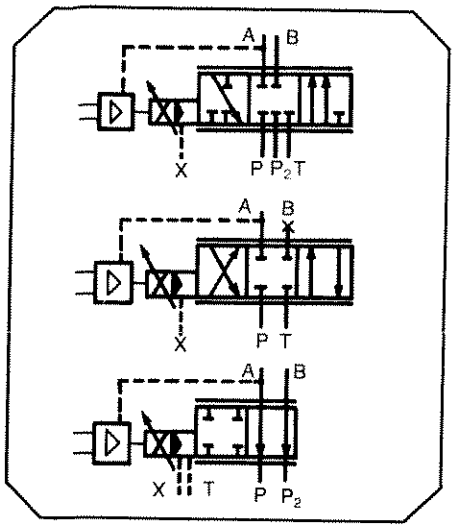
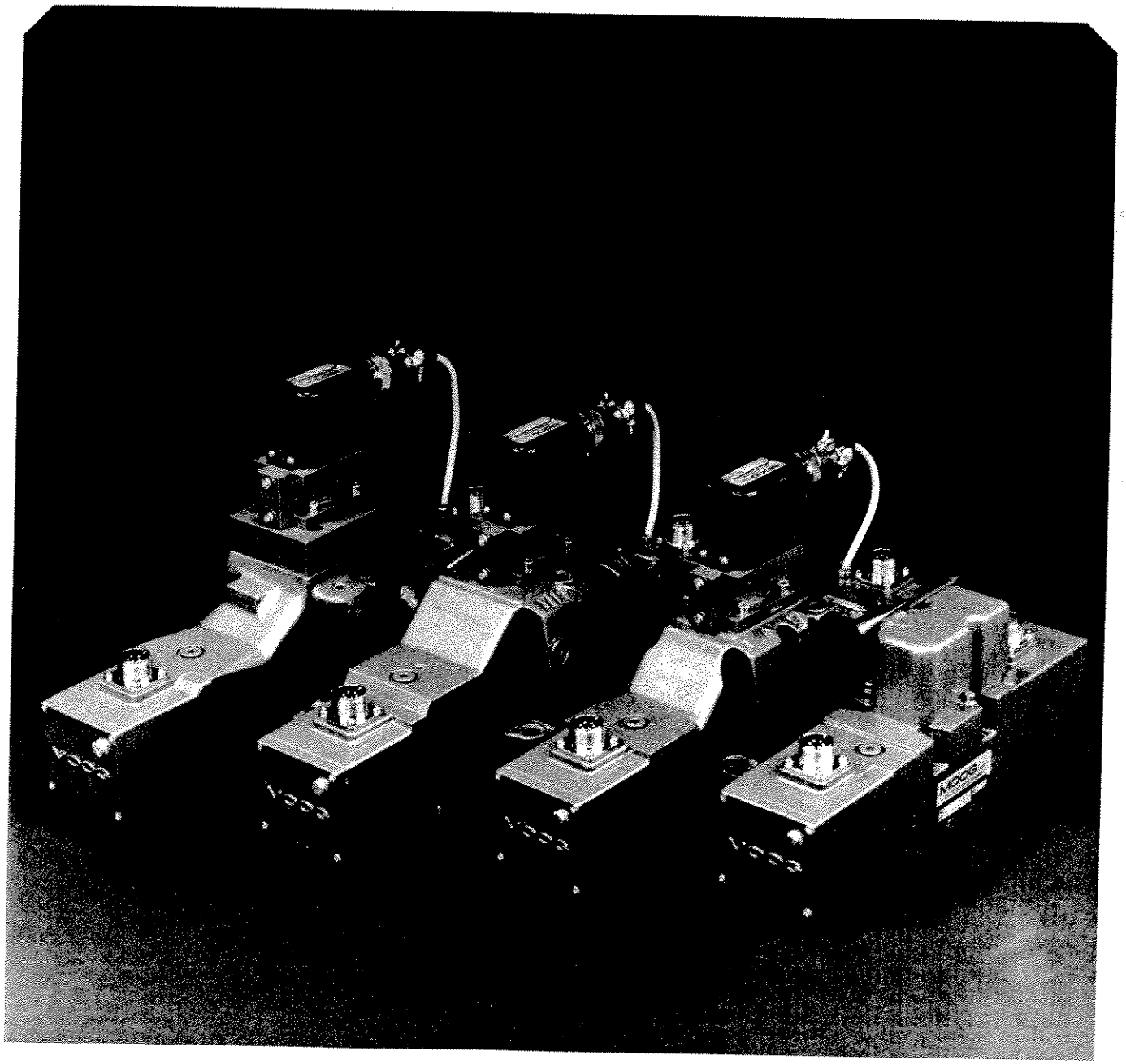
MOOG



P-Q Proportional control valves
Series D 650

Rated flow 23 . . . 800 l/min (Δp_N = 10 bar)
Operating pressure up to 350 bar

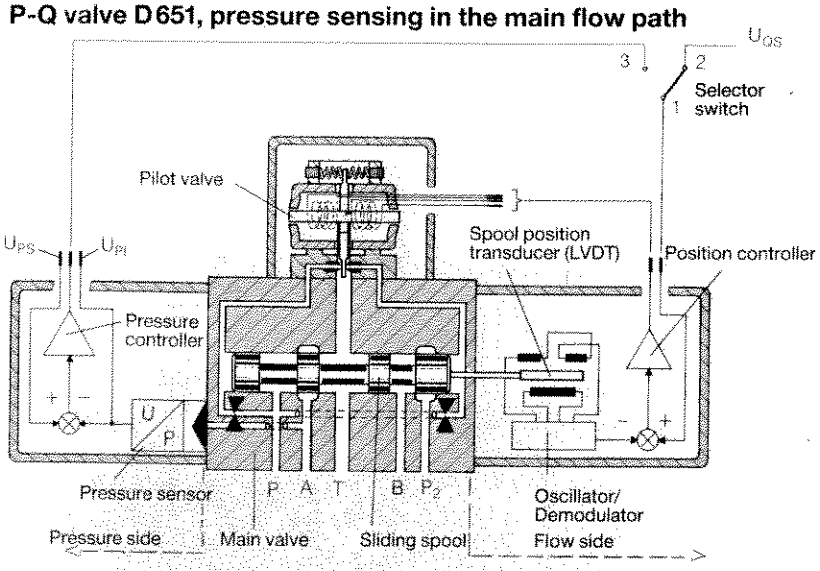
Port pattern in accordance with DIN 24340
Form A 10 to A 25



General

The MOOG P-Q proportional control valve is a 2-function valve which can be used to control both flow rate and pressure precisely and rapidly. It is a compact unit which can be **optimized for each application.** It contains integrated electronics for position control of the sliding spool and integrated electronics with pressure sensor for pressure control. Nowadays, several valves are used in many hydraulic systems in order to achieve the same function.

P-Q valve D651, pressure sensing in the main flow path



Flow rate setpoint or position setpoint U_{QS}
actual position value U_{LI}
pressure setpoint U_{PS}
actual pressure value U_{PI} [1])
sliding spool displacement X
load pressure P_L

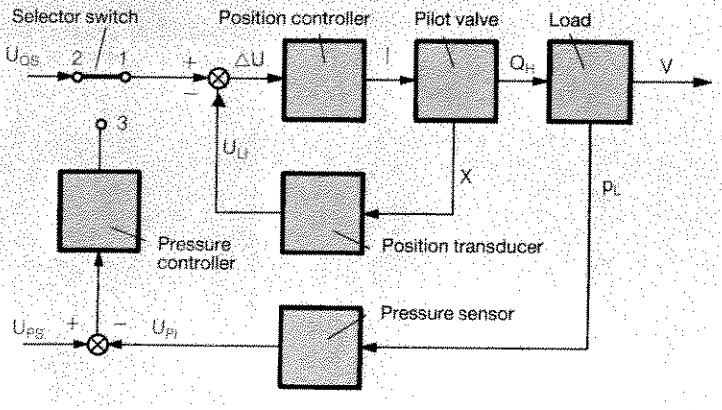
[1]) U_{PI} can be tapped at the electrical connector for testing, monitoring and recording purposes.

Advantages of the P-Q proportional control valve

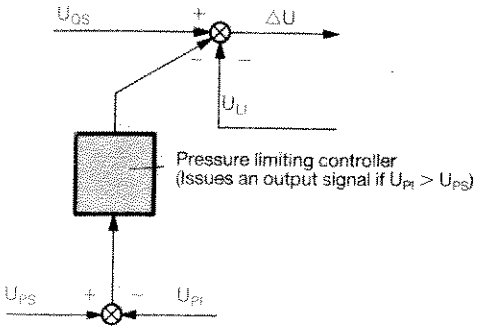
- Compact unit, which can be used to control both flow rate and pressure rapidly and precisely. This permits hydraulic systems to be simplified.
- Supplied as a completely pre-set and tested unit to simplify installation and service.
- For the flow rate function, the spool position control loop produces a high resolution. This increases reproducibility of machine parameters.
- Optimized electronic pressure control or pressure limiting control with high precision, independent of the valve flow rate. This permits pressures and forces to be retained within narrow limits on machinery.
- Parallel hydraulic flow paths option on valve D651 extends the nominal flow range if used in the main flow path.
- Small electrical control power.
  Current consumption of the complete unit 300 mA maximum.
- Incorporating robust pilot stage which has been successfully applied in practice for many years.
- High controlling forces ensure reliable movement of the sliding spool.
- Wide adjustment range for the pressure setpoint (e. g. in the case of P-Q valve in the

Block diagram

Flow control and change to pressure control



Flow control with superimposed pressure limiting control



Technical Data

Hydraulic characteristics

Operating pressure range:	
Main stage:	0 . . . 210 bar / 350 bar
Pilot valve:	15 . . . 210 bar (350 bar on request)
Maximum return port pressure:	20% of pilot pressure, with spikes to a maximum of 140 bar
Pressure setpoint range:	
P-Q valve in the main flow path:	0 . . . 210 bar / 350 bar
P-Q valve in the bypass flow path:	$\triangle p_x$ . . . 210 bar / 350 bar
Operating fluid:	mineral based hydraulic oil
Viscosity range:	15 . . . 45 mm^2/s (cSt)
Temperature range:	−20 . . . +80° C
System filter:	high-pressure filter without bypass fitted with dirt alarm mounted wherever possible directly upstream of the P-Q valve. Also return line or bypass flow filtration depending upon the system.
Filter rating:	
for operability:	$\beta_{25} \geqq 75$ (25 μm absolute)
for long life:	$\beta_{15} \geqq 75$ (15 μm absolute) or better
Seal material:	Buna N (others on request)
Degree of protection (DIN 40 050):	IP 65
Installation position:	preferably horizontal (to assist air vent)

Summary of characteristics

Series		**D651**	**D652**	**D653**	**D654**
Port pattern in accordance with DIN 24 340	[mm]	Form A 10 port Ø 10,5	Form A 16 port Ø 19	Form A 25 port Ø 26	Form A 25 port Ø 32
Nominal flow rate Q_N (±10 %) at $\triangle p_N$ = 10 bar[2])	[l/min]	23; 35[3]) 2 × 70[4])	225[3])	425[3])	800[3])
Null flow[1])	[l/min]	< 4,5	< 4,5	< 4,5	< 5,0
Pilot valve oil flow at 100 % step input[1])	[l/min]	3	3	3	3
Spool stroke	[mm]	± 2,5	± 4	± 5	± 7
Flow function Threshold[1])	[%]	< 0,25	< 0,4	< 0,4	< 0,4
Hysteresis[1])	[%]	< 1	< 1,5	< 1,5	< 1,5
Response time (without flow) for 100 % spool stroke[1])	[ms]	28	35	45	70
Null shift for $\triangle T$ = 55°C	[%]	< 1,5	< 1,5	< 1,5	< 1,5
Pressure function Threshold[1])	[%]	< 0,05	< 0,05	< 0,05	< 0,05
Hysteresis[1])	[%]	< 0,2	< 0,2	< 0,2	< 0,2
Linearity	[%]	< 1	< 1	< 1	< 1
Null shift for $\triangle T$ = 55°C	[%]	< 1,5	< 1,5	< 1,5	< 1,5
Mass	[kg]	6,5	12,4	17,7	15,3

[1]) At 140 bar operating and pilot pressure
[2]) Pressure drop per metering land
[3]) On the 3-way version
[4]) If the valve is not used with parallel flow paths to double flow (i. e. Q_N = 70 l/min in place of 2 × 70 l/min), P_2

Electrical Characteristics

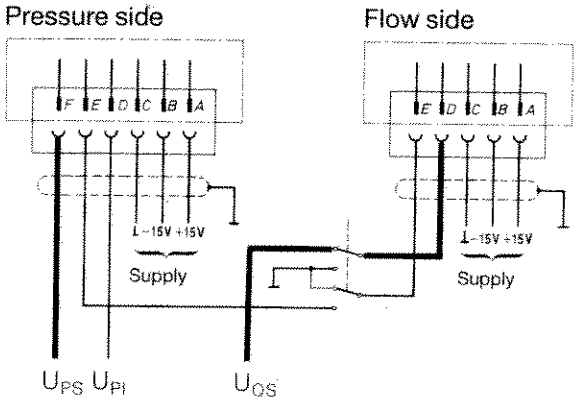
Supply voltage:	± 15 V DC, stabilized
Current consumption:	300 mA maximum
Input impedance:	> 50 kOhm
Flow setpoint U_{QS}:	0 . . . ± 10 V for P-Q valve in the main flow path
	0 . . . + 10 V for P-Q valve in the bypass flow path
Pressure setpoint U_{PS}:	0 . . . + 10 V[1])
Actual pressure value U_{PI}:	0 . . . − 10 V[1])

[1]) 0 . . . 210 bar on version F
0 . . . 350 bar on version K

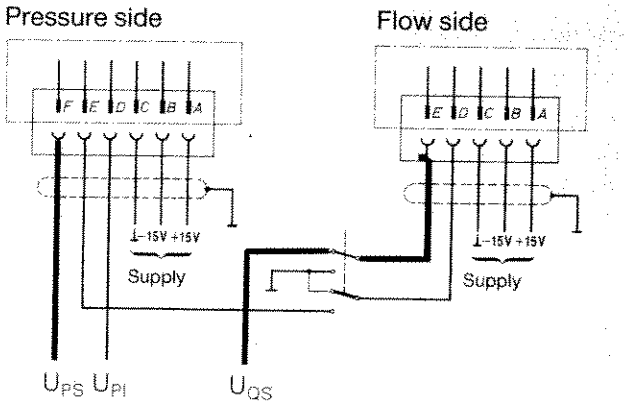
Electrical connection

Flow control and change to pressure control

P-Q valve in the main flow path

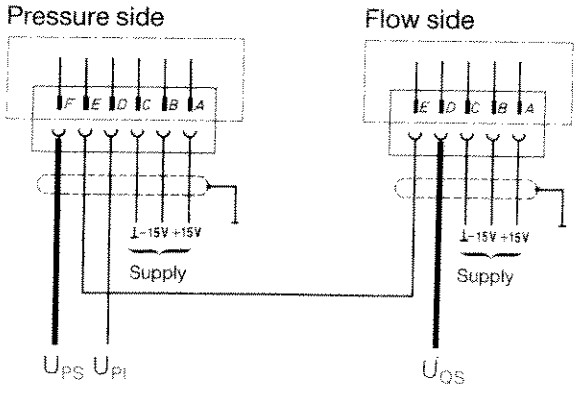


P-Q valve in the bypass flow path

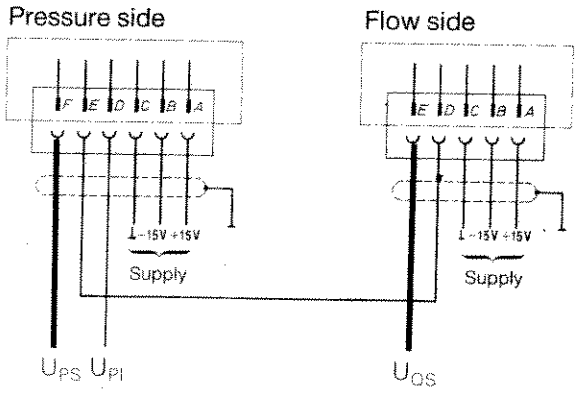


Flow control with superimposed pressure limiting control

P-Q valve in the main flow path



P-Q valve in the bypass flow path



Polarity with flow control

P-Q valve in the main flow path
U_{QS} +, flow out of port A

P-Q valve in the bypass flow path
U_{QS} +, valve closes

Additional technical data and dimensions are specified in our valve data sheets.

Functional characteristics

Flow function

The external selector switch must be set to position 1-2. The position of the sliding spool is measured by a contactless electrical position transducer and is compared, in the form of an actual position voltage U_{LI} with the command voltage U_{QS} by the position controller. If the actual value differs from the setpoint, the position controller drives current through the coils of the pilot valve, which moves the sliding spool so that the difference is reduced to zero. This means that the displacement of the sliding spool from the center position is proportional to the electrical command. If the polarity of the command signal changes, the direction of displacement will also change. The actual **valve flow** is dependent upon the valve opening and the valve pressure drop.

The following relationship applies:

$$Q_X = Q_N \sqrt{\frac{\triangle p_X}{\triangle p_N}}$$

Valve flow rate Q_X
Nominal flow rate Q_N[1])
Valve pressure drop $\triangle p_X$
Nominal pressure drop $\triangle p_N$

[1]) Valve fully opened
$\triangle p_X = \triangle p_N$

At constant valve pressure drop, the valve flow rate is dependent only upon valve opening. The flow rate characteristic curves on the valve data sheets indicate this relationship. For reasons of simplification, the position setpoint is designated the flow rate setpoint.

Pressure function

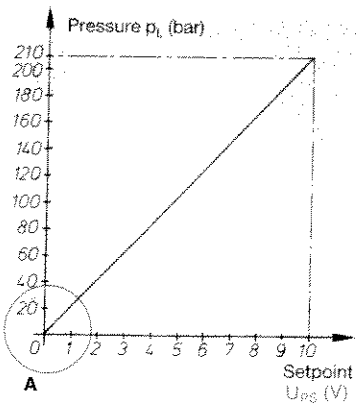
With the pressure function, the user may opt for one of the following two modes:

Flow control and change to pressure control
The external selector switch must be set to position 1-3 for pressure control.
The load pressure to be regulated at port A is measured with a built-in pressure sensor and is compared, in the form of actual pressure voltage U_{PI} with the pressure command voltage U_{PS} by the pressure controller.
If the actual pressure value differs from the pressure setpoint, the pressure controller changes the spare position command and, thus, the valve flow so that the difference is reduced to zero. This means that the regulated pressure is proportional to the applied pressure setpoint.

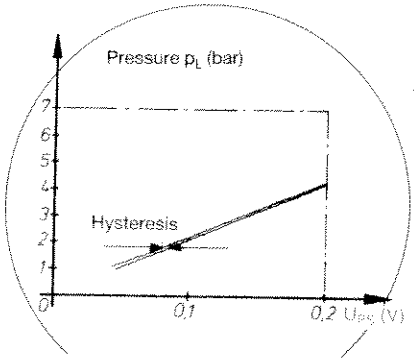
Flow control with superimposed pressure limiting control
Basically, the P-Q valve controls the flow rate. Provided the actual pressure voltage U_{PI} is less than the pressure command voltage U_{PS}, the output signal of the pressure limiting controller is zero and thus has no effect upon the flow rate control circuit. If, owing to the load (resistance to motion), U_{PI} becomes greater than U_{PS}, the pressure limiting controller intervenes in the flow rate control system and reduces the load velocity such that the actual pressure value is limited to the pressure setpoint.
With a P-Q valve in the main flow path, this is performed by reducing

Pressure limiting control is only effective if a corresponding flow rate setpoint is applied.

Example for pressure gain curve
Valve in the main flow path – maximum operating pressure 210 bar – version F.
The hysteresis is better than 0.1% because of the high resolution of the spare position control loop and a special loop design of the pressure controller:



Section A

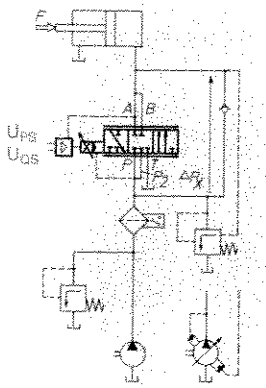


Notes to application

The preferred applications for the P-Q valve are velocity control systems and pressure or force control circuits.
For increasing the accuracy, a velocity control loop can be formed by additional feedback of the load velocity using suitable electronic circuitry.

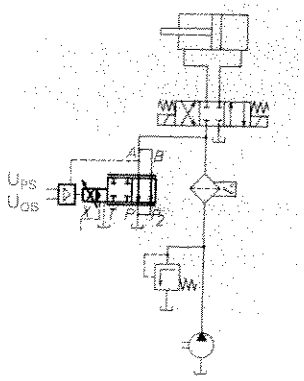
P-Q valve in the main flow path

The P-Q valve operates as an electrically adjustable restrictor from P ⧫ A (P_2 ⧫ B), from A ⧫ T and as an electrically adjustable pressure reducing valve.



P-Q valve in the bypass flow path

The P-Q valve operates as an electrically adjustable bypass restrictor and as an electrically adjustable pressure limiting valve.



Load pressure-independant valve flow can be achieved by using a 2-way or 3-way compensator (depending upon the pressure source). It guarantees a constant valve pressure drop $\triangle p_X$. Efficiency is increased, in particular, if a variable displacement pump is used which produces a constant valve pressure drop $\triangle p_X$ by a suitable controller. As described, the pressure function operates on the closed-loop principle. This requires optimisation and matching of the pressure controller to the load. The load is responsible for characteristics crucial to the optimization, e. g. the trapped oil volume downstream of port A, the structural stiffness etc. which frequently differ substantially

Ordering Information

Model number D65X-XXX X

Type designation P XX X X X X X N X X

Series

1	Form A 10; 10,5 mm Ø
2	Form A 16; 19 mm Ø
3	Form A 25; 26 mm Ø
4	Form A 25; 32 mm Ø

Model designation
(is assigned at the factory, includes all specifications)

Factory identification

Electronics board, pressure side
A, B, C . . .
(is assigned at the factory)

Electronics board, flow side
A, B, C . . .
(is assigned at the factory)

Seal material

N	Buna N others on request

Pilot supply pressure

	Series D651
A	internally via P (not for the bypass application)
C	15 to 210 bar externally via X
L	25 to 350 bar externally via X

	Series D652, D653, D654		
		Supply X	Return Y
A	15 to 210 bar	internal	internal
B	15 to 210 bar	external	external
C	15 to 210 bar	external	internal
D	15 to 210 bar	internal	external

Flow coefficient	**Nominal flow rate Q_N** at $\triangle p_N$ = 10 bar per metering land
	Series D651
23	23 l/min on 3-way version
35	35 l/min on 3-way version
70	2×70 l/min on 2×2-way version and 5-way version[1])
02	**Series D652** 225 l/min on 3-way version
03	**Series D653** 425 l/min on 3-way version
04	**Series D654** 800 l/min on 3-way version

Spool position on mainstage
without electrical supply

2	at full end position P ◗ A
3	at full end position A ◗ T

Maximum operating pressure

F	210 bar
K	350 bar

Valve version

	Flow control / change to pressure control
M	Valve in the main flow path
B	Valve in the bypass flow path
	Flow control / pressure limiting control
N	Valve in the main flow path
C	Valve in the bypass flow path

Sliding spool configuration

B	**Series D651,** axis cut, linear flow characteristic
P	**Series D652, D653, D654,** axis cut, curvilinear flow characteristic

[1]) If the valve is not going to be used with parallel flow paths to double flow (i. e. Q_N = 70 l/min in place of 2 × 70 l/min), P_2 and B must be sealed on the mounting manifold

3.01 en 08.84 All data subject to change Printed in W-Germany 3.000 WP