Directional spool valve banks type SWS

Directly solenoid actuated (on/off or proportional)

Pre-release A

Flow Q_{max} = 25 lpm
Operation pressure p_{max} = 315 bar

1. General information

The directional valve banks type SWS are a refined version of type SWR. Basic function is the directional control of hydraulic consumers (cylinders, motors). But this new concept enables also the incorporation of additional functions for each individual valve section on both the pump (check or throttle valves) and the consumer side (over-center, shock, or check valves).
The actuation is carried out via pressure tight, single acting solenoids which act directly on the valve spool.
A variety of connection blocks (featuring pressure and return ports) as well as end plates offer solutions to many applications.

Order examples

Example 1: Combination with compact-hydraulic power pack

HK 448/1 - Z12.3 - AS1F2/120 - SWS2F - G06 /MP /DW /2AN130 BN80
- W /M /R /2
- D /MF /0 /2AL4B140 BL4C140 -1 - G24

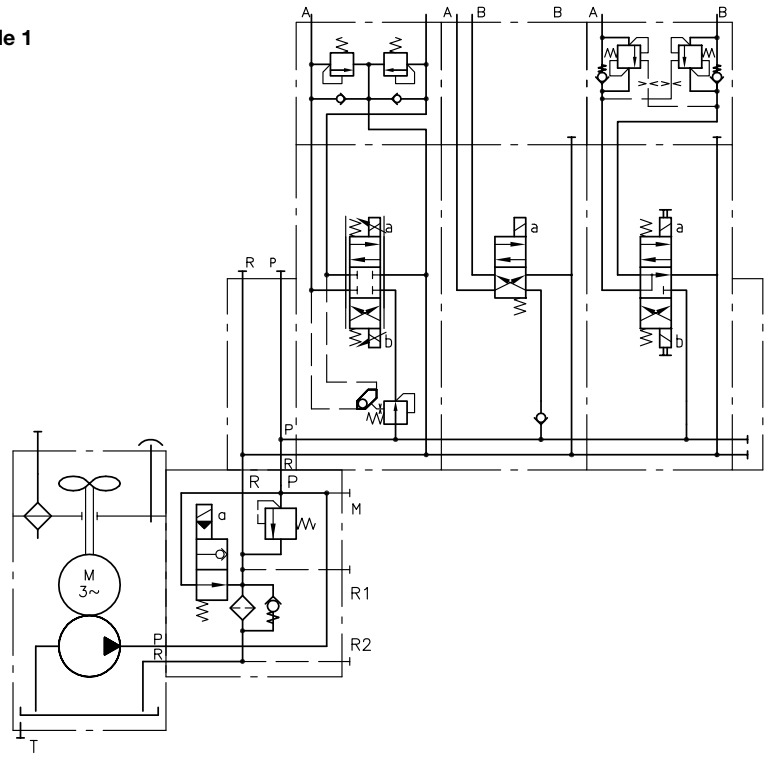
Example 2: Valve bank with proportional-flow control valve in the connection block

SWS2 SE22F-A6 - G12 /MP /DW /2AS250 BS310
- D06 /M /DW /2AL320
- B /M /Q /2 -1 - G24 - 300

Example 3: Lifting module for reach trucks

HMT34DH - 1/220 - 90F - D12 /MPF /DW /2AL4B200 BL4C200
- G /M /0 /02
- G /M /0 /02 - G24

Hydraulic circuit and illustration acc. to example 1



2.1

2. Type coding key, overview

Order example:

SWS2 A6 - G06 /MP /DW /2AN130 BN310
- W /M /0 /02 - 1 - G24 - 200

Pressure setting (bar)

Solenoid voltage (see section 4.2)

End plates (see table 2)

Ancillary blocks, additional functions on the consumer side (see table 7)

/01, /02	Without ancillary block (A, B = G 1/4 or G 3/8)
/1, /2	Ancillary block (A, B = G 1/4 or G 3/8) no additional functions
/2AS.. BS..	Shock valve at A and B (G 3/8) with pressure setting
/2AN.. BN..	Shock and suction valve at A and B (G 3/8) with pressure setting
/2AN..	Shock and suction valve at A (G 3/8) with pressure setting
/2AL.. BL..	Over-center valve at A and B (G 3/8) with pressure setting
/2AL..	Over-center valve at A (G 3/8) with pressure setting
/1AV..	Sequence valve at A (G 1/4 or G 3/8) with pressure setting
/2RH	Releasable check valves

Ancillary blocks, additional functions on the pump side (see table 6)

/0	Without additional function, retrofitting is not possible
/2	Without additional functions, prepared for refitting of /Q, /B or /R
/B..	Orifice with diameter
/R	Check valve
/Q	Throttle (adjustable)
/DW	Flow control valve
/TV	Preference flow divider (only available for the first valve section) in combination with over-center valve

Solenoid actuation (see table 5)

/M	On/off solenoid (standard)
/MF (A, B)	Elevation stop at A and B (or only at A or B)
/MD (A, B)	Knob to the elevation stop at A and B (or only at A or B)
/MP	Proportional solenoid
/MPF (A, B)	Proportional solenoid with elevation stop
/MM (A, B)	Double solenoid (rapid transverse or creeping operation) at A and B (or only at A or B)

Flow, only in combination with /DW or /MP (see table 4)

03, 06, 12, 20	Max. flow at A and B (lpm)

Flow pattern symbols (see table 3)

G, D, E, O, N, B, Q, W, R	Flow pattern symbols
Z	Pressure reducing valve to the pressure reduction of all subsequent valve sections

Connection block / adapter plate (see table 1)

A5	Without pressure limiting valve
A6, A7	With pressure limiting valve
S6, S7, V6, V7	Additional idle circulation valve
SE..A6, SE..A7	Additional 3-way flow control valve
F	Direct mounting onto compact-hydraulic power packs

Basic type and size

SWS 2

3. Available versions, main data

3.1 Connection blocks, adapter plates, and end plates

Order example: **SWS 2 A6 - G/M/0/02 - 1 - G 24 - 200**

- **SWS 2** — Basic type and size: Flow Q_{max} = 25 lpm; Pressure p_{max} = 315 bar
- **A6** — Basic type and size
- **G/M/0/02** — For valve sections see sect. 3.2
- **1** — Desired pressure setting (bar) available pressure ranges: (0) ... 80 bar; (0) ... 160 bar; (0) ... 315 bar. Pressure specification determines the spring. Specification is superfluous with connection block A5 and adapter plate F
- **G 24** — For actuation solenoids **G 12** to **WG 230**, see sect. 4.2
- **200** — Desired pressure setting (bar)

Table 1: Connection block, adapter plate

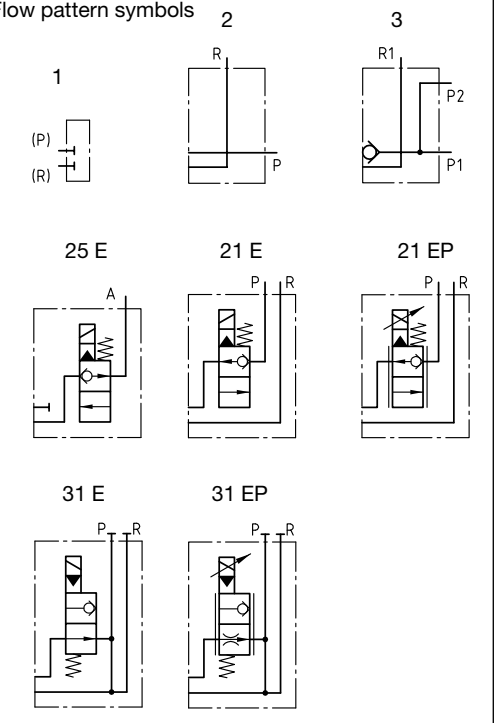
P (pump port) and R (return port) = G 3/8 DIN ISO 228/1 (BSPP)
M (Port for pressure gauge) = G 1/4 DIN ISO 228/1 (BSPP)

Coding		Pressure limiting valve [1]	Idle circulation valve acc. to D 7490/1	Symbole
				= ..6 = ..7
A	**5**	No pressure limiting valve	without	A 5; A 6 and A 7
	6	Tool adjustable		
	7	Manually adjustable		
S [3]	**6**	Tool adjustable	EM 21S Idle circulation while deenergized	S 6 and S 7; V 6 and V 7
	7	Manually adjustable		
V [3]	**6**	Tool adjustable	EM 21V Idle circulation while energized	
	7	Manually adjustable		
	F	Direct mounting onto compact-hydraulic power packs MP acc. to D 7200H HK acc. to D 7600-... HC acc. to D 7900		Is to be directly mounted onto connection block A(AS, AV)1, and 2 (3, 4) acc. to D 6905 A.
SE [3]	**30 F** **22 F** **15 F** **10 F** **6 F** **4/18 F** [2] **3/26 F** [2] **3/7 F** [2] **3 F**	A 6 and A 7	3-way flow control valve with metering throttle closed, while deenergized (Regulation range starting from approx. 0.1 lpm up to the respective specified max figure e.g. 30 F & Q_{max} = 30 lpm)	Order example: SWS 2 SE 22F-A6-...-200
... / TV ...		Tool adjustable	With preference flow devider, for flow pattern symbol and order example see table 6	

Table 2: End plates

Coding	Brief description
1	Standard
2	Additional pump and return port (P1, R1 = G 3/8)
3	Additional pump port P1, P2 and return port R1 (G 1/2)
25 E	Switchable additional return port A (G 3/8)
21 E	Switchable additional pump outlet port to the supply for further valve banks
21 EP	Like 21 E, but with prop. valve to the stepless quantity dosage (e.g. for a smooth start or for pumps)
31 E	End plate with idle circulation valve (e.g. as alternative for connection blocks)
31 EP	Like 31 E, but with prop. valve (e.g. to prevent start jumps)

Flow pattern symbols



[1] The spring dome of the pressure limiting valve is made of zinc pressure die-cast (standard). The (optional) steel spring dome should be used, wherever pressure surges of more than 20 ... 25 bar could occur in the return duct. This must be specified in uncoded text.

[2] Metering throttle with non-linear characteristic and specification of the fine control block and the max. flow at completely open metering throttle

[3] There is also an end plate available featuring a (optionally proportional) by-pass valve (type 31 E or 31 EP acc. to table 2)

3.2 Valve sections

3.2.1 Directional spool valves

Order example: **SWS2 A6 - G /M /0 /02**
- D06 /MP/DW /2AS180 BS180 - 1 -G24 - 200

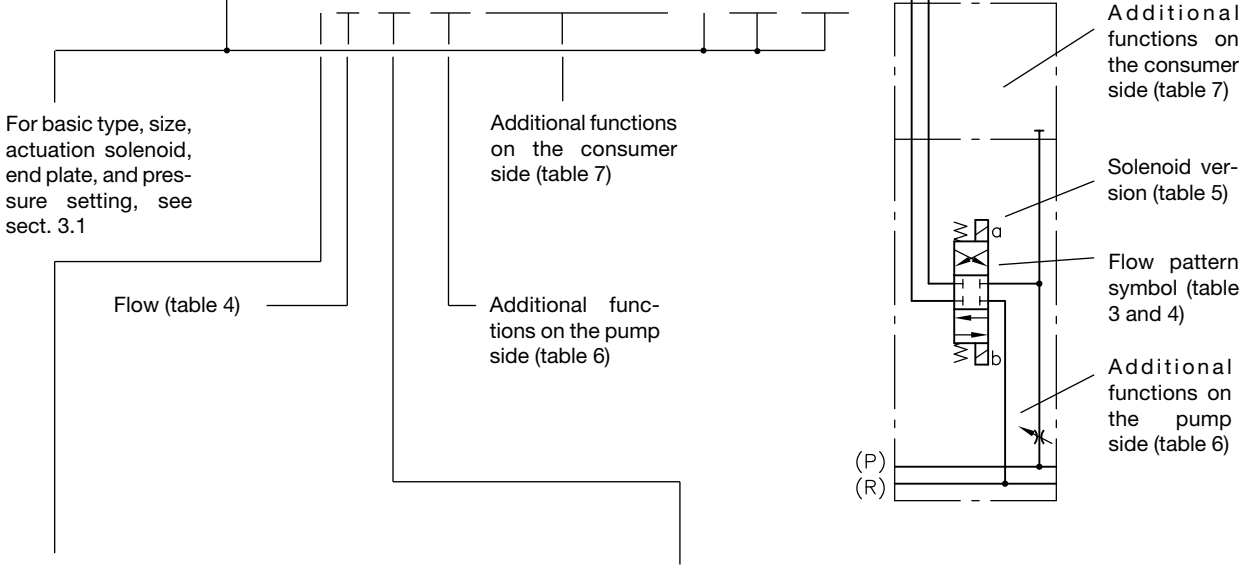


Table 3: Flow pattern symbols

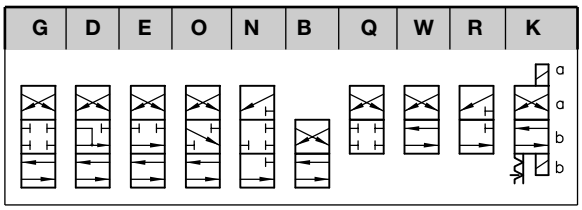


Table 4: Flow
Attention: Only in connection with coding /MP (table 5) and/or /DW (table 6)!

Coding	03	06	12	20	without
Flow $Q_{A, B\ max}$ (lpm)	3	6	12	20	---

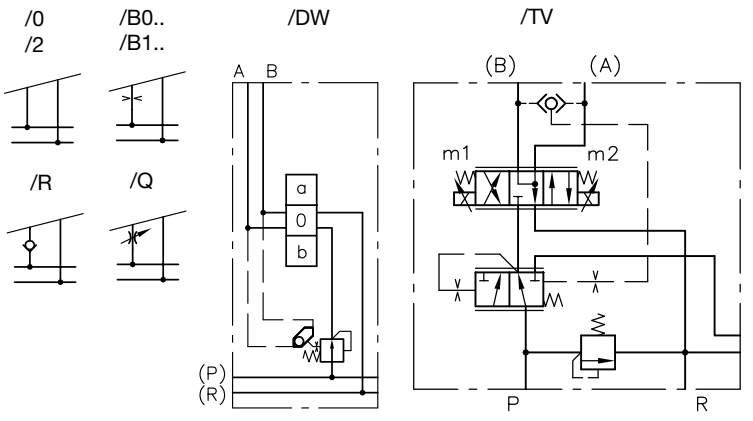
Table 5: Solenoid version

Coding	Brief description	Flow pattern symbols
/M	On/off solenoid	
/MF **/MFA** **/MFB**	On/off solenoid with elevation stop (set screw) for A and B (/MF), for A (/MFA) or for B (/MFB)	
/MD **/MDA** **/MDB**	On/off solenoid with elevation stop (turn knob) for A and B (/MD), for A (/MDA) or for B (/MDB)	
/MP	Proportional solenoid	
/MPF	Proportional solenoid with elevation stop	
/MMD **/MMA** **/MMB**	Double solenoid for rapid transverse/creeping operation for A and B (/MM), for A (/MMA) or for B (/MMB)	

Table 6: Pump sided additional function

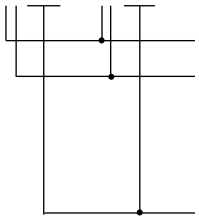
Coding	Brief description
/0	Without additional function, retrofitting is not possible
/2	Without additional functions, prepared for refitting of /Q, /B or /R
/B..	Orifice with -∅ (mm)
/R	Check valve
/Q	Throttle (adjustable)
/DW	Flow control valve (retrofitting is not possible), for a load independent flow limitation, most advantageous in combination with /MP(F) table 5 and coding for flow acc. to table 4
/TV	Preference flow devider with a defined for this consumer. Attention: This is only available for the first valve section (this feature is housed in the connection block) and in combination with over-center valve (/2AL.. BL..) acc. to table 7, see order example

Flow pattern symbols



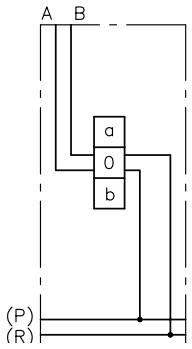
Order example:
SWS 2 -D06/MP/TV/2AL4D180 BL4D180
-G/M/0/2
-31EP-G24

Table 7: Additional functions on the consumer side

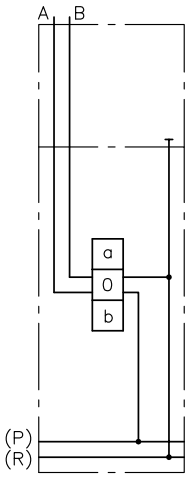
Coding	Brief description	Tapped ports A and B
/01	Without additional function (no connection block), cannot be combined with additional functions acc. to table 6	G 1/4
/02		G 3/8
/1	Without additional function, ports in the ancillary block	G 1/4
/2		G 3/8
/2AN.. BN.. /2AN..	Shock and suction valve, with pressure specification for A and B or A only	G 3/8
/2AS.. BS..	Shock valves for A and B	G 3/8
/1AV..	Sequence valve for the consumer port A	G 1/4
/2AL... BL... /2AL...	Over-center valve (example: /2AL4C200 BL4B180) for A and B or A only  4 = Release ration Valve version (flow dependent) A = appr. 20 lpm B = appr. 14 lpm C = appr. 10 lpm D = appr. 6 lpm Pressure setting max. 380 bar	G 3/8
/2RH	Double check valve (Release ration 1 : 2.5)	G 3/8

Flow pattern symbols

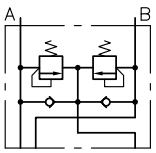
/01 and /02



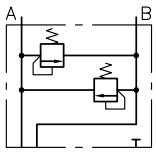
/1 and /2



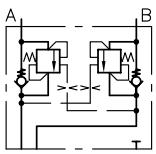
/2AN... BN...



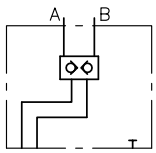
/2AS... BS...



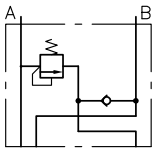
/2AL... BL...



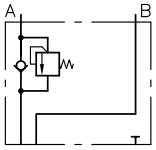
/2RH



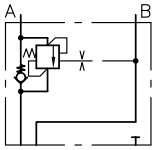
/2AN...



/1AV...



/2AL...



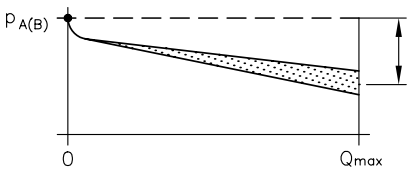
3.2.2 Intermediate sections

Pressure reducing valve

The valve can be ordered anywhere between the directional spool valve sections. All subsequent spool valve sections receive only pressure fluid with the set pressure (secondary pressure), independent of the higher system pressure upstream. Coding Z1 ... Z8 may be added any position within the complete valve bank coding, see order example in the margin.

Table 8: Pressure reducing valve		
Adjustable pressure range [1] from ... to (bar)	Coding: Tool adjustable	Coding: Manually adjustable
160 ... 250	**Z 1**	**Z 5**
60 ... 160	**Z 2**	**Z 6**
30 ... 130	**Z 3**	**Z 7**
10 ... 30	**Z 4**	**Z 8**

$p_{A(B)}$ - $Q_{A(B)}$ - curve (tendency)



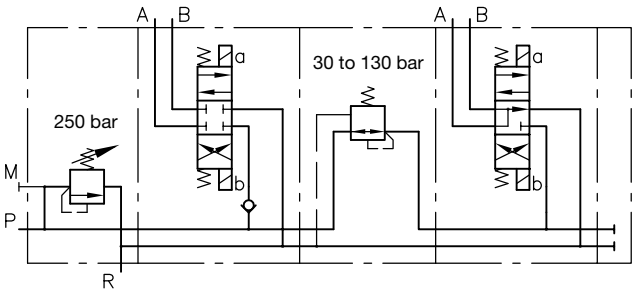
≈ -10 ... -15% of the pressure setting depending on pressure range

Order example and flow pattern symbol

SWS 2 A7 - G/M/R/02

-Z3

-D/M/0/02 - 1 -G24 - 250



Primary side up to 250 bar

Pressure reducing valve

Secondary side up to 130 bar

Pressure specifications corresponding to the order example

[1] Pressure setting (monitored by a pressure gauge) at $Q_{A(B)}$ = 0 lpm (Consumer on the secondary side in stop position)

Valves coding Z are always set for max. pressure at HAWE, if a specification is missing in the order. When a specific pressure setting is desired, thus should be specified in the order coding in uncoded text.

Example: SWS 2 A6 - .. **Z3** ... - 1 - G 24 - 210, Z3 set for 100 bar

The order coding for spares or storing is as follows:
ADM 22 PA for Z1; ADM 22 PC for Z2; ADM 22 PD for Z3; ADM 22 PF for Z4
ADM 22 PAR for Z5; ADM 22 PCR for Z6; ADM 22 PDR for Z7; ADM 22 PFR for Z8
Sub-plate for pressure reducing valve HAWE-No. 7451 004

Intermediate section with flow limitation for all subsequent functions

Order example: SWS 2 A6 - G/M/R/02

- ZSB 15

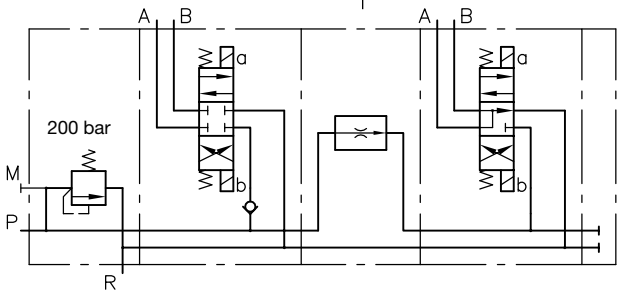
- D/M/0/02 - 1 - G 24 - 200

ZSB ...

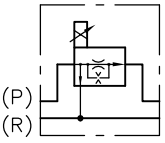
Intermediate section featuring a drop-rate braking valve type SB 1 acc. to D 6920 pressure p_{max} = 315 bar

Adjustable response flow 2.5 ... 35 lpm

Flow pattern symbol corresponding the order example



Intermediate section with proportional 3-way flow control valve

Coding Basic type	Metering throttle	Brief description	Flow pattern symbol
ZSE	**22 F** **15 F** **10 F** **6 F** **4/18 F** **3/26 F** **3/7 F** **3 F**	A inter-section with a 3 way-proportional-flow control valve is used to limit the flow for all subsequent valve sections A bypass nozzle prevents blocking of the 3 way flow control valve when all valves are closed. The control characteristics corresponds is like with connection blocks type SWS 2 SE.. (see table 1 and curve in sect. 4.1).	

4. Additional parameter

4.1 General and hydraulic data

Design	Directional spool valve
Surface protection	Spool valve housing nitrous hardened, solenoid zinc galvanized
Installed position	Any, for fastening see dimensional drawings in section 5.1 ++
Pipe connection	Pipe thread DIN ISO 228/1 (BSPP)
Port coding	P = Pressurized fluid inlet port (pump) G 3/8 A, B = Consumer G 3/8 or G 1/4 (dep. on type) R = Return port G 3/8 M = Port for pressure gauge G 1/4
Flow direction	In accordance with arrow direction in the flow pattern symbols; It is not permissible to reverse the flow direction !
Over lapping	Positive
Operation pressure	p_{max} = 315 bar (all ports)
Flow	Flow Q_{max} = 25 lpm; Permissible return flow approx. 50 lpm (The piston side of a differential cylinder should be connected to A, if the return exceeds 25 lpm)
Hydraulic fluid:	Fluids acc. to DIN 51524 table 1 to 3; ISO VG 10 to 68 acc. to DIN 51519 Viscosity range: min. approx. 4; max. approx. 1500 mm²/s Optimal operation range: approx. 10...500 mm²/s Also suitable are biologically degradable pressure fluids of the type HEPG (Polyalkylenglycol) and HEES (synth. Ester) at operation temperatures up to approx. +70°C.HETG (seed oil) is not suited.
Temperature	Ambient: approx. -40...+80°C; Fluid: -25...+80°C, pay attention to the viscosity range! Start temperature down to -40°C are allowable (Pay attention to the viscosity range during start!), as long as the operation temperature during subsequent running is at least 20K higher. Biological degradable pressure fluids: Pay attention to manufacturer's information. With regard to the compatibility with sealing materials do not exceed +70°C. **Restrictions for version with ex-proof solenoid!**
Max. contamination	Conforming 18/14 ISO 4406

Mass (weight)

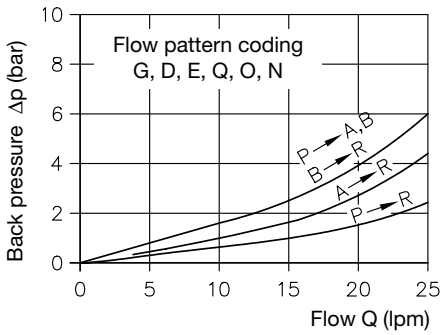
Spool valve (incl. actuation)	
Coding	appr. kg
G, D, E, O, N	1.8
B, Q, W, R, K	1.3

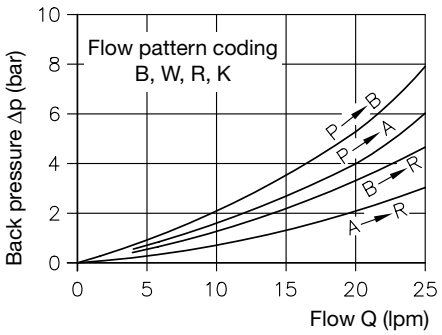
Connection blocks	
Coding	appr. kg
A 5	0.8
A 6, A 7	1.5
S 6, S 7, V 6, V 7	1.8
F	0.8
SE	2.6

Ancillary blocks	
Coding	appr. kg
/1. /2	0.5
others	1.0

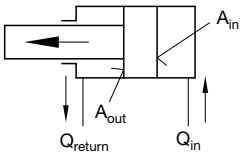
Intermediate sections	
Coding	appr. kg
Z1 ... Z 8	1.5
ZSB	1.1
ZSE	2.0

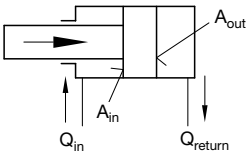
Δp-Q curve
The characteristics apply to all spool valve sections, no matter where they are installed within the valve bank. The measurable deviations are insignificant.





These curves always apply to one flow direction only P→R (idle circulation), P→A(B) or A(B)→R. The total back pressure (Δp_{total}) with 4/3- or 4/2-way directional valves is taken at P. It consists of an inflow share (Δp_{in}) and an outflow share (Δp_{out}). Important: Consumers with unequal area ration (e.g. differential cylinders) show uneven flow at the consumer ports, i.e. a lso (Δp_{in}) and (Δp_{out}) won't be equal regardless of the direction of movement!



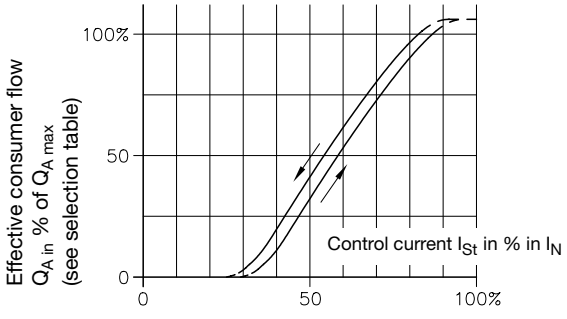


$$Q_{return} = Q_{in} \frac{A_{out}}{A_{in}}$$

$$\Delta p_{return} = \Delta p_{in} + \Delta p_{out} \frac{A_{out}}{A_{in}}$$

Q-I curve for proportional flow control valve (connection block)

Viscosity during the measuring approx. 60 mm²/s



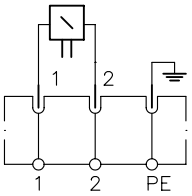
4.2 Solenoid

Electrical data (/M... table 5)

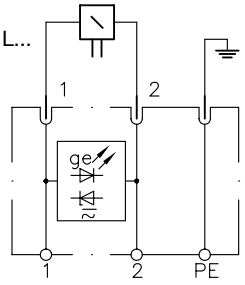
Solenoid	Manufactured and tested conforming VDE 0580, operating pressure resistant in the pressure fluid Reference value for nom. power P_N , 24.4 W ± approx. 6% dep. on nom. voltage U_N and brand								
Coding	G 12 X 12 L 12	G 24 X 24 L 24	G 24 EX 1)	G 48 X 48	G 80 X 80	G 98 X 98 2)	G 205 X 205 2)	WG 110	WG 230
Nom. voltage U_N	12V DC	24V DC	24V DC	48V DC	80V DC	98V DC	205V DC 50/60Hz	110V AC 50/60Hz	230V AC
Nom. power P_N (W)	28	28	23.6	28	28	28	28	28	28
Nom. current I_{20} (A)	2.34	1.17	1.0	0.58	0.35	0.28	0.14	0.28	0.14

Circuitry (valid for solenoid a and b)

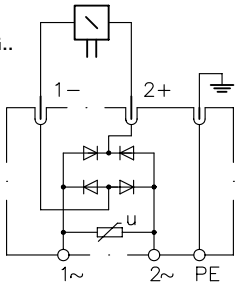
DC-voltage Coding G...



Coding L...



AC-voltage Coding WG..

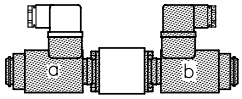


Plug

A DIN 43650 Pg 9 (see also D 7163)

Coding G (...V DC) is only available with gray or black plugs
Coding WG (..V AC) is only available with black plug, featuring an internal bridge rectifier circuit

Gray plug / Black plug



Relative duty cycle: 100% ED
Stamping on the solenoid

Operation:

At ambient temperature (°C)	< 40	60	80
Duty cycle (%)	100	approx. 60	approx. 40

Switching times (reference value)	On: approx. 60 ... 70 ms Off: approx. 30 ... 60 ms
Switching operations	approx. 3600 switchings / h
Protection class DIN 40050	Solenoid IP 54, connection area IP 65 (device socket in assembled state)
Insulation material class	F
Surface temperature	approx. 85°C at 20°C ambient temperature
Mounting	The solenoid can be simply removed after slackening the knurled nut, easing replacement in case of an electrical defect.

Proportiona solenoid (/MP.. table 5):

Solenoid	Conforming VDE 0580	
Nom. voltage UN	12V DC	24V DC
Coil resistance R20	6.0 Ω	24.0 Ω
Current , cold I20	2.5 A	1.25 A
Nom. current IN , 70% of I20	1.35 A	0.88 A
Power , cold $P_{20} = R_{20} \times I_{20}^2$	30 W	30 W
Nominal power $P_N = R_{20} \times I_{20}^2$	21 W	21 W
Recom. dither frequency	50 ... 150 Hz	
Dither amplitude	20 ... 40% of I_N	
Relative duty cycle	100% ED (ref. temp. $\vartheta 11$ = 50°C)	
Electrical connection	DIN 43650 B (industrial standard)	
Protection class DIN 40050	Solenoid IP 54, connection area IP 65 (device socket in assembled state)	

1) **Ex-proof solenoid**

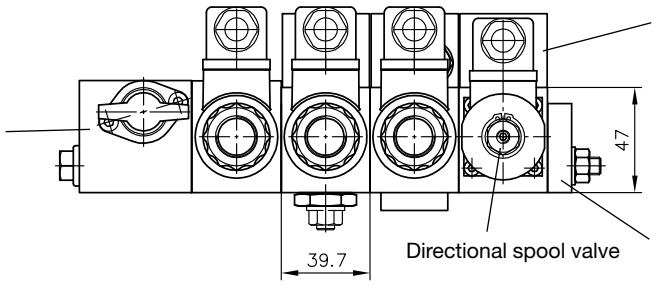
ATEX-Certificate of conformity	TÜV-A 03ATEX 0017 X
Coding	Ⓔx II 2 G Ex d IIB + H2 T4 Ⓔx II 2 D Ex mbD 21 T135°C
Duty cycle	IP 67 (IEC 60529)
Restrictions for use:	
Ambient temperature	-35 ... +40°C
max. fluid temperature	+70°C
el. protection against overload (conf. IEC 60127)	I_F < 1,6 A-T
Surface coating	Housing galvanically zinc coated Coil and connection cavity are moulded
Electrical connection	3x0,5 mm²
Cable length	3 m, Option 10 m (cable ÖLFLEX-440P ® Co. LAPP, D-70565 Stuttgart)

Attention : Protect the complete valve against direct sun light.
Observe the operation manuals B 03/2004 and B ATEX!
Electrical lay-out and testing conforming EN 60079, VDE 0170-1, VDE 0170-5

2) These solenoids are intended to be connected via a customer furnished bridge rectifier to mains 50/60Hz.: G 98 for mains 110V AC; G 205 for mains 230V AC

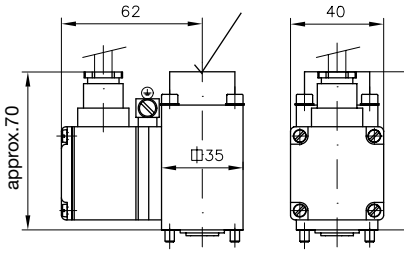
5. Unit dimensions

All dimensions in mm, subject to change without notice !

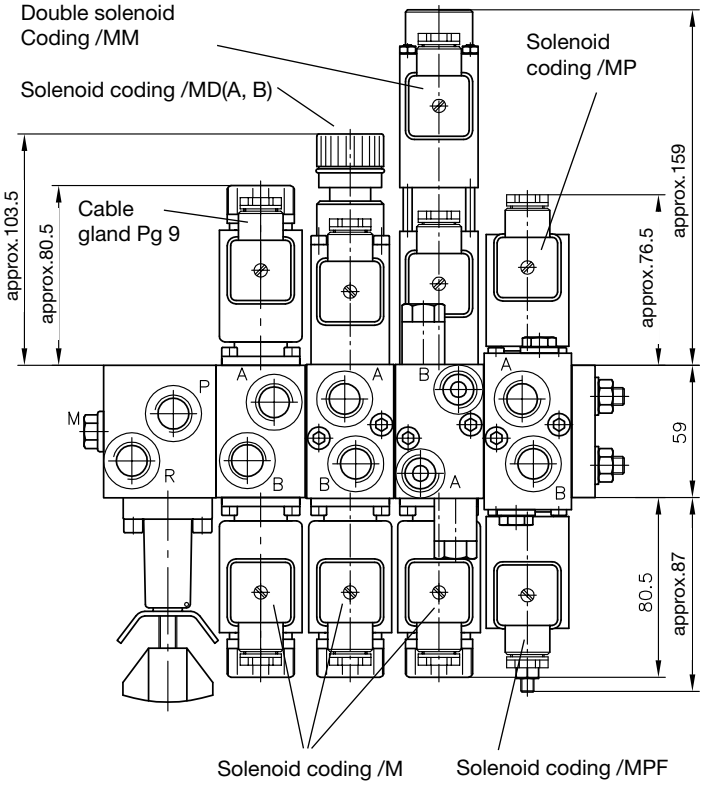


Solenoid (ex-proof version)
Coding G 24 ex

Manual emergency actuation

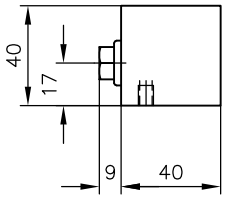


Double solenoid
Coding /MM

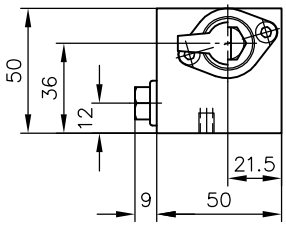


5.1 Connection blocks and adapter plates

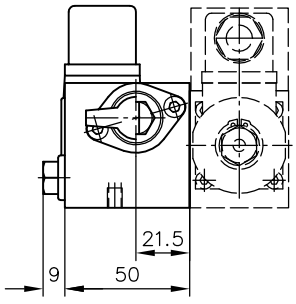
Coding **A 5**



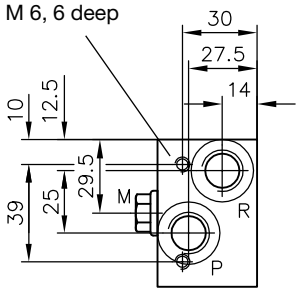
Coding **A 6, A 7**



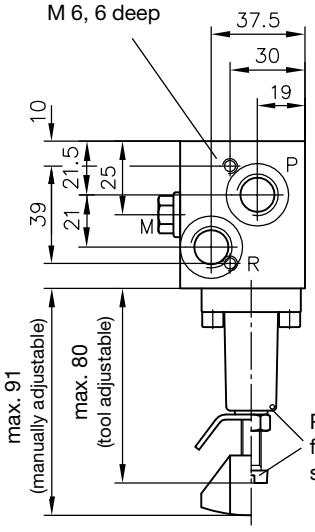
Coding **S(V) 6, S(V) 7**

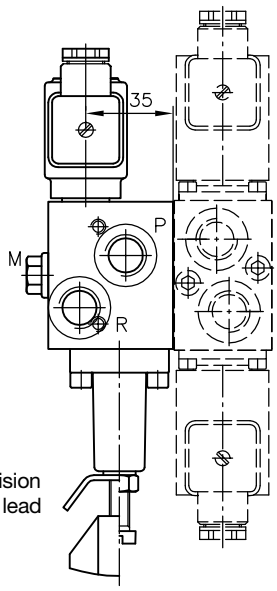


M 6, 6 deep

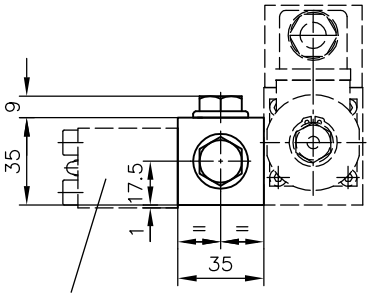


M 6, 6 deep

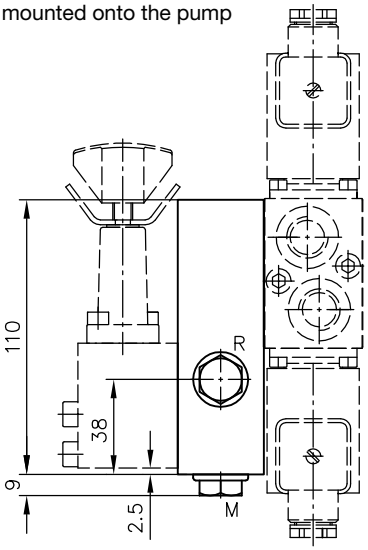




Coding **F**



Connection block directly mounted onto the pump

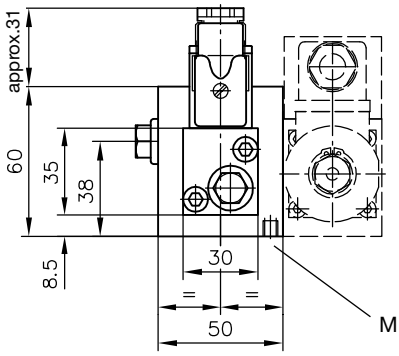


Ports DIN ISO 228/1 (BSPP):

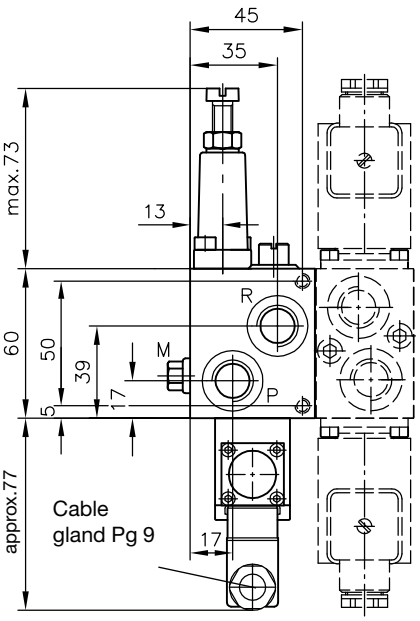
R = Return port G 3/8

M = Port for pressure gauge G 3/8

Coding **SE ... F**



M 6, 6 deep



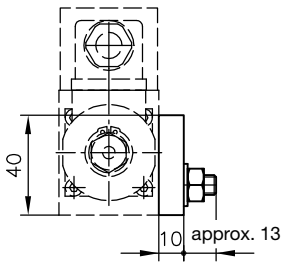
Ports DIN ISO 228/1 BSPP):

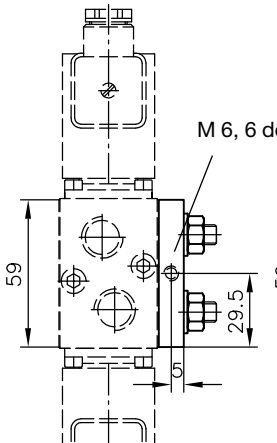
P, R = G 3/8

M = G 1/4

5.2 End plates

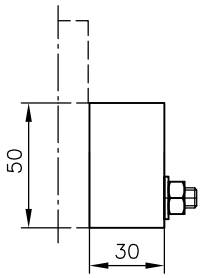
Coding **1**

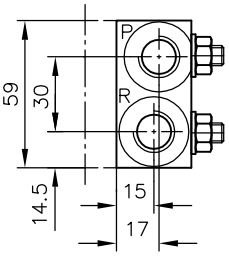




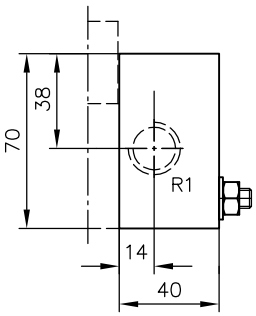
M 6, 6 deep

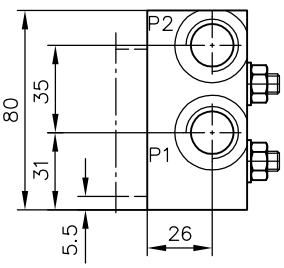
Coding **2**



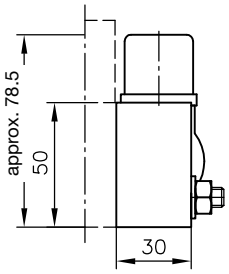


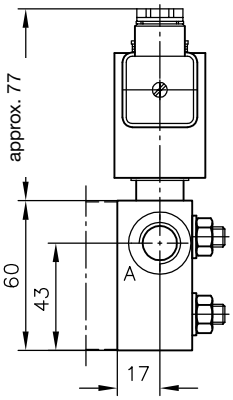
Coding **3**



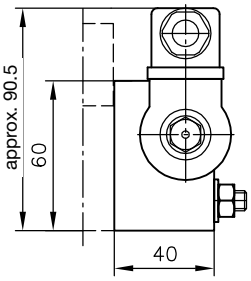


Coding **25 E**

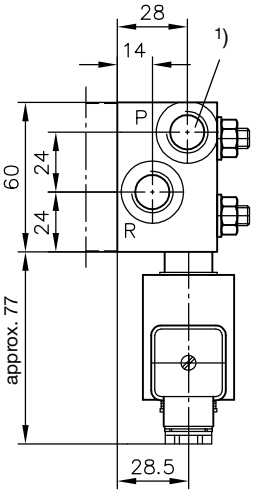




Coding **21 E(EP)**
31 E(EP)



[1]) Ports P and R are blocked with tapped plugs for 31 E(EP)



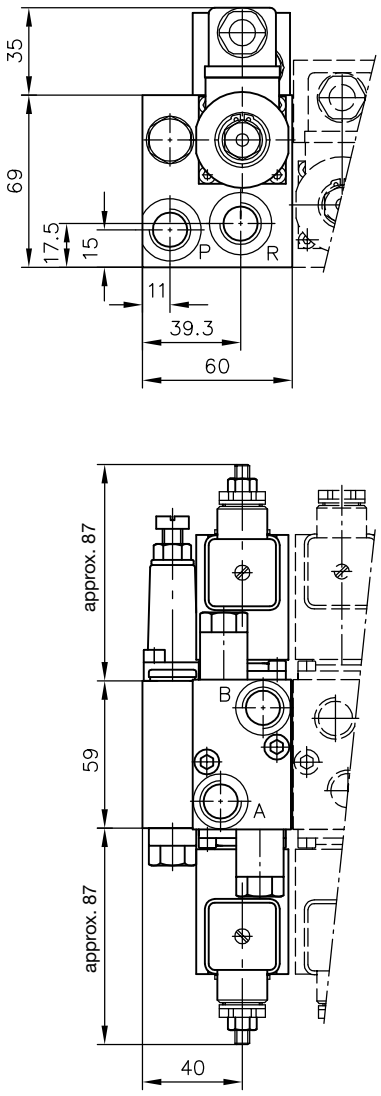
Ports DIN ISO 228/1 (BSPP):

A, P and R = G 3/8 with coding 2, 25 E, 21 E(P) and 31 E(P)

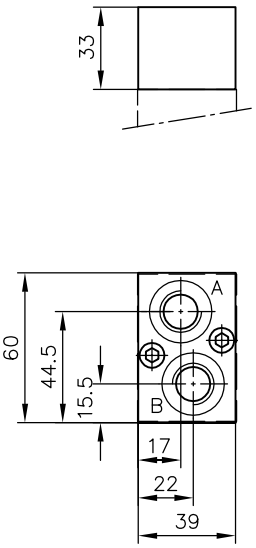
P1, P2, R1 = G 1/2 with coding 3

5.3 Ancillary blocks

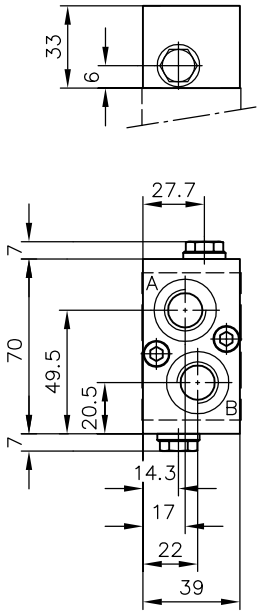
Coding **/TV**



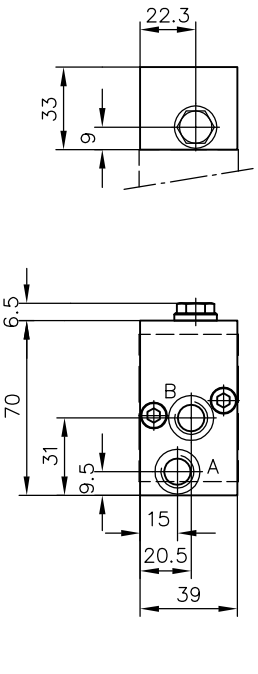
Coding **/1(2)**



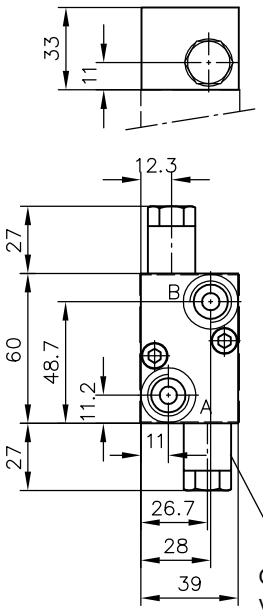
Coding **/2AN.. BN..**
/2AN..
/2AS.. BS..



Coding **/1AV..**

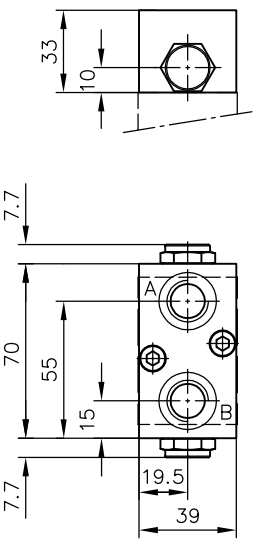


Coding **/2AL.. BL..**
/2AL..



Omitted at version /2AL...

Coding **/2RH**

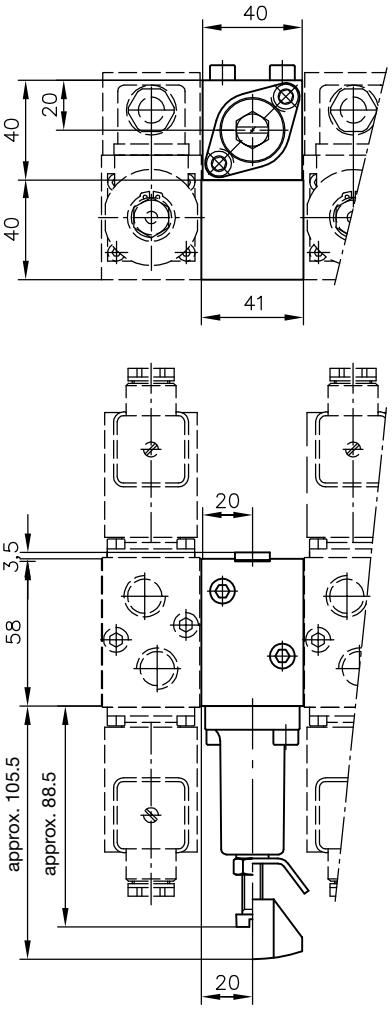


Ports DIN ISO 228/1 (BSPP):

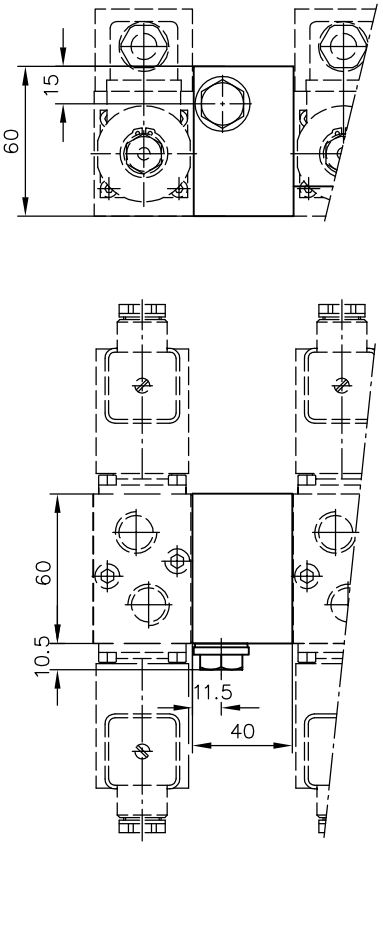
Coding	/TV	/1 /1AV..	/2 /2AN.. BN.. /2AN /2AS.. BS.. /2AL.. BL.. /2RH
P and R	G 3/8	---	---
A and B		G 1/4	G 3/8

5.4 Intermediate sections

Coding **Z 1 ... Z 8**



Coding **ZSB**



Coding **ZSE**