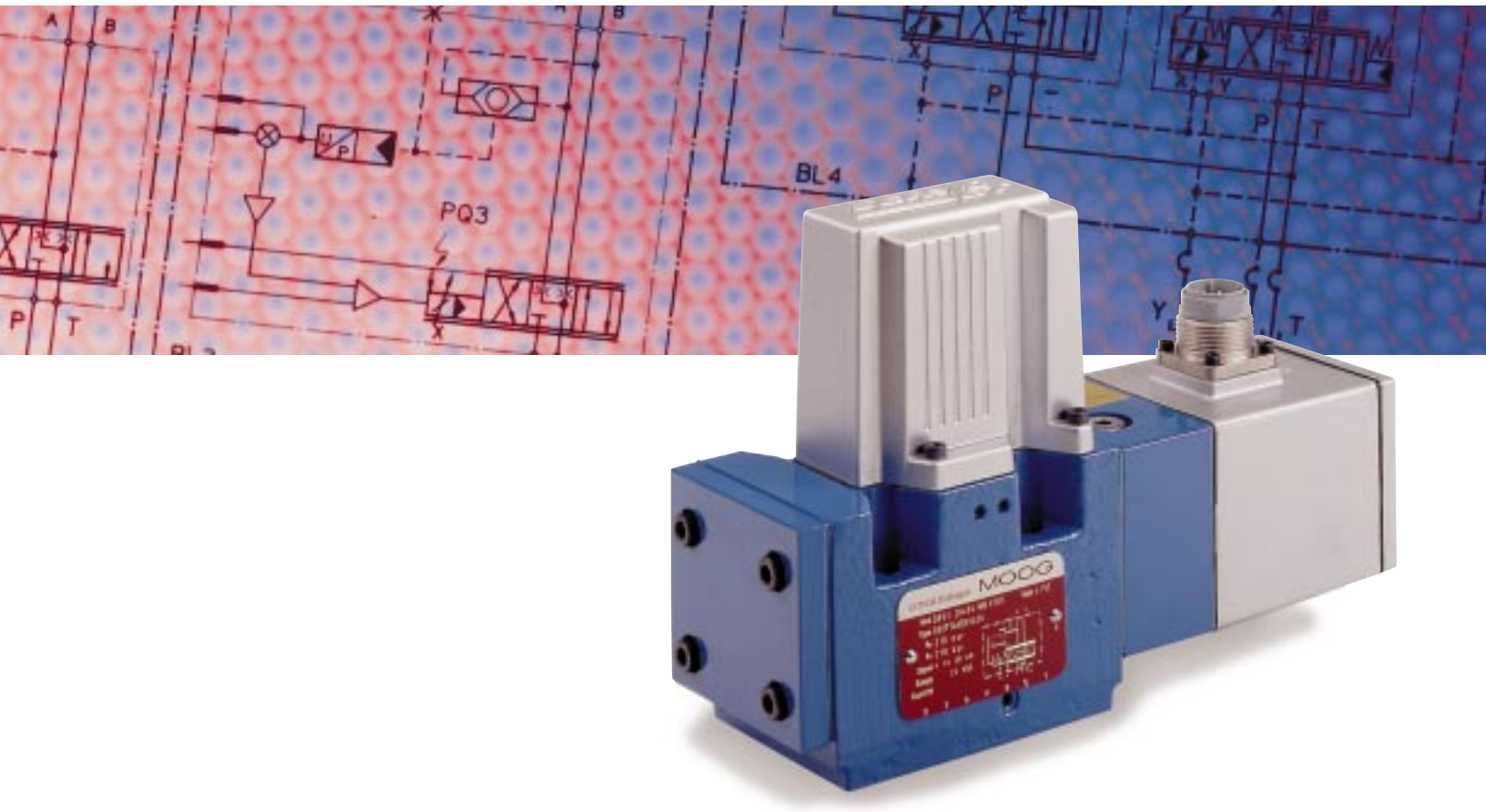
MOOG

D691 Series
PQ Servo-Proportional Valves with Integrated Electronics



D691 SERIES
SERVO-PROPORTIONAL CONTROL VALVES – PQ VERSION TWO STAGE WITH SERVOJET

D691 SERIES SERVO-PROPORTIONAL VALVES

The D691 servo-proportional control PQ-Valves are dual function valves for 2x2-, 3-, 4- and 5-way applications.

The PQ-Valves **modulate** a fluid flow and **control** closed loop pressure (upper or lower pressure limit) control. The valves are suitable for pressure control and pressure limiting applications.

The control electronics for the spool position transducer, pressure loops, and pressure transducer are integrated in the valve.

Moog created the first closed loop PQ valve nearly 15 years ago. Since then, Moog has produced more than 25,000 PQ-Valves. Applications include injection molding, heavy industry, presses and paper processing. The valves have proved to be extremely reliable, especially when high dynamic performance is required.

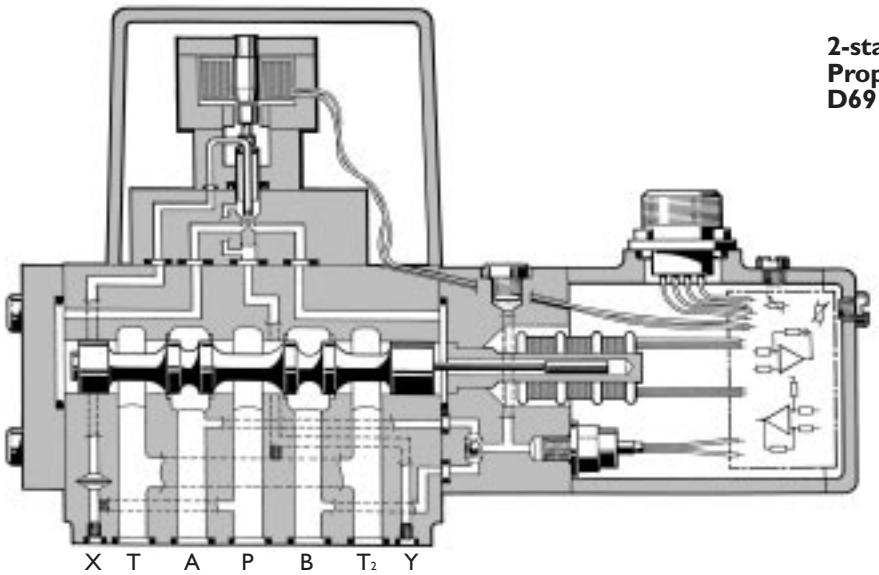
Over the years, Moog has made steady improvements to its basic PQ design. Our new ServoJet pilot is a new innovation that results in increased energy savings and robustness.

The integrated valve electronics require either a 24 Volt DC or a ±15 Volt DC power supply.

The valve series described in this catalog has successfully passed EMC tests required by the EC Directive. Please take notice of the references in the electronics section.

VALVE FEATURES SERVOJET

- Improved flow recovery (> 90% of the pilot stage internal leakage flow) contributes to energy savings, especially for machines with multiple valves.
- Improved dynamics due to high natural frequency (500 Hz) of the ServoJet pilot stage.
- Reliable operation. The high pressure recovery of the ServoJet stage (more than 80% Δp at 100% command signal) provides higher spool driving forces and ensures enhanced spool position repeatability.
- Operational with only 215 psi pilot pressure. Allows for proportional control in low pressure systems such as turbine controls.
- The pilot stage filter has almost unlimited life due to the 200 µm nominal fineness.
- Improved frequency response allows high spool position loop gain. The high loop gain provides excellent static and dynamic response, resulting in superior control system performance.
- Fail-safe versions with defined spool position.



2-stage Proportional PQ-Valve D691 Series

Our Quality Management System is certified in accordance with DIN EN ISO 9001.

DIN ISO 9001 certified BVQI

This catalog is for users with technical knowledge. To ensure that all necessary characteristics for function and safety of the system are given, the user has to check the suitability of the products described here. In case of doubt, please contact Moog.

FLOW RATE MODE

An electrical command signal (flow rate set point) is applied to the integrated position controller which drives the valve coil. The position transducer (LVDT), which is excited via an oscillator, measures the position of the spool (actual value, position voltage).

This signal is then demodulated and fed back to the controller where it is compared with the command signal. The controller drives the pilot valve until the error between command signal and feedback signal is zero. Thus the position of the spool is proportional to the electrical command signal.

FLOW RATE AND PRESSURE DROP

The actual flow is dependent upon electrical command signal and valve pressure drop. The flow for a given valve pressure drop can be calculated using the square root function for sharp edged orifices as follows:

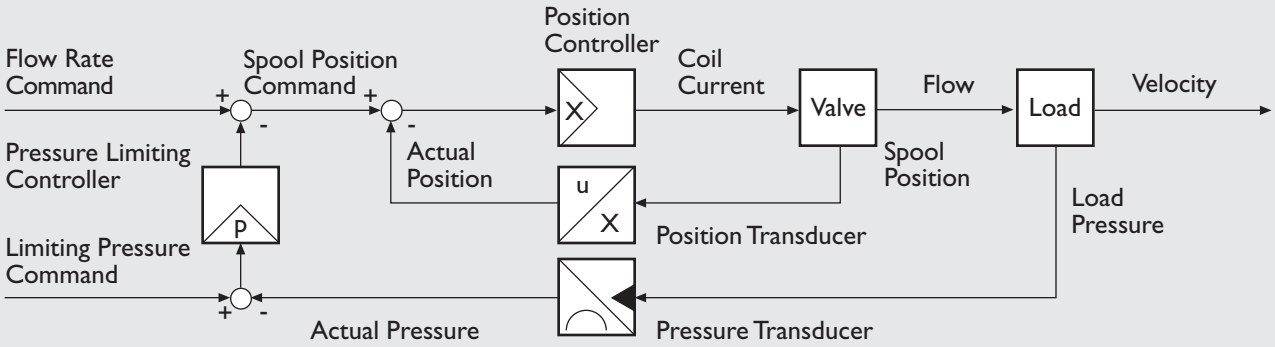
$$Q = Q_N \sqrt{\frac{\Delta p}{\Delta p_N}}$$

Q [gpm] = calculated flow

Q_N [gpm] = rated flow

Δp [psi] = actual valve pressure drop

Δp_N [psi] = rated valve pressure drop



PRESSURE CONTROL MODE

The aforementioned flow rate control is superimposed with pressure limiting control. Both command signals (external flow command signal and limiting pressure command signal) must always be present.

The difference between external flow command signal and output signal of the pressure limiting controller results in a spool position command signal. This output signal is zero as long as the actual pressure is smaller than the limiting pressure command value. If the actual pressure value exceeds the limiting pressure command value, the pressure limiting controller reduces the spool position command signal until the actual pressure value equals the limiting pressure command value.

If pressure control has to be installed (instead of pressure limiting), the external flow command signal must be selected high, so that the limiting function actually occurs. This is necessary because the pressure limiting controller can only reduce the spool position command. The external flow command signal should be larger than 30 % of rated signal (see diagrams on page 4).

EXTERNAL PILOT PRESSURE

If large flow rates with high valve pressure drop are required an appropriate higher pilot pressure has to be chosen to overcome the flow forces. An approximate value can be calculated as follows:

$$P_X \geq 1.7 \cdot 10^{-2} \cdot \frac{Q}{A_K} \cdot \sqrt{\Delta p}$$

Q [gpm] = max. flow

Δp [psi] = valve pressure drop with Q

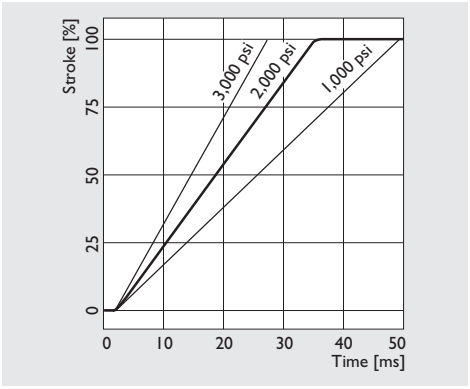
A_K [in^2] = spool drive area

P_X [psi] = pilot pressure

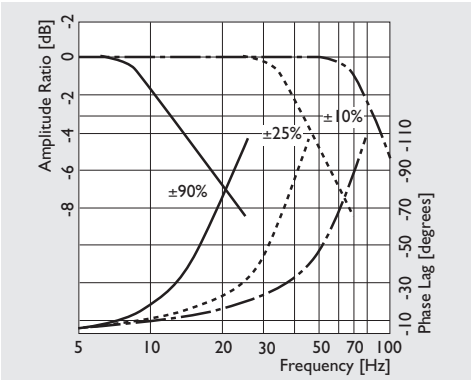
The pilot pressure p_x has to be at least 215 psi above the return pressure of the pilot stage.

D691 SERIES
TYPICAL CHARACTERISTIC CURVES
FLOW AND PRESSURE RESPONSE

FLOW STEP RESPONSE

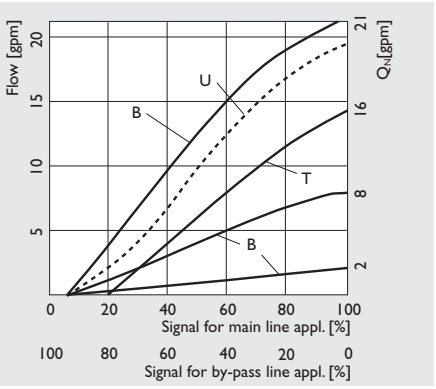


FREQUENCY RESPONSE (FLOW)



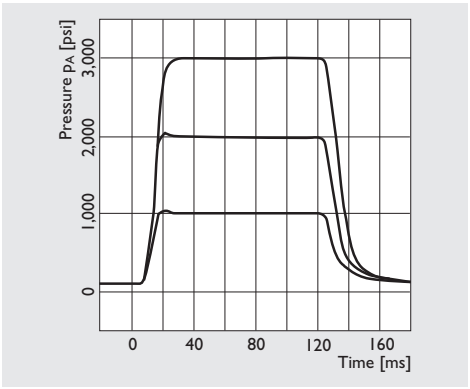
Frequency response data measured at 2,000 psi pilot pressure, and fluid viscosity of 32 mm²/s.

FLOW VS. SIGNAL CURVE

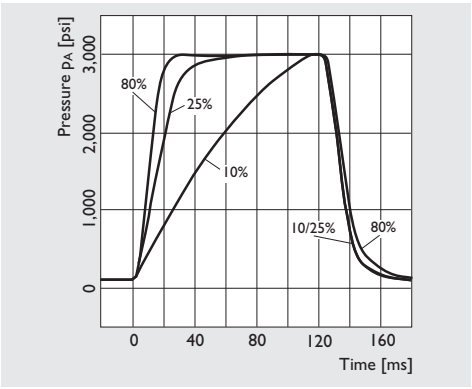


at Δp_N = 150 psi
Spool B: ~critical lap, linear characteristic
Spool U: ~critical lap, curvilinear characteristic (5-way only)
Spool T: ~20% overlap, linear characteristic

PRESSURE STEP RESPONSE

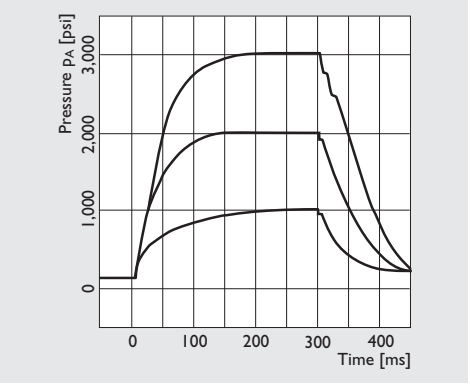


Optimized and measured with entrapped fluid volume of 61 in³.
Valve flow command 80% of rated.

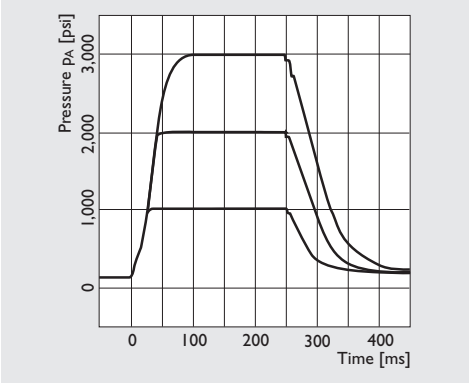


Optimized and measured with entrapped fluid volume of 61 in³.
Valve flow command 10 / 25 / 80% of rated.

Examples for pressure step response show the effect of valve flow setting and entrapped fluid volume on pressure control dynamics. Valve type D691-...Q30 KB... with optimized PID pressure limiting controller at operating pressure p_P = 3,570 psi.



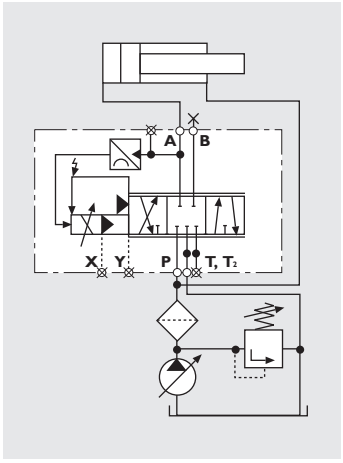
Optimized for entrapped fluid volume of 61 in³ but measured with 305 in³.
Valve flow command 80% of rated.



Optimized and measured with entrapped fluid volume of 305 in³.
Valve flow command 80% of rated.

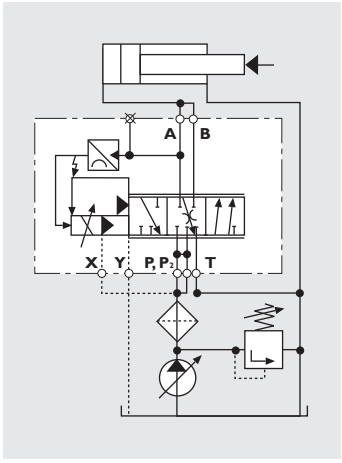
APPLICATION NOTES

3-way valve in main line



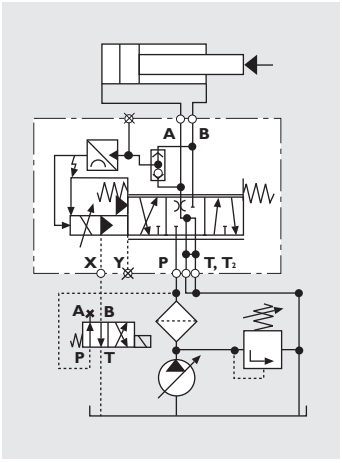
The device operates as a 3-way pressure reducing valve with flow from P ➧ A or A ➧ T. Only one load port (A) is used.

5-way valve in main line



The device operates like the 3-way PQ-Valve but with doubled flow rate into the load. A directional change of the load motion requires an external force.

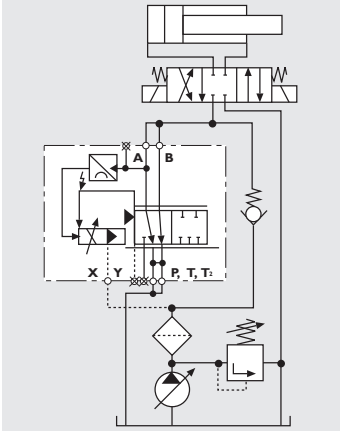
4-way valve in main line



Without shuttle valve
The device operates from P ➧ A like a 3-way PQ-Valve. In the opposite direction, P ➧ B, it allows only flow modulation. This means the direction of load motion can be reversed (open loop velocity control for load retract).

With shuttle valve
The device operates as an electrically adjustable 4-way throttle valve, i. e. the load can be operated with pressure control in both directions of motion. Only one of the load ports is pressure controlled. The shuttle valve transmits the driving (higher) load pressure to the single pressure transducer. An electronic logic circuit provides for the coordination of motion direction and pressure control depending on the polarity of the flow rate command signal. The other port is more or less open to tank line which is provided by the special spool land location. The spring centered fail-safe version requires external pilot supply port X to be used.

2x2-way valve in by-pass line (bleed off)



The device has parallel flow paths and operates as an electrically adjustable pressure relief valve from A ➧ T and B ➧ T_2, respectively. At zero command signal the valve is fully open, i. e. the pressure in the load ports is zero apart from minor pressure build up due to line losses. A minimum pilot pressure (p_X > 215 psi) has to be secured. This can be achieved by a check valve with 215 psi cracking pressure (as shown) or by a separate pilot supply pump.

COMMAND SIGNAL FOR FLOW Q

Voltage command
0 to ±10 V
The spool stroke of the valve is proportional to ($V_4 - V_2$). 100% valve opening P ⏵ A and B ⏵ T is achieved at +10 V input signal. At 0 V command the spool is in a centered position.

Current command
0 to ±10 mA
(4 to 20 mA resp.)
The spool stroke of the valve is proportional to I_4 (I_4-I_2 mA resp.). 100% valve opening P ⏵ A and B ⏵ T is achieved at +10 mA (20 mA resp.) input signal. At 0 mA (12 mA resp.) command the spool is in a centered position. Command signal for pressure p Voltage command 0 to +10 V. The controlled load pressure is proportional to ($V_9 - V_2$). 100% rated pressure is achieved at +10 V input signal.

Current command
0 to +10 mA
(4 to 20 mA resp.)
The controlled load pressure is proportional to I_9. 100% rated pressure is achieved at +10 mA (20 mA resp.) input signal.

ACTUAL VALUE SPOOL POSITION Q

Valves with voltage and current command input
The actual value, i.e. the spool position, can be measured between pins 6 and 7. This signal can be used for monitoring and fault detection purposes. The signal must be measured with a voltmeter having an input impedance greater than 1 MΩ (diagram below, left). The spool stroke range corresponds to ±10 V. The centered position is at 0 V. +10 V corresponds to 100% valve opening P ⏵ A.

If the actual value shall be used with a machine control system the differential input circuit must be applied (diagram below, right).

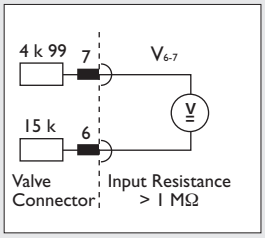
Actual value pressure p
Signal levels for actual pressure output ($V_{10} - V_2$ and 110 resp.) are given in the wiring table below.

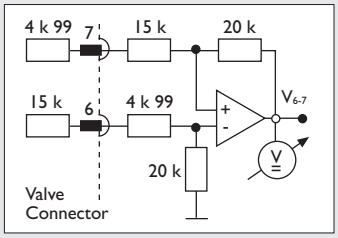
Note:
When the p-potentiometer is readjusted with reference to a manometer this output will not change.

GENERAL REQUIREMENTS

- Supply 24 VDC, min. 19 VDC, max. 32 VDC. Current consumption max. 300 mA
- All signal lines, also those of external transducers, shielded
- Shielding connected radially to ⊥ (0 V), power supply side, and connected to the mating connector housing (EMC)
- **EMC**: Meets the requirements of EN 55011/03.91 class B, EN 50081-1/01.92, and EN 50082-2/03.95, performance criteria class A
- Protective grounding lead ≥ .75 mm²
- Note: When making electrical connections to the valve (shield, protective grounding) appropriate measures must be taken to ensure that locally different earth potentials do not result in excessive ground currents. See also Moog Application Note AM 353 E.

Circuit diagram for measurement of actual value V_{6-7} (spool position)

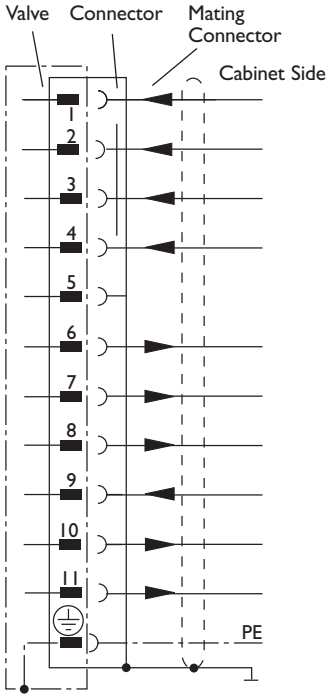




Measurement between pin 6 and signal ground results in an actual value of 2.5 to 13.5 V.

CONNECTOR WIRING

Valve with 11+PE pole connector to DIN 43563 and mating connector (metal shell) with advancing protective grounding connection ⏚



Function	Voltage Command	Current Command	
Supply	24 VDC (min. 19 VDC, max. 32 VDC)		
Supply / Signal Ground	⊥ (0 V)		
Enabled Not Enabled	V_{8-2} > +8.5 VDC V_{3-2} < +6.5 VDC	I = 1.2 mA at 24 VDC	
Input Rated Command Q	0…±10 VDC Input Resistance 50 kΩ	0…±10 mA Load Resistance 500 Ω	+4…+20 mA Load Resistance 250 Ω
Not Used			
Output Actual Value Q (Differential)	0…±10 V R_a: ca 20 kΩ		
Enabled and Supply Acknowledged	V_{8-2} > +8.5 VDC = o.k. V_{3-2} < +6.5 VDC = not o.k.	Output I_{max} : 20 mA	
Input Rated Command p	0…±10 VDC Input Resistance = 50 kΩ	0…±10 mA Load Resistance = 500 Ω	+4…+20 mA Load Resistance 250 Ω
Output Actual Value p	0…±10 VDC Output Resistance = 10 kΩ	0…±10 mA Load Resistance Max. = 1 kΩ	+4 to +20 mA Load Resistance Max. 500 Ω
Position Error, Logic	V_{8-2} > +8.5 VDC: < 30% V_{3-2} < +6.5 VDC: > 30%	Output I_{max} : 20 mA	
Protective Grounding			

COMMAND SIGNAL FOR FLOW Q

Voltage command 0 to ±10 V
The spool stroke of the valve is proportional to ($V_4 - V_3$). 100% valve opening P ➧ A and B ➧ T is achieved at +10 V input signal. At 0 V command the spool is in a centered position.

Current command 0 to ±10 mA (4 to 20 mA resp.)
The spool stroke of the valve is proportional to I_4 (I_4 – 12 mA resp.). 100% valve opening P ➧ A and B ➧ T is achieved at +10 mA (20 mA resp.) input signal. At 0 mA (12 mA resp.) command the spool is in a centered position.

COMMAND SIGNAL FOR PRESSURE P

Voltage command 0 to +10 V
The controlled load pressure is proportional to ($V_9 - V_3$). 100% rated pressure is achieved at +10V input signal.

Current command 0 to +10 mA (4 to 20 mA resp.)
The controlled load pressure is proportional to I9. 100% rated pressure is achieved at +10 mA (20 mA resp.) input signal.

Actual value spool position (Q)
Signal levels for actual flow output ($V_6 - V_3$ and I6 resp.) are given in the wiring table below.

Actual value pressure p
Signal levels for actual pressure output ($V_{10} - V_3$ and I10 resp.) are given in the wiring table below.

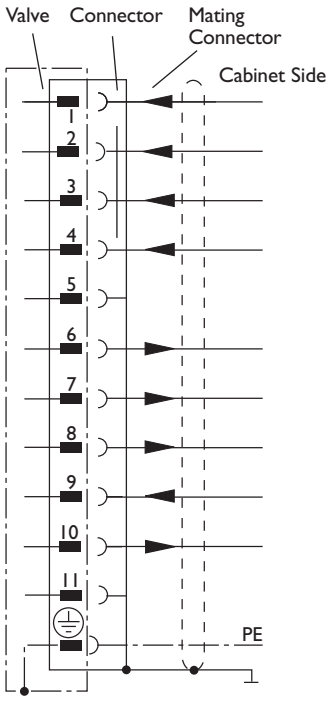
Note: When the p-potentiometer is readjusted with reference to a manometer this output will not change.

GENERAL REQUIREMENTS

- Supply ±15 VDC. ±3% Current consumption max. ±250 mA
- All signal lines, also those of external transducers, shielded
- Shielding connected radially to ⊥ (0 V), power supply side, and connected to the mating connector housing (EMC)
- **EMC**: Meets the requirements of EN 55011/03.91 class B, EN 50081-1/01.92, and EN 50082-2/03.95, performance criteria class A
- Protective grounding lead ≥ 0.75 mm²
- Note: When making electrical connections to the valve (shield, protective grounding) appropriate measures must be taken to ensure that locally different earth potentials do not result in excessive ground currents. See also Moog Application Note AM 353 E.

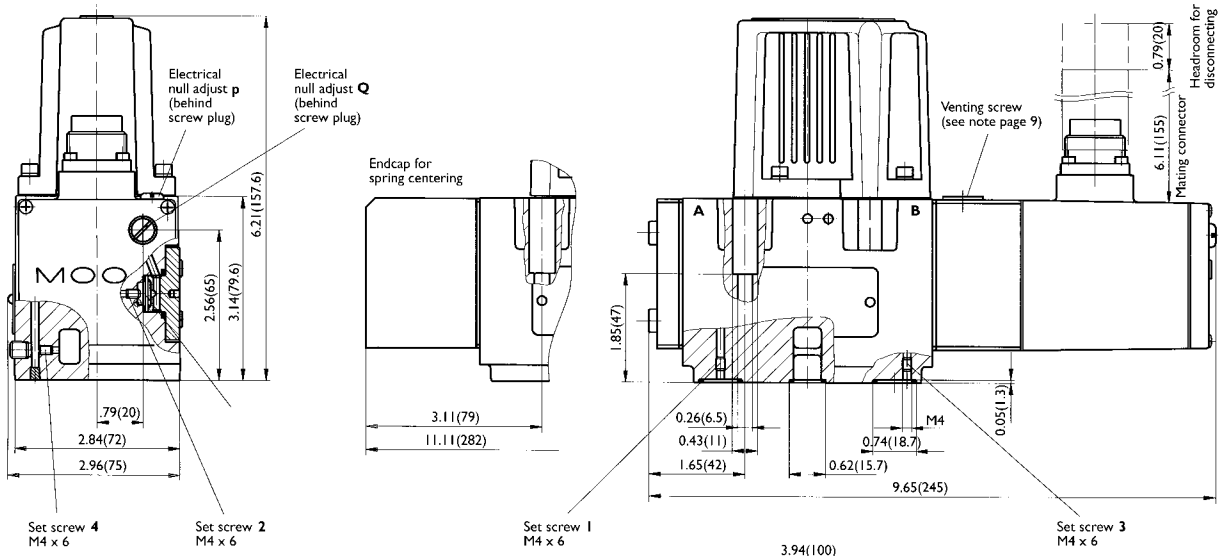
CONNECTOR WIRING

Valve with 11+PE pole connector to DIN 43563 and mating connector (metal shell) with advancing protective grounding connection ⏚



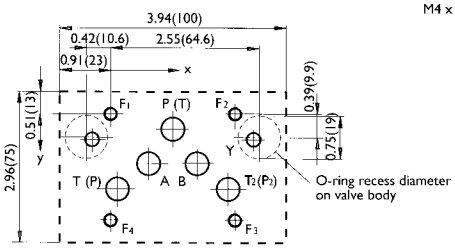
Function	Voltage Command	Current Command	
Supply	+15 VDC ±3%		
Supply	+15 VDC ±3%		
Supply / Signal Ground	⊥ (0 V)		
Input Rated Command Q	0…±10 VDC Input Resistance 100 kΩ	0…±10 mA Load Resistance 400 Ω	+4…+20 mA Load Resistance 200 Ω
Not Used			
Output Actual Value Spool Position	0…±10 VDC Input Resistance 100 kΩ	0…±10 mA Load Resistance 400 Ω	+4…+20 mA Load Resistance 200 Ω
Relay Output	24 VDC, max. 0.5 A. For inductive loads a corresponding commutating diode is necessary. The relay contact deenergizes and the pilot stage is disconnected when a supply voltage becomes less than 12 V (thus also in case of a cable break). The spool then moves to the determined position without electrical supply. Cable break of the ⊥ - wire will not be monitored.		
Input Rated Command p	0…±10 VDC Input Resistance = 100 kΩ	0…±10 mA Load Resistance = 500 Ω	+4…+20 mA Load Resistance 250 Ω
Output Actual Value p	0…±10 VDC Output Resistance = 10 kΩ	0…±10 mA Load Resistance Max. = 500 Ω	+4 to +20 mA Load Resistance Max. 500 Ω
Not Used			
Protective Grounding			

D691 SERIES
INSTALLATION DRAWING
SPARE PARTS, ACCESSORIES



The mounting manifold must conform to ISO 4401-05-05-0-94.
Attention: notice O-ring recess dia of X and Y ports. For valves in 4/3-way version with Q_N > 16 gpm and in 2x2-way version the non standard 2nd return port T_2 must be used.
With 5-way version the P and T ports are interchanged, i.e. T changes to P, T_2 changes to P_2 and P changes to T.

For maximum flow the manifold ports P, A, B, T and T_2 require to have Ø 0.45 in (deviation from standard). Mounting surface needs to be flat within .001 in. Average surface finish value Ra better than 1 µm.



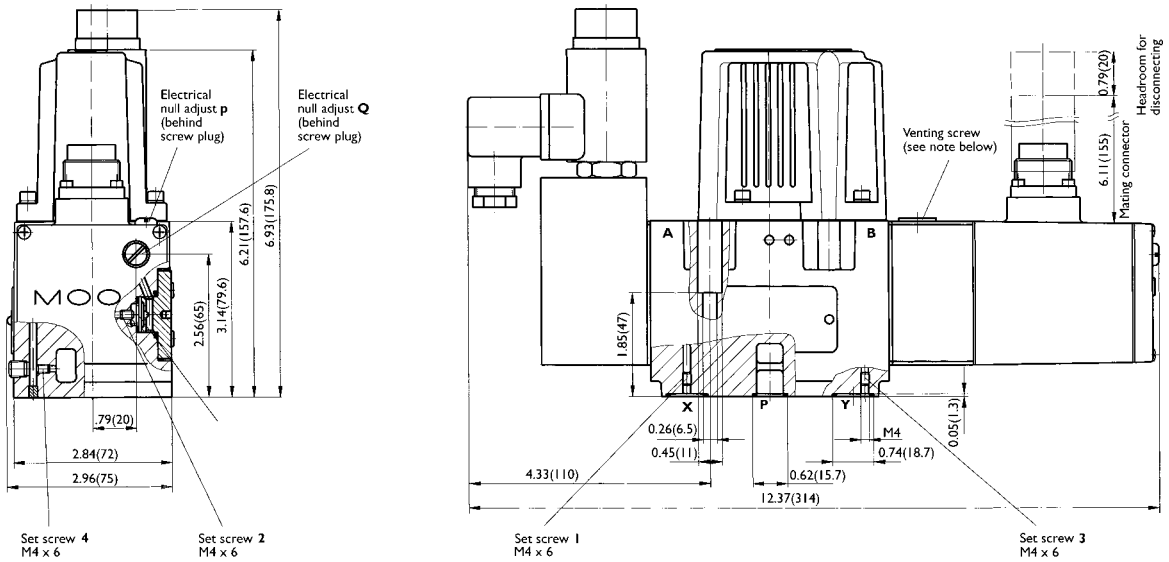
	P	A	B	T	T_2	X	Y	F_1	F_2	F_3	F_4
	Ø0.45	**Ø0.45**	**Ø0.45**	**Ø0.45**	**Ø0.45**	Ø0.25	Ø0.25	M6	M6	M6	M6
x	1.06	0.66	1.47	0.13	2.00	-0.32	2.44	0	3.13	2.13	0
y	0.25	0.84	0.84	1.28	1.28	0.43	0.43	0	0	1.81	1.81

CONVERSION INSTRUCTION

for operation with internal or external pilot connection	Pilot flow supply	Set screw M4 x 6 bore **1**	Set screw M4 x 6 bore **2**	Pilot flow return	Set screw M4 x 6 bore **3**	Set screw M4 x 6 bore **4**
	Internal P	closed	open	Internal T	closed	open
	External X	open	closed	External Y	open	closed

SPARE PARTS AND ACCESSORIES

O-rings (included in delivery)			NBR 85 Shore	FPM 85 Shore
for P, T, T_2, A, B	5 pieces ID 0.489 x Ø 0.070		45122-004	42082-004
for X, Y	2 pieces ID 0.615 x Ø 0.070		45122-011	42082-011
Mating connector, waterproof IP65 (not included in delivery)			for cable diameter	
11+PE pole	B97024-111	DIN 43651	min. Ø 0.433 in, max. Ø .512 in	
Flushing plates	for P, A, B, T, T_2, X, Y	for P, T, T_2, and X, Y	for P, T, T_2, and X, Y	
	B67728-001	B67728-002	B67728-003	
Mounting manifold	see special data sheet			
Mounting bolts (not included in delivery)		required torque	required	
M6 x 60 DIN 912-10.9	A03665-060-060	9.6 ft-lb	4 pieces	
Replaceable filter	A67999-200	200 µm nominal		
O-rings for filter change		HNBR	NBR 85 Shore	FPM 85 Shore
filter	1 piece ID .512 x Ø .059	—	66117-013-015	A25163-013-015
filter cover	1 piece ID .670 x Ø .079	B97009-080	—	—
Usit ring for venting screw	1 piece U 11, 8-18, 5-1, 5	A26541-084		



The mounting manifold must conform to ISO 4401-05-05-0-94. (see page 8)

FUNCTION

For applications with proportional control PQ-Valves where certain safety regulations are applicable, a defined metering spool position is needed in order to avoid potential damage. Therefore a fail-safe version is offered as an option for proportional control PQ-Valves. After external triggering, this fail-safe function causes a defined metering spool position: overlapped or underlapped middle position.

In order to move the spool to the safe position the two control chambers of the main stage are hydraulically short circuited via a 2/2-way poppet valve. The spring force moves the spool into the defined metering spool position.

VENTING OF THE PRESSURE TRANSDUCER

Before operating the valve, the internal lines of the pressure transducer must be carefully vented.

When selecting the installation position of the valve, care must be taken so that the bleeding screw is effective.

In other words, if the load is located higher than the PQ-Valve, the load must be vented at its highest point, which would not be at the valve.

Caution: Vent only at reduced pressure! Danger of injury!

ELECTRICAL CHARACTERISTICS

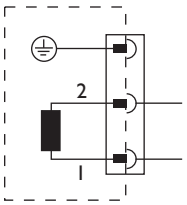
Of the 2/2-way poppet valve for the electrical fail-safe version.

Nominal voltage V_N 24 VDC
Nominal power P_N 29 W

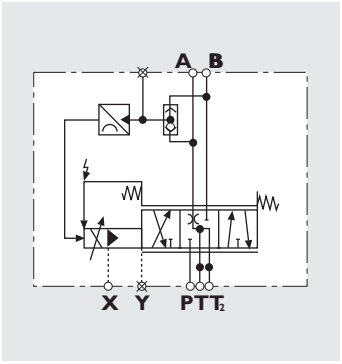
Hydraulically activated valves for the fail-safe version on request.

CONNECTOR WIRING

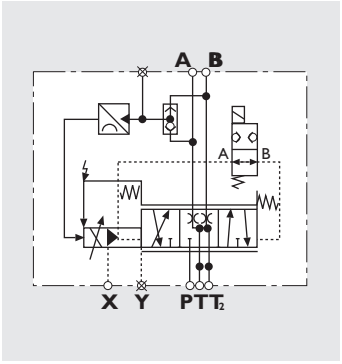
DIN 43650-1
Form A: 2+PE - PG9



BLOCK DIAGRAMS



Spring centered version
(Installation drawing see page 8)



Version with poppet valve and spring centering

TECHNICAL DATA

Model…Type			D691 –…
Mounting Pattern	ISO with additional 2nd T port		ISO 4401 - 05 - 05 - 0 - 94
Valve Body Version			3-way, 4-way, 5-way, 2x2 way, 2-stage with standard spool
Pilot Stage	ServoJet		Standard
Pilot Connection	optional, internal or external		X and Y
Installation options			any position, fixed or moveable Note: consider air vent location
Vibration			30 g, 3 axes
Mass		[lb]	13.9
Rated Flow ±10% at Δp_N = 150 psi		[gpm]	2 / 8 / 16 / 21 / 2 x 21
Maximum Operating Pressure			
Main Stage:	port P, A, B	[psi]	5,000
	port T with Y internal	[psi]	3,000
	port T with Y external	[psi]	5,000
Pilot Stage:	regular version	[psi]	4,000
	with dropping orifice (on request)	[psi]	5,000
Temperature Range	fluid and ambient	[°F]	-4 to 176
Seal Material			NBR, FPM, others on request (pilot stage always HNBR)
Operating Fluid			Mineral oil based hydraulic fluid (DIN 51524, part 1 to 3) other fluids on request
Viscosity	recommendable		70 to 210 sus @ 100° F
	allowable		25 to 1800 sus @ 100° F
System Filtration			High pressure filter (without by-pass, but with dirt alarm) mounted in the main flow and if possible directly upstream of the valve. In combination with a fast regulating VD pump, a by-pass filter is possible.
Class of Cleanliness			The cleanliness of the hydraulic fluid greatly effects the performance (spool positioning, high resolution) and wear (metering edges, pressure gain, leakage) of the valve.
Recommended Cleanliness Class			
For normal operation:			ISO 4406: < 16/13
For longer life:			ISO 4406: < 14/11
Filter Rating Recommended			
For normal operation:			$\beta_{15} \geq 75$ (15 µm absolute)
For longer life:			$\beta_{10} \geq 75$ (10 µm absolute)
Response Time [1])	for 0 to 100% stroke	[ms]	25
Threshold [1])	Q-function	[%]	< 0.05
	p-function	[%]	< 0.05
Hysteresis [1])	Q-function	[%]	< 0.3
	p-function	[%]	< 0.2
Linearity [1])	p-function	[%]	< 0.5
Null Shift	Q-function	[%]	< 1.0
with ΔT = 55 K	p-function	[%]	< 1.5
Null Leakage Flow [1])			
total, max.		[gpm]	0.92
pilot stage only		[gpm]	0.45
Pilot Flow [1]) max. with 100% step input		[gpm]	0.45
Spool Stroke		[in]	±0.012
Spool Drive Area		[in²]	0.310
Degree of Protection			IEC 144 class IP 65 with mating connector mounted
Shipping Plate			Delivered with an oil sealed shipping plate under the mounting surface.

[1]) Measured at P_X = 3,000 psi pilot or operating pressure, respectively, and fluid viscosity of 32 mm^2/s

ORDERING INFORMATION / SPARE PARTS

Model Number

D691 • • • • • •

Specification status	
–	Series specification
E	Preseries specification
Z	Special specification

Model Designation	
	Assigned at the factory

Factory Identification

Type Designation

• • • • • • • • • • • • • •

Valve Version	
Q	Standard spool

Rated Flow	
	Q_N gpm[l/min] at Δp_N = 150 psi
08	2(8)
30	8(30)
60	16(60)
80	21(80)

Pressure Ranges			
	Rated pressure for 100% signal	max. operating pressure	typical non-linearity
	[psi]	[psi]	[%]
C	1,500	2,285	< 0.35
D	2,000	2,285	< 0.25
F	3,000	3,570	< 0.21
K	5,000	5,700	< 0.17
X	Special version		

Spool Type		
B	3-way:	P ◗ A, A ◗ T; ~critical, linear characteristic
U	5-way:	P ◗ A, P_2 ◗ B, A ◗ T; ~critical, curvilinear characteristic
T	4-way:	linear characteristic P ◗ A and P ◗ B: 20% overlap A ◗ T and B ◗ T: 15% underlap
Z	2x2-way:	A ◗ T and B ◗ T_2: linear characteristic, closed at 90% signal (by-pass mode only)
X	Special version	

Pilot Stage		
	Version	Pilot Flow [gpm] at p_x = 2,000 psi
A	ServoJet	0.34

Preferred configurations highlighted.
All combinations may not be available.
Options may increase price and delivery.
Technical changes are reserved.

Valve Version	
N	Valve in main line, maximum pressure Limiting control
K	Valve in main line, minimum press. Limiting control
C	Valve on by-pass line
A	4-way valve with shuttle valve

Supply Voltage		
0	±15 VDC	±3%
2	24 VDC	(19 to 32 VDC)

Command Signals for Flow Q and Pressure p		
	Command signal Q	Command signal p
A	±10 VDC	0 to +10 VDC
B	±10 mA	0 to +10 mA
S	+4 to +20 mA	+4 to +20 mA

Valve Connector	
E	11+PE-pole DIN 43651

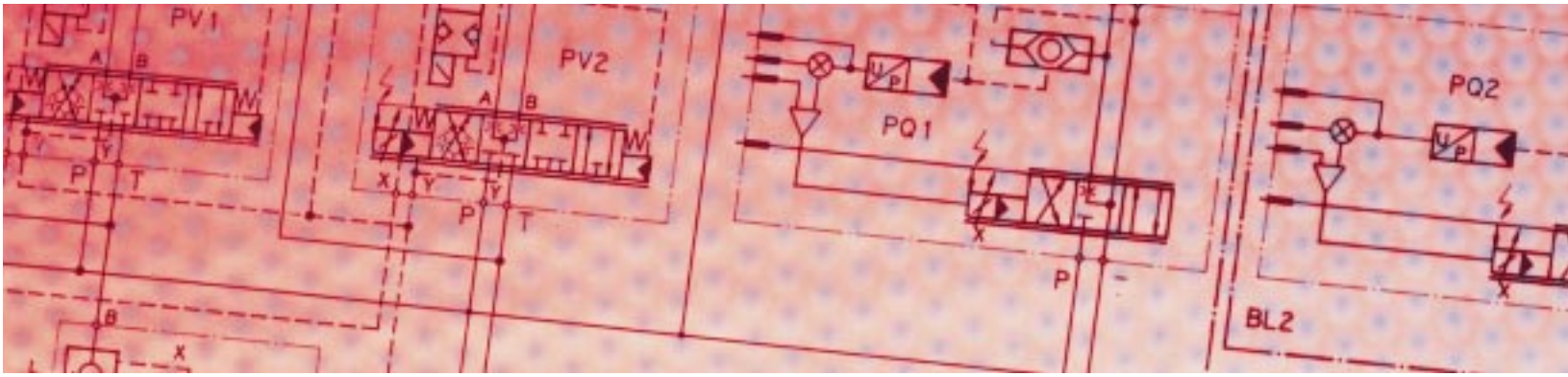
Seal Material	
N	NBR – Standard
V	FPM (Viton) – optional
	Others on request

Pilot Connections and Pressure			
	Pressure [psi]	Supply	Return
E	215 to 4,000	internal	internal
F	215 to 4,000	external	external
G	215 to 4,000	external	internal
H	215 to 4,000	internal	external
J	360 to 5,000	internal	internal
K	360 to 5,000	external	external
L	360 to 5,000	external	internal
M	360 to 5,000	internal	external

Spool Position without Electrical Signal					
	Mechanical fail-safe version				
	Position	p_P [psi]		p_x extern [psi]	
A	End position defined A ◗ T				
B	End position defined P ◗ A				
M	Mid position defined	≥ 215		< 15	
	Undefined	≥ 215		≥ 215	
R	Mid position defined	≥ 215		< 15	
	P ◗ B, A ◗ T	≥ 215		≥ 215	
L	Mid position defined	≥ 215		< 15	
	P ◗ B, A ◗ T	≥ 215		≥ 215	
	Electronically controlled fail-safe version				
	Position	p_P [psi]	p_x	SV*	VE**
W	Mid position defined	≥ 215	≥ 215	off	on
	Mid position defined	≥ 215	< 15	on	on

SV* = Solenoid Valve
VE* = Valve Electronics

Australia	Mulgrave
Brazil	São Paulo
China	Hong Kong
	Shanghai
Denmark	Cöpenhagen
England	Tewkesbury
Finland	Espoo
France	Rungis



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