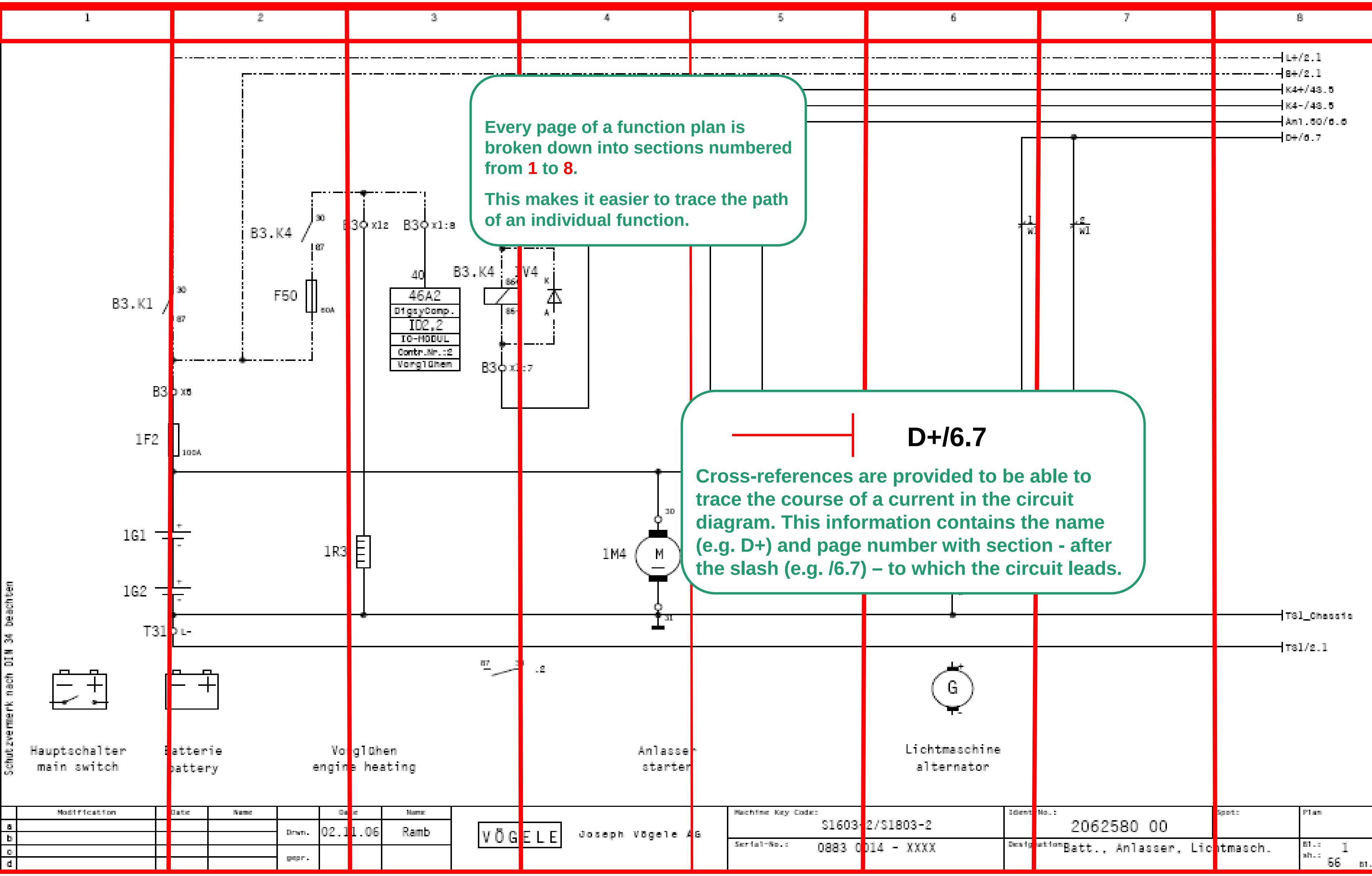
Fuses used at VÖGELE:

Low-voltage high-power fuses (heater – 230 V AC)

Car fuses (switch box – 24 V DC)

Glass fuses (heater control)

E.10.0 Reading a circuit diagram   E.10.1 Circuit diagram



Every page of a function plan is broken down into sections numbered from **1** to **8**.

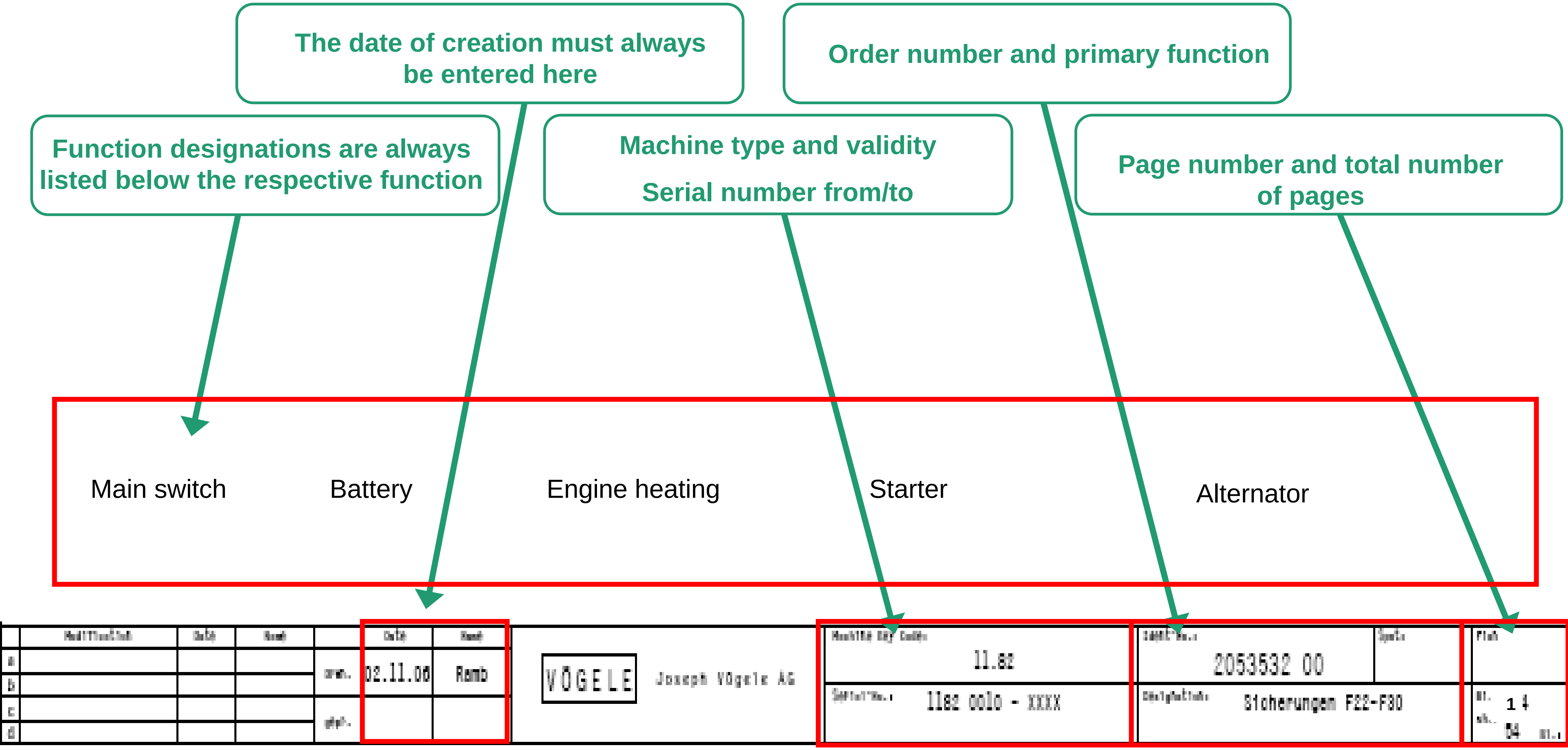
This makes it easier to trace the path of an individual function.

D+/6.7

Cross-references are provided to be able to trace the course of a current in the circuit diagram. This information contains the name (e.g. D+) and page number with section - after the slash (e.g. /6.7) – to which the circuit leads.

E.10.0 Reading a circuit diagram

E. 10.2 Bottom bar and information



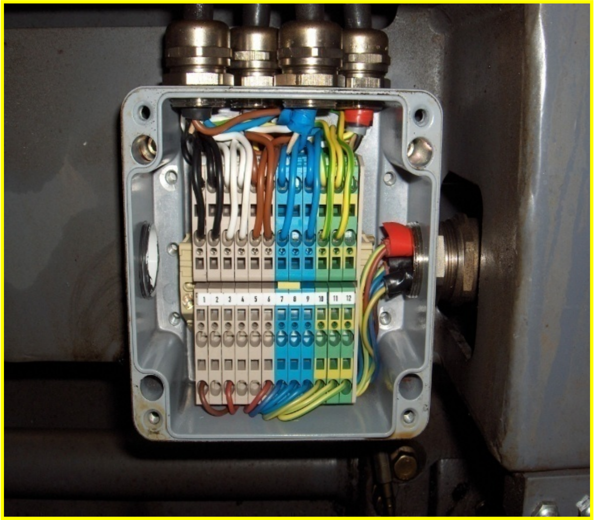
E.11.0 Mains systems

E.11.1 Mains 230 V / 400 V AC

In 230 V / 400 V AC mains systems, it is important to know the colours of the individual wires and to connect these correctly. As a rule, there are three phases, **L1** (usually **black**), L2 (usually white) and **L3** (usually **brown**).
The **blue** wire is always the **N** (**neutral conductor**, **neutral wire**).
The **green** / yellow wire is always the **earth** wire.

Measuring between a phase and N yields a measurement of approx. 230 V AC.
If the measurement is made between two phases, the measurement is approx. 400 V AC.

L1 – N = approx. 230 V AC L1 – L2 = approx. 400 V AC
L2 – N = approx. 230 V AC L1 – L3 = approx. 400 V AC
L3 – N = approx. 230 V AC L2 – L3 = approx. 400 V AC



Example: Heater distribution box

Example: Measurement between L1 - N

E.11.0 Mains systems

E.11.2 Mains 24 V DC

The aforementioned colour-coding rule does not apply to the low-voltage mains network.
The low voltage mains network at VÖGELE operates at 24 V DC.
However, the wires are coloured and a few „VÖGELE rules“ do apply.

Abbreviations:
wt – white / bk – black / rd – red / gr – grey / gn – green /
yl – yellow / vio – violet / bn – brown / bl – blue

Some wires also have two colours. Such combinations can be encountered with virtually all colours, such as wtyl = white/yellow; bkgn = black/green; brbl = brown/blue.
However, black wires printed with a number are usually used nowadays.

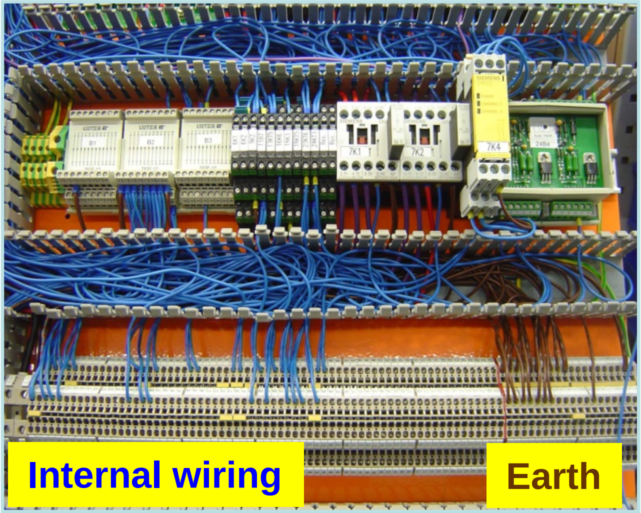
VÖGELE rules:
The connecting wires on solenoids usually have even numbers (2,4,6,8, etc.) on the earth side (exception: Danfoss).

Earth wires are usually brown or brown/white (8V earth).

As of the -1 Series, all internal wiring is finished in terminal box blue.

As of Ergo Plus, the connecting wires between the terminal box and control desk are white (0.5mm²).

Example: Two-colour wire



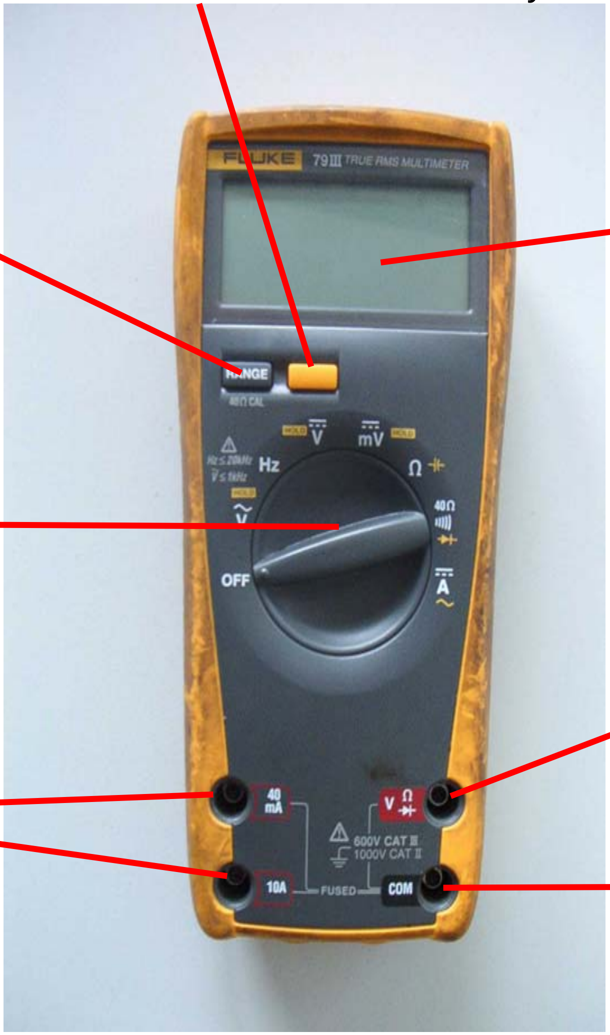
Example: Terminal box

E.12.0 Measuring instruments

E.12.1 Multimeters – Part 1

Yellow button
Activates functions marked in yellow

Range button
Switches between ranges:
e.g. 10V, 0.01V



Display

Rotary function selection switch
(for setting the measuring range)

Connecting ports for measuring
current intensity
Note measuring range!!

Connecting ports
for measuring voltage
for resistance or for
testing diodes

Connecting port
Earth

E.12.0 Measuring instruments

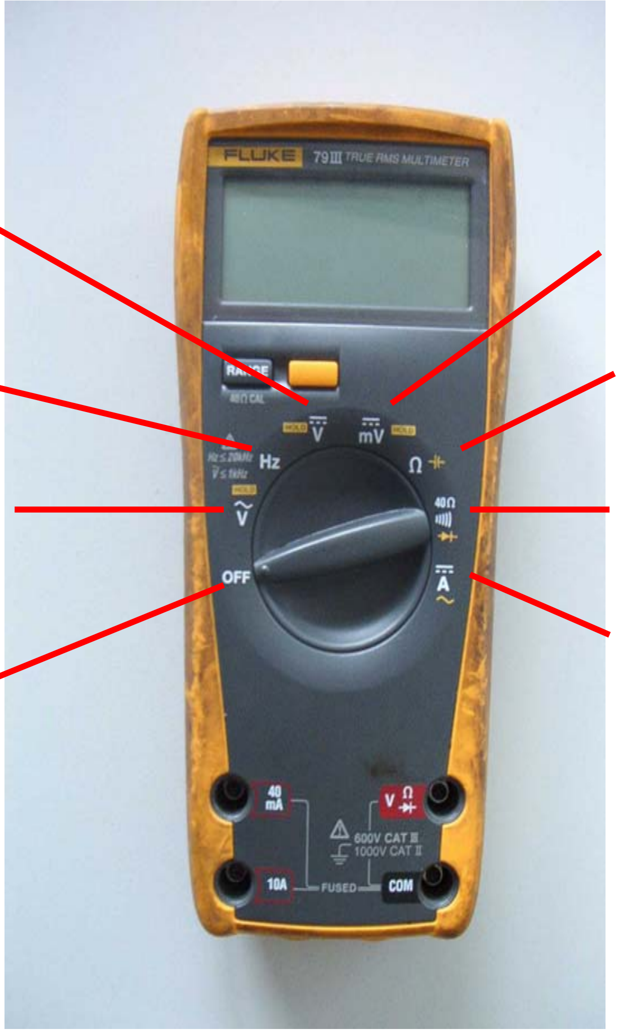
E.12.1 Mutimeters - Part 2

DC voltage (V-) measuring range
or **Hold measured value**

Frequency (Hz) measuring range
or **Hold measured value**

AC voltage (V~) measuring range

Switch off multimeter (OFF)



DC voltage (mV-) measuring range
or **Hold measured value**

Resistance (Ω) measuring range
or **Hold measured value**

Continuity test measuring range,
or **Diode test**

Current intensity (A) measuring range, direct and **alternating current**

E.12.0 Measuring instruments

E.12.2 Clamp-on amperemeters – Part 1

Measuring clamp

Lever to open **measuring clamp**

Switch between AC / DC

„Soft crest“ button
for recording peak and
effective values

Switch between Min / Max
This activates a record

Measuring range:
Current (A)

Measuring range:
Frequency (Hz)

Measuring range:
Voltage (V)

Pressing the „**Hold**“ function key holds the measured value in the display. The measuring instrument could now be removed from the measuring point and the value would still be displayed.

„Range“ button (working range)

„**On/Off**“ button

Continuity test

Measuring range: Resistance (Ω)

E.12.0 Measuring instruments

E.12.2 Clamp-on amperemeters – Part 2

The clamp-on amperemeter can also be used to measure voltages and resistances.

Ports for plugging in the measuring contacts.

Accessories:
Crocodile clips for attaching to the probe ends.