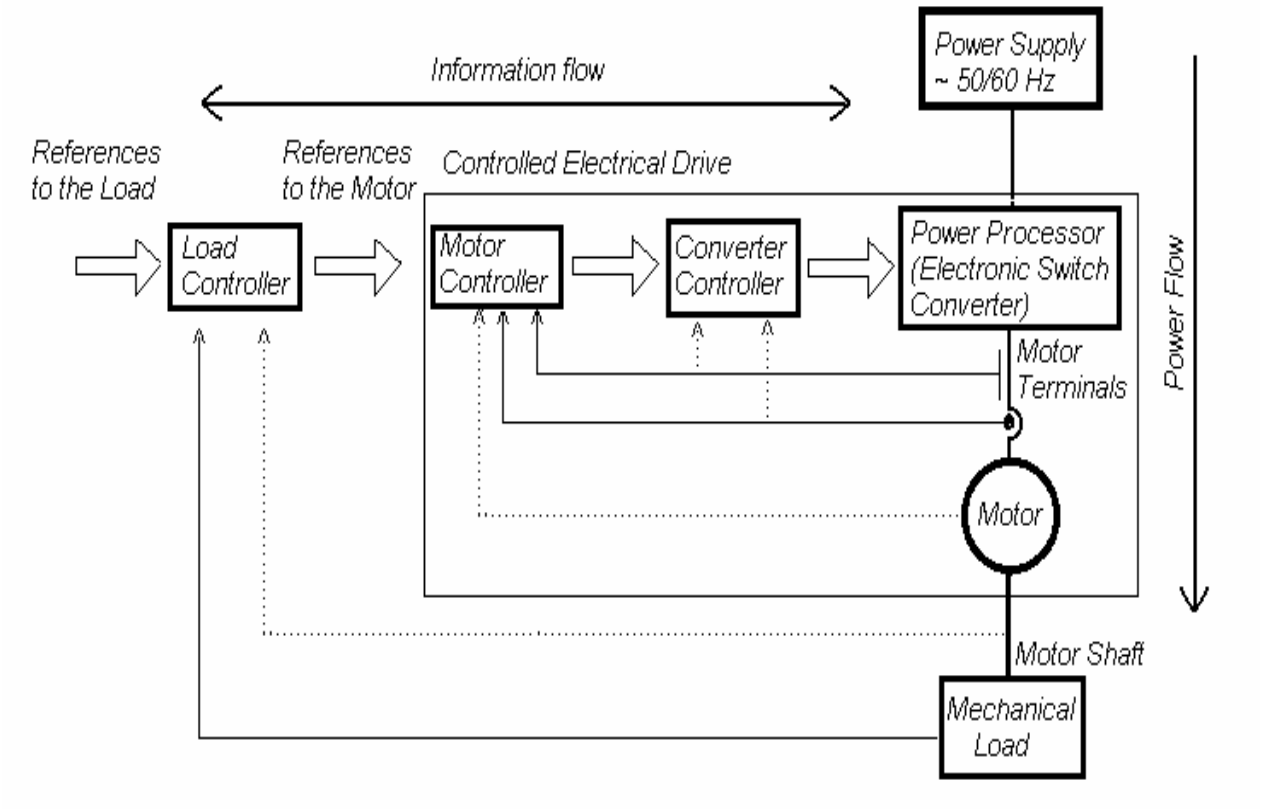
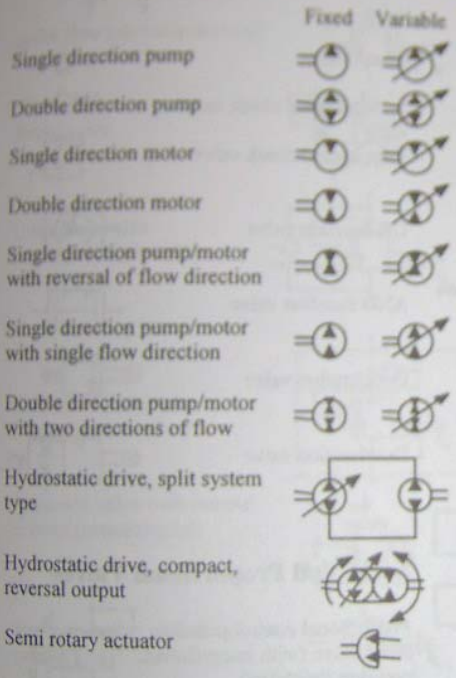

Power Supply
~ 50/60 Hz
Information flow
References
to the Load
References
to the Motor
Controlled Electrical Drive
Load
Controller
Motor
Controller
Converter
Controller
Power Processor
(Electronic Switch
Converter)
Power Flow
Motor
Terminals
Motor
Motor Shaft
Mechanical
Load

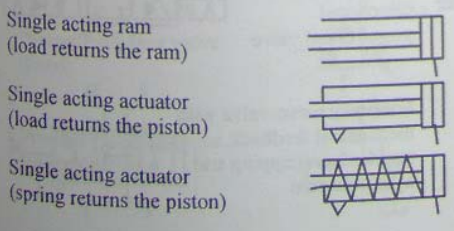
APPENDIX A
FLUID POWERS SYMBOLS

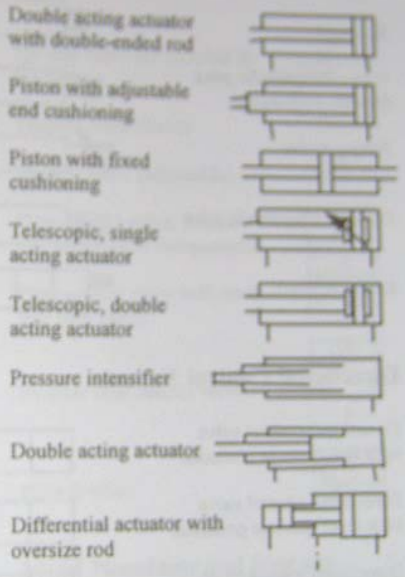
The symbols listed below are used to describe hydraulic system layouts (or circuits), and are based upon the German standard DIN-ISO 1219 (1978) and the international standard ISO 1219-1 (1991) for fluid power symbols.

Pumps, Motors, and Drives

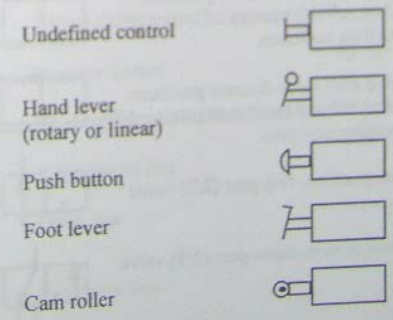


Linear Actuators (Cylinders)

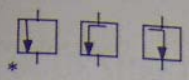




Valve Control Mechanisms



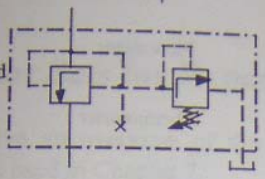
Pressure-relief valve (fixed)



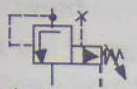
Pressure-relief valve (adjustable)

Detailed symbol of Pilot-operated Pressure-relief valve (compounded relief valve)

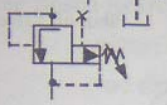
Simplified detailed symbol of compounded relief valve (pilot flow externally drained)



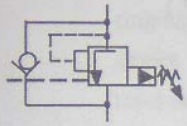
(pilot flow internally drained)



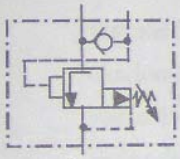
Brake valve



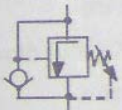
Unloading valve (accumulator charging valve)



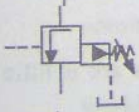
Counter balance valve (back pressure valve)



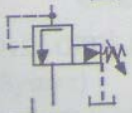
Sequence valve with remote control (external pilot)



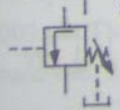
Sequence valve with direct control (internal pilot)



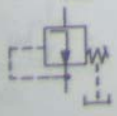
Offloading valve



Pressure reducing valve (fixed)

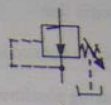


Pressure reducing valve (adjustable)

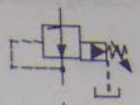


Pressure Control Valves

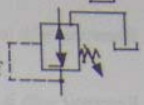
Throttling orifice normally closed or normally open (*: optional)



Pilot-operated pressure reducing valve



Pressure reducing valve with secondary system relief



Flow Control Valves

Throttle valve not affected by viscosity

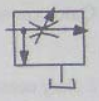
Throttle valve (fixed)

Throttle valve (adjustable)

Flow control valve, pressure and temperature compensated

Flow control valve with reverse free flow check

By-pass flow control valve



Flow divider

Fluid Plumbing and Storage

Fluid flow direction

Adjustability

Pressure source

Working line, return line, feed line

Pilot control line

Drain line

Enclosure line

Plunger (piston or ball)

Spring

Detent mechanism

Pressure relief

Pressure applied

Pneumatic pilot

Hydraulic pilot

Solenoid

Solenoid/hydraulic pilot (electro-hydraulic)

Torque motor

Pneumatic/hydraulic pilot

Spring centred

Directional Control Valves

Directional control valve with two discrete positions

Directional control valve with three discrete positions

Directional control valve with significant cross-over positions

Valve with two discrete positions and an infinite number of intermediate throttling positions

Valve with three discrete positions and an infinite number of intermediate throttling positions

Two-position, two-port (2/2) valve

Two-position, three-port (3/2) valve

Two-position, four-port (4/2) valve

Two-position, five-port (5/2) valve

Three-position, four-port (4/3) valve with fully closed centre configuration

Port labelling:

- working lines A, B
- pilot lines X, Y
- pressure line P
- tank line T

Check valve

Spring-loaded check valve

Pilot-loaded check valve

OR function valve

AND function valve

Deceleration valve

Deceleration valve

Servo and Proportional Valves

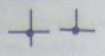
Proportional control pressure relief valve (with integral max. pressure limitation)

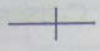
Pilot-operated directional proportional valve

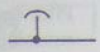
Four-way servo-valve with mechanical feedback, standard overlapping and hydraulic zero

Flexible line 

Electric line 

Pipeline connections 

Crossing pipelines (not connected) 

Air vent 

Reservoir with inlet below fluid level 

Reservoir with inlet above fluid level 

Miscellaneous Symbols

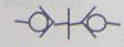
Electric motor 

Heat engine 

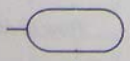
Electric motor with pump and drive coupling 

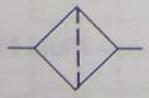
Plugged line

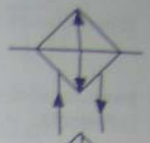
Plugged line with take-off line

Quick connect coupling 

Rotary connection 

Accumulator 

Filter, strainer 

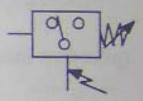
Cooler with coolant lines 

Heater 

Pressure gauge, pressure indicator 

Flow meter 

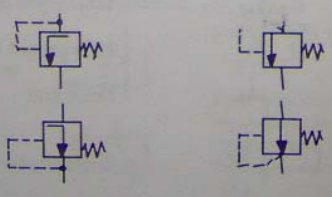
Thermometer 

Pressure switch (electrical) 

Shut-off valve 

Note that the symbols for pressure valves are a little bit different between the DIN-ISO 1219 and ISO 1219-1 versions:

DIN-ISO 1219 ISO 1219-1



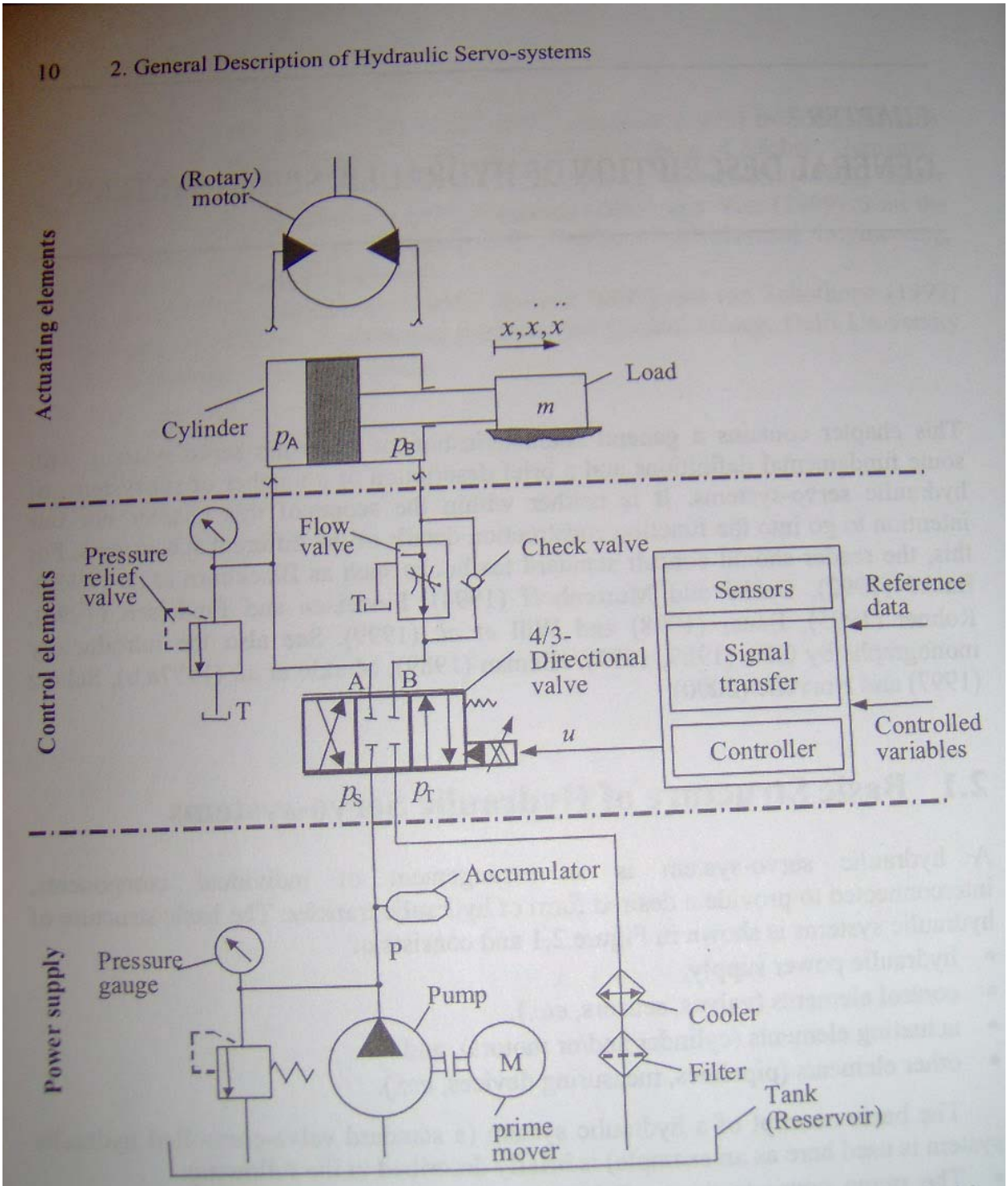


Figure 2.1. Basic structure of hydraulic systems (see Appendix A for hydraulic symbols)

2.2.1 Valves

Valves are the most important mechanical (or electrical) link to the fluid interface in hydraulic systems.

2.2.1.1 Valve Types

Basically there are four main categories of valves in hydraulics:

(a) **Pressure valves** are used to control actuator force, and to determine and (pre)select pressure levels at which certain machine operations must occur:
- *Pressure-relief valves* limit the maximum permissible system pressure, and divert some or all of the pump's flow to the tank when the pressure setting of the relief valve is reached. Pressure relief valves are "normally closed".
- *Pressure-reducing valves* limit and maintain a constant downstream pressure (sub-circuit pressure) that is smaller than the system pressure regardless of pressure fluctuations in the main circuit upstream. Pressure reducing valves are "normally open".

(b) **Check valves** are a very special type of directional control valve, as they only permit fluid flow in one direction while blocking flow in the reverse direction. They can be divided into unloaded or spring-loaded check valves, and check valves for logic operations (OR, AND).

(c) **Flow valves** are used to control the rate of flow from one part of the hydraulic system to another, *i.e.*, they limit the maximum speed of cylinders and motors, limit the maximum power available to sub-circuits by controlling the flow of them, or proportionally divide or regulate the pump flow to various branches of the circuit.

(d) **Directional valves** are used as multi-polar switches. Before the advent of servo and proportional valves they were used to control the direction of actuator motion, selected alternative control circuits, and performed logic control functions. Nowadays, however, proportionally variable controls allow infinitely adaptable and quickly variable setting of actuators with regard to force, speed and stroke position.

2.2.1.2 From Solenoid-valves to Servo-valves

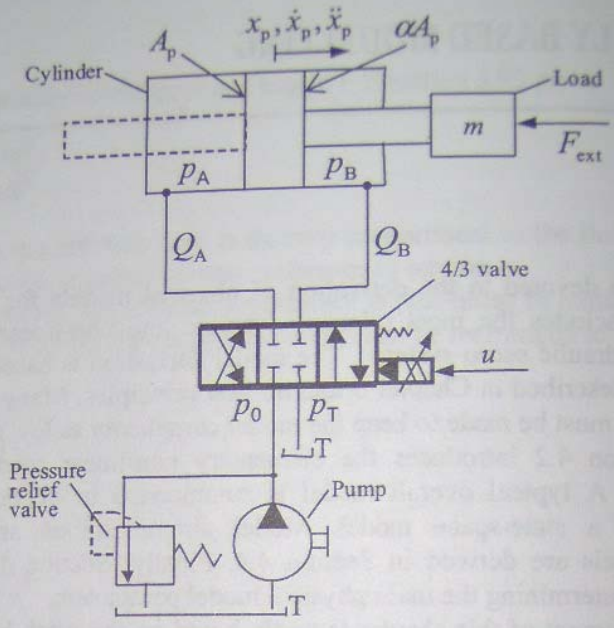


Figure 4.1. Valve–cylinder combination with power supply

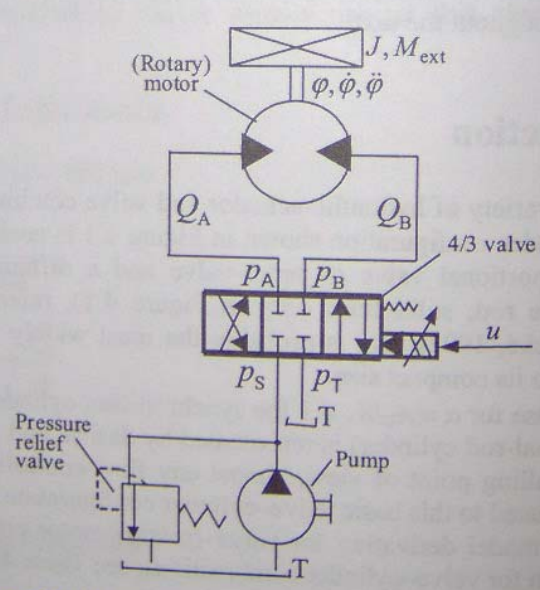


Figure 4.2. Valve–motor combination with power supply

4.1.1 Characterisation of Subsystems

Although a general characterisation of hydraulic servo-systems has already been given in Chapter 2, a more precise description, in view of the mathematical modelling of this system, is to be given, including the system boundary.

4.2.3.4 Pressure Dynamics in Closed-circuit Hydrostatic Transmissions

In a hydrostatic transmission designed as a closed-circuit drive, the hydraulic fluid from the hydraulic motor returns directly to the pump inlet, not to a reservoir. Usually, the pump has variable displacement and is designed for both flow directions. Additional fluid is pumped into the low-pressure side of the circuit by means of a replenishing pump to replace leakage losses and establish a minimum pressure in each line. Safety relief valves provide protection for the system from damage due to pressure peaks, they absorb shocks during motor reversal, and they limit maximum system pressure. Moreover, a flushing valve is normally used to select the pressure switch and the system relief valve into the high-pressure circuit side, and to divert excessive hot and contaminated fluid from the motor discharge through a filter and cooler back to the tank. A schematic representation of a closed hydrostatic drive is depicted in Figure 4.12.

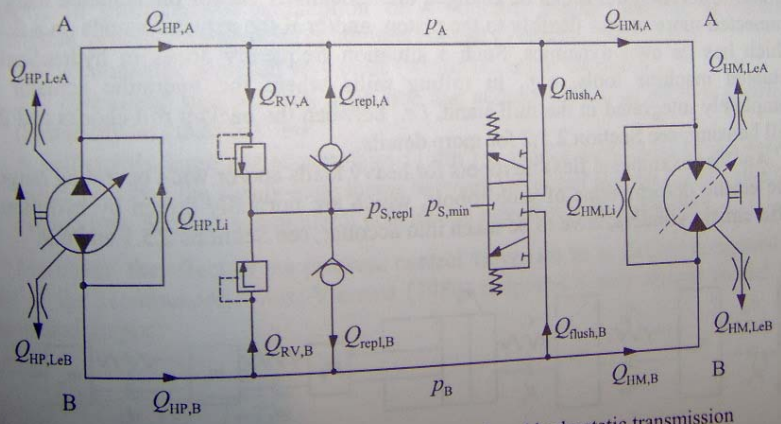
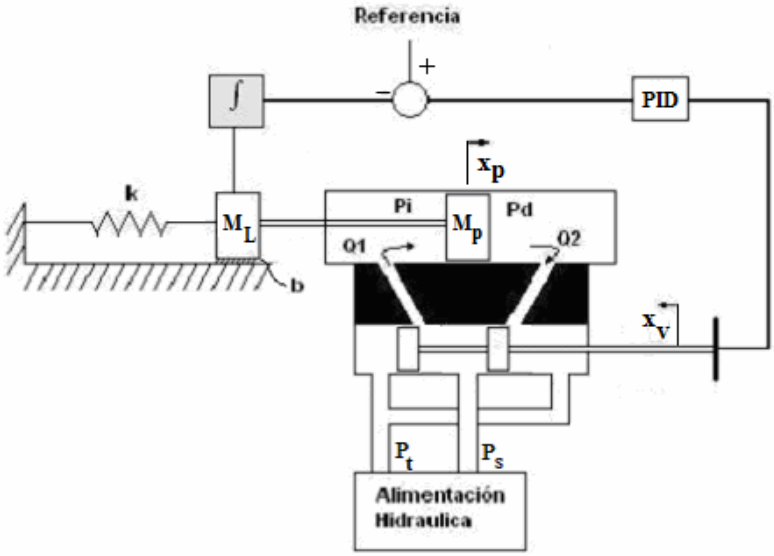


Figure 4.12. A schematic representation of a closed hydrostatic transmission



Control de posición a través de una válvula de 4 vías.