# PQ-Proportional Valves
# with integrated Electronics
# D691 Series
# ISO 4401 Size 05

# D691 Series
## Proportional Control PQ-Valves
## Two stage with SERVO JET

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

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

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

For over 15 years MOOG has built PQ-Valves with integrated electronics. During this time more than 30 000 PQ-Valves have been delivered and successfully applied to injection molding, heavy industry, presses and paper processing. The valves have proved to be reliable especially when high dynamic performance is required.

The valves have been continually developed. With MOOG's new ServoJet pilot stage a further step has been taken in the direction of energy saving and robustness.

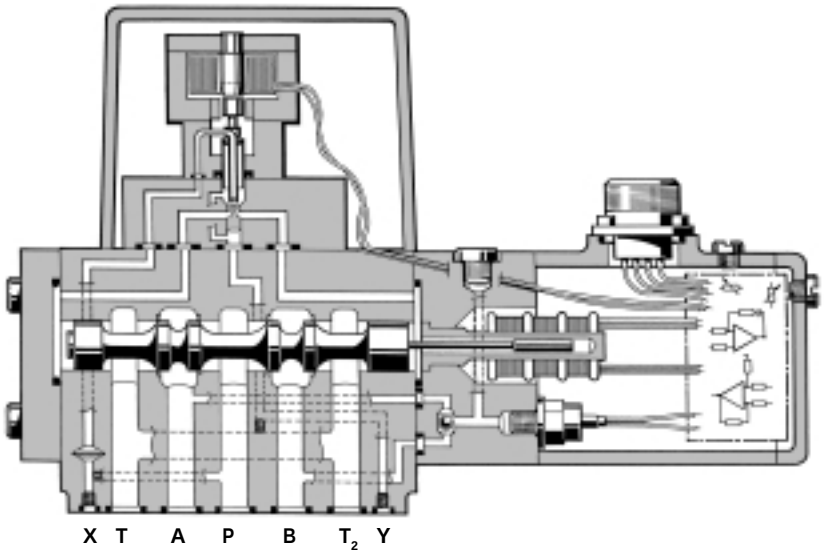
This pilot stage uses the jet pipe principle which for over 8 years has been operating reliably in different MOOG valves.

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

CE The valve series described in this catalogue have successfully passed EMC tests required by EC Directive. Please take notice of the respective references in the electronics section.

**Operational features** SERVO JET

- ❒ Considerably **improved flow recovery** (more than 90% of the pilot stage internal leakage flow) contributes to energy saving, 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 15 bar pilot pressure.** With this a robust proportional control valve for low pressure systems is available.
- ❒ 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** version with defined safe spool position using a spring, a poppet valve or by external supply cut off.




**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 catalogue 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).

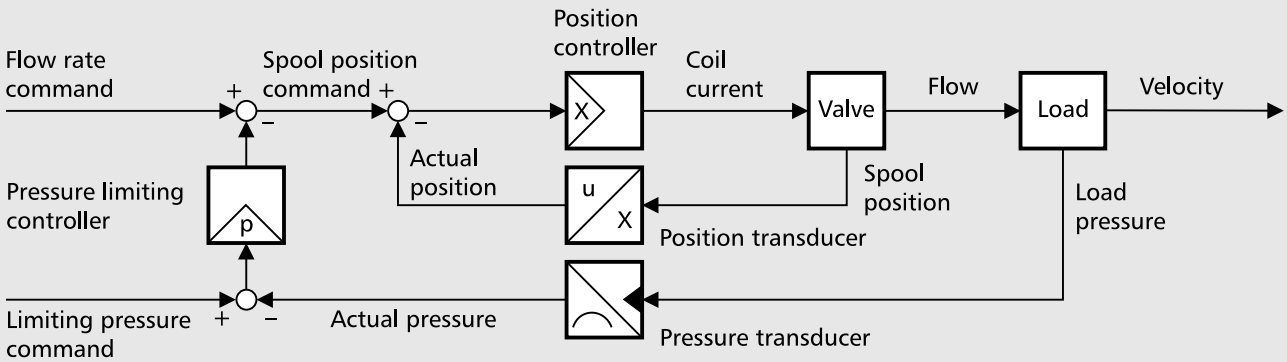
This signal is then demodulated and fed back to the controller where it is compared with the command signal. The controller drives the pilot valve until the error between command signal and feedback signal is zero. Thus the position of the spool is proportional to the electrical command signal.

### 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:

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

$Q$ [l/min] = calculated flow
$Q_N$ [l/min] = rated flow
$\Delta p$ [bar] = actual valve pressure drop
$\Delta p_N$ [bar] = rated valve pressure drop




### Pressure control mode

The afore mentioned flow rate control is superimposed with a 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 instead of pressure limiting a pressure control has to be installed, the external flow command signal must be selected that 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:

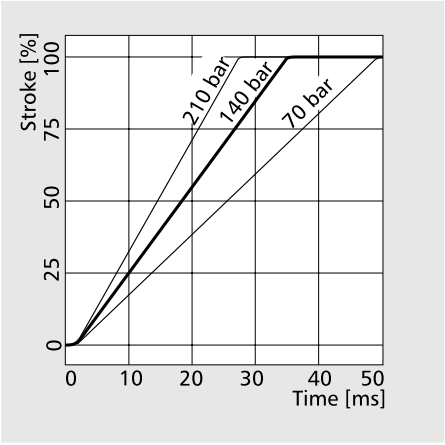
$$p_X \geq 1{,}7 \cdot 10^{-2} \cdot \frac{Q}{A_K} \cdot \sqrt{\Delta p}$$

$Q$ [l/min] = max. flow
$\Delta p$ [bar] = valve pressure drop with Q
$A_K$ [cm²] = spool drive area
$p_X$ [bar] = pilot pressure

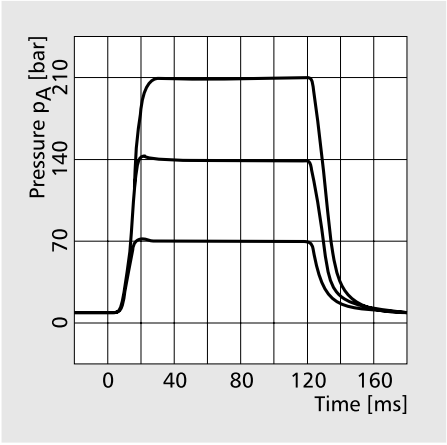
The pilot pressure $p_X$ has to be at least 15 bar above the return pressure of the pilot stage.

# D691 Series
## Typical characteristic curves
## Flow and pressure response

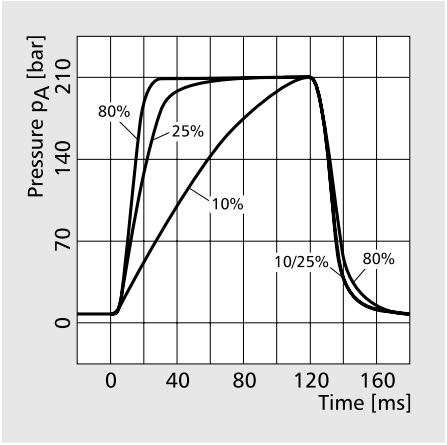
### Flow step response




### Pressure step response

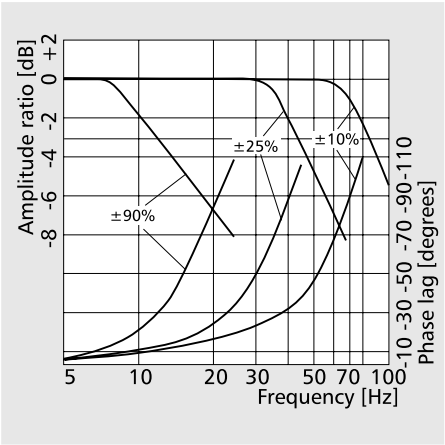



Optimised and measured with entrapped fluid volume of 1000 cm³.
Valve flow command 80 % of rated.

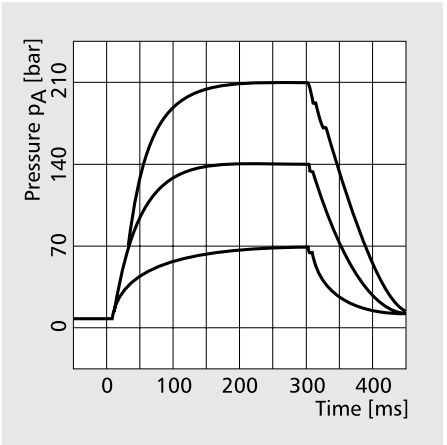



Optimised and measured with entrapped fluid volume of 1000 cm³.
Valve flow command 10 / 25 / 80 % of rated.

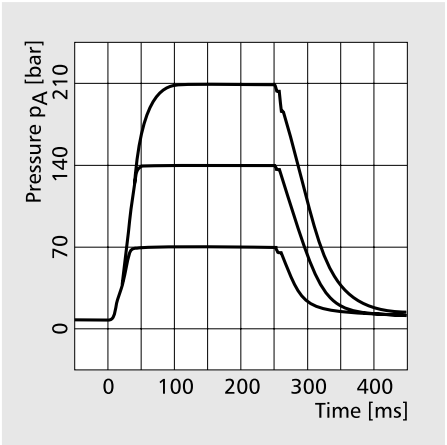
### Frequency response (flow)



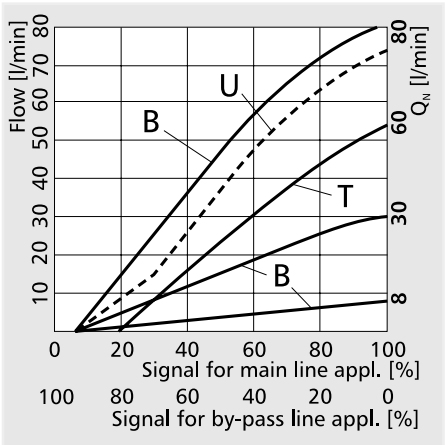

Frequency response data measured at 140 bar pilot pressure, fluid viscosity of 32 mm²/s and fluid temperature of 40 °C.




Optimised for entrapped fluid volume of 1000 cm³ but measured with 5000 cm³.
Valve flow command 80 % of rated.




Optimised and measured with entrapped fluid volume of 5000 cm³.
Valve flow command 80 % of rated.

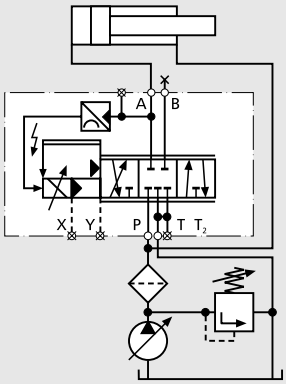



**Flow vs. signal curve**
at $\Delta p_N$ = 5 bar per land
Spool B: ~critical lap, linear characteristic
Spool U: ~critical lap, curvilinear characteristic (5-way only)
Spool T: ~20 % overlap, linear characteristic

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 $p_p$ = 250 bar.

**Note:** It is necessary to adapt the valve p-electronics to the load conditions for any new application. If required please contact MOOG for assistance.

### 3-way valve in main line

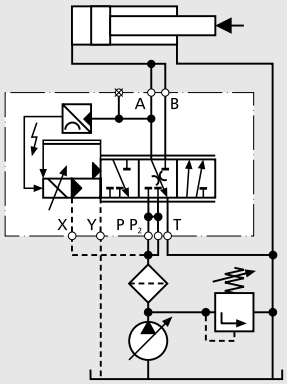



optional: X and Y external

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.

**Venting of pressure transducer**
Before first operation of 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 that the bleeding screw can become effective.
If the load is located higher than the PQ-Valve the load also must be vented at its highest point.
**Caution: Vent only at reduced pressure! Danger of injury!**

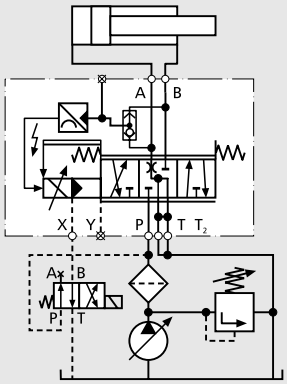
### 5-way valve in main line




only with X and Y external
P and T ports interchanged,
**not** conforming to ISO 4401

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

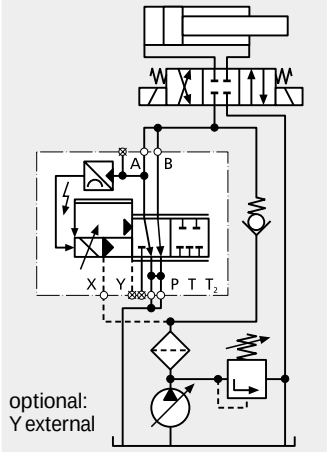



optional: Y external

**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. By 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)




optional:
Y external

The device has parallel flow pathes and operates as 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 pres-sure build up due to line losses. A minimum pilot pressure ($p_X$ > 15 bar) has to be secured. This can be achieved by a check valve with 15 bar 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 ($U_4 - U_2$). 100 % valve opening P ⏵ A und B ⏵ T is achieved at +10 V input signal. At 0 V command the spool is in a centred 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 centred position.

**Command signal for pressure p**
**Voltage command 0 to +10 V**
The controlled load pressure is proportional to ($U_9 - U_2$). 100 % rated pressure is achieved at +10 V input signal.

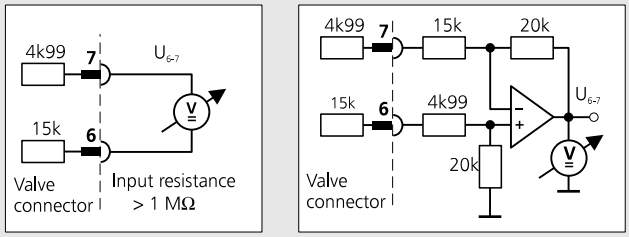
**Current command 0 to +10 mA (4 to 20 mA resp.)**
The controlled load pressure is proportional to $I_9$. 100 % rated pressure is achieved at +10 mA (20 mA resp.) input signal.

**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 centred 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 ($U_{10} - U_2$ and $I_{10}$ resp.) are given in the wiring table beloow.
**Note:** When the **p**-potentiometer is readjusted with reference to a manometer this output will not change.

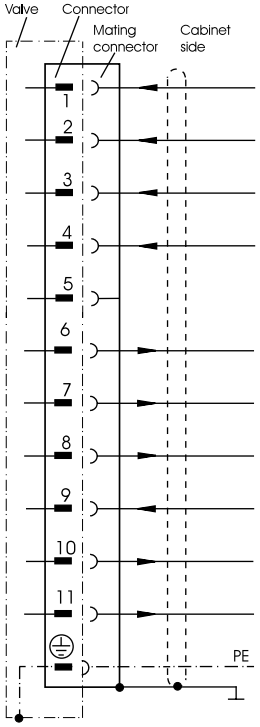
**General requirements**
- ❒ Supply 24 VDC, min.19 VDC, max. 32 VDC. Current consumption max. 300 mA
- ❒ All signal lines, also those of external transducers, shielded
- ❒ Shielding connected radially to ⊥ (0 V), power supply side, and connected to the mating connector housing (EMC)
- ❒ **EMC**: Meets the requirements of EN 55011/03.91 class B, EN 50081-1/01.92, and EN 50082-2/03.95, perf. crit. 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

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




Measurement between pin 6 and signal ground results in an actual value of +2,5 V to +13,5 V.

**Wiring for valves with 11+PE pole connector**
to DIN 43 651 and mating connector (metal shell) with leading protective grounding connection (⏚)




| Function | Voltage command | Current command | |
|---|---|---|---|
| Supply | 24 VDC (min. 19 VDC, max. 32 VDC) | | |
| Supply / Signal ground | ⊥ (0 V) | | |
| Enabled<br>Not enabled | $U_{3-2}$ > +8,5 VDC<br>$U_{3-2}$ < +6,5 VDC | I = 1,2 mA at 24 VDC | |
| Input rated command Q | 0 to ±10 V<br>Input resistance 50 kΩ | 0 to ±10 mA<br>Load resistance 500 Ω | 4 to 20 mA<br>Load resistance 250 Ω |
| not used | | | |
| Output actual value spool position (Q) (differential) | 0 to ±10 V<br>$R_a$: approx. 20 kΩ | | |
| Enable and / or supply acknowledged | $U_{8-2}$ > +8,5 VDC = ok.<br>$U_{8-2}$ < +6,5 VDC = not ok. | Output $I_{max}$: 20 mA | |
| Input rated command p | 0 to +10 V<br>Input resistance 50 kΩ | 0 to +10 mA<br>Load resistance 500 Ω | 4 to 20 mA<br>Load resistance 250 Ω |
| Output actual value p* | 0 to +10 V<br>Output resistance 10 kΩ | 0 to +10 mA<br>Load resistance max. 1kΩ | 4 to 20 mA<br>Load resistance max.500 Ω |
| Position error, logic | $U_{11-2}$ > +8,5 VDC: <30 %<br>$U_{11-2}$ < +6,5 VDC: >30 % | Output $I_{max}$: 20 mA | |
| Protective grounding | | | |

***** not affected by **p**-potentiometer (pages 8 and 9)

**Command signal for flow Q**
**Voltage command 0 to ±10 V**
The spool stroke of the valve is proportional to ($U_4 - U_3$). 100 % valve opening P ➧ A und B ➧ T is achieved at +10 V input signal. At 0 V command the spool is in a centred 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 centred position.

**Command signal for pressure p**
**Voltage command 0 to +10 V**
The controlled load pressure is proportional to ($U_9 - U_3$). 100 % rated pressure is achieved at +10V input signal.

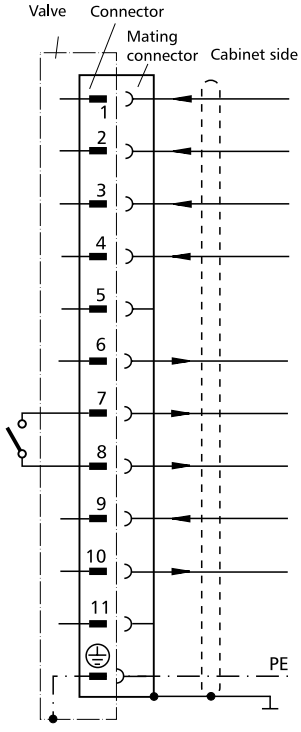
**Current command 0 to +10 mA (4 to 20 mA resp.)**
The controlled load pressure is proportional to $I_9$. 100% rated pressure is achived at +10 mA (20 mA resp.) input signal.

**Actual value spool position (Q)**
Signal levels for actual flow output ($U_6 - U_3$ and $I_6$ resp.) are given in the wiring table below.

**Actual value pressure p**
Signal levels for actual pressure output ($U_{10} - U_3$ and $I_{10}$ 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. ±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, perf. crit. 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

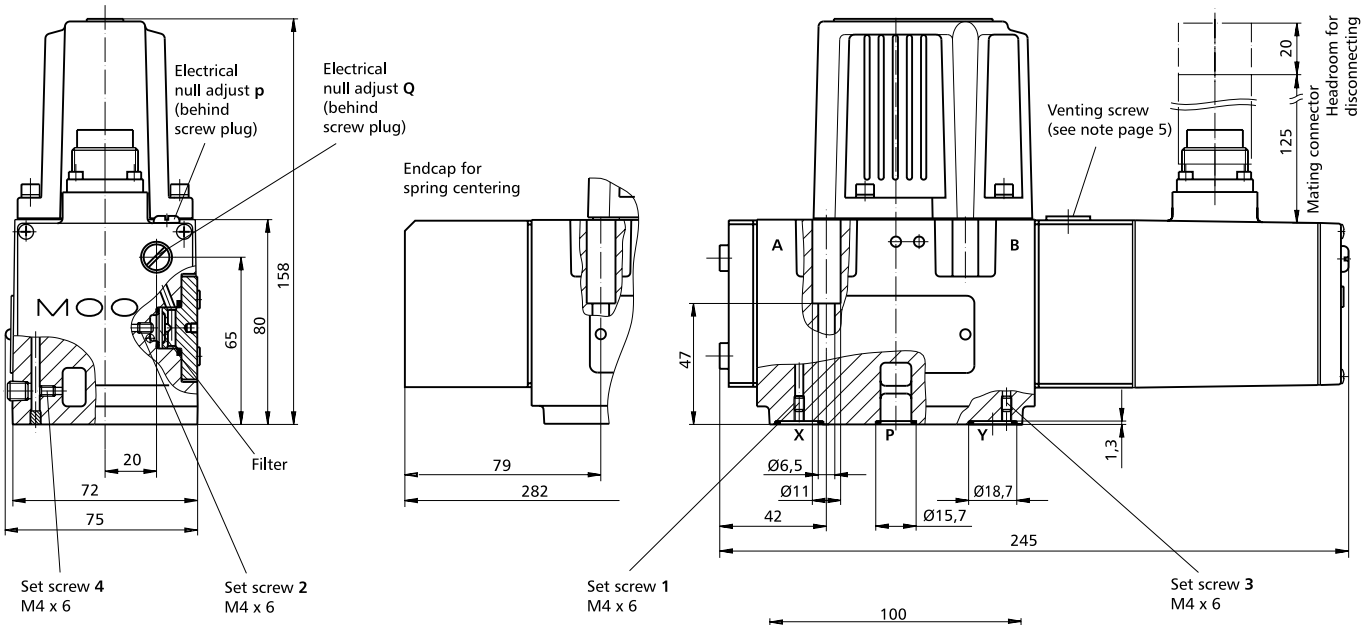
**Wiring for valves with 11+PE pole connector**
to DIN 43 651 and mating connector (metal shell) with leading protective grounding connection (⏚)

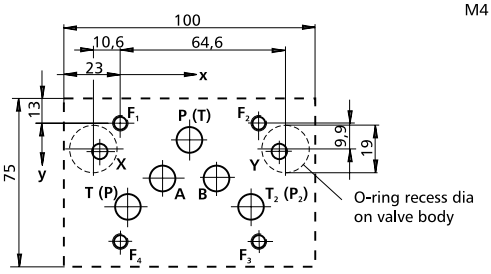



| Function | Voltage command | Current command | |
|---|---|---|---|
| Supply | +15 VDC ±3 % | | |
| Supply | –15 VDC ±3 % | | |
| Supply / Signal ground | ⊥ (0 V) | | |
| Input rated command Q | 0 to ±10 V<br>Input resistance 100 kΩ | 0 to ±10 mA<br>Load resistance 400 Ω | 4 to 20 mA<br>Load resistance 200 Ω |
| not used | | | |
| Output actual value spool position (Q) | 0 to ±10 V<br>Output resistance 10 kΩ | 0 to ±10 mA<br>Load resistance max. 500 Ω | 4 to 20 mA<br>Load resistance max. 500 Ω |
| Relay output | 24 VDC, max. 0,5 A. For inductive loads a corresponding commutating diode is necessary.<br>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.<br>Cable break of the ⊥ - wire will not be monitored. | | |
| Input rated command p | 0 to +10 V<br>Input resistance 100 kΩ | 0 to +10 mA<br>Load resistance 500 Ω | 4 to 20 mA<br>Load resistance 250 Ω |
| Output actual value p* | 0 to +10 V<br>Output resistance 10 kΩ | 0 to +10 mA<br>Load resistance max. 500 Ω | 4 to 20 mA<br>Load resistance max. 500 Ω |
| not used | | | |
| Protective grounding | | | |

***** not affected by **p**-potentiometer (pages 8 and 9)

# 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 $Q_N$ > 60 l / min 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 11,5 mm** (deviation from standard).
Mounting surface needs to be flat within 0,02 mm. Average surface finish value Ra better than 1µm.

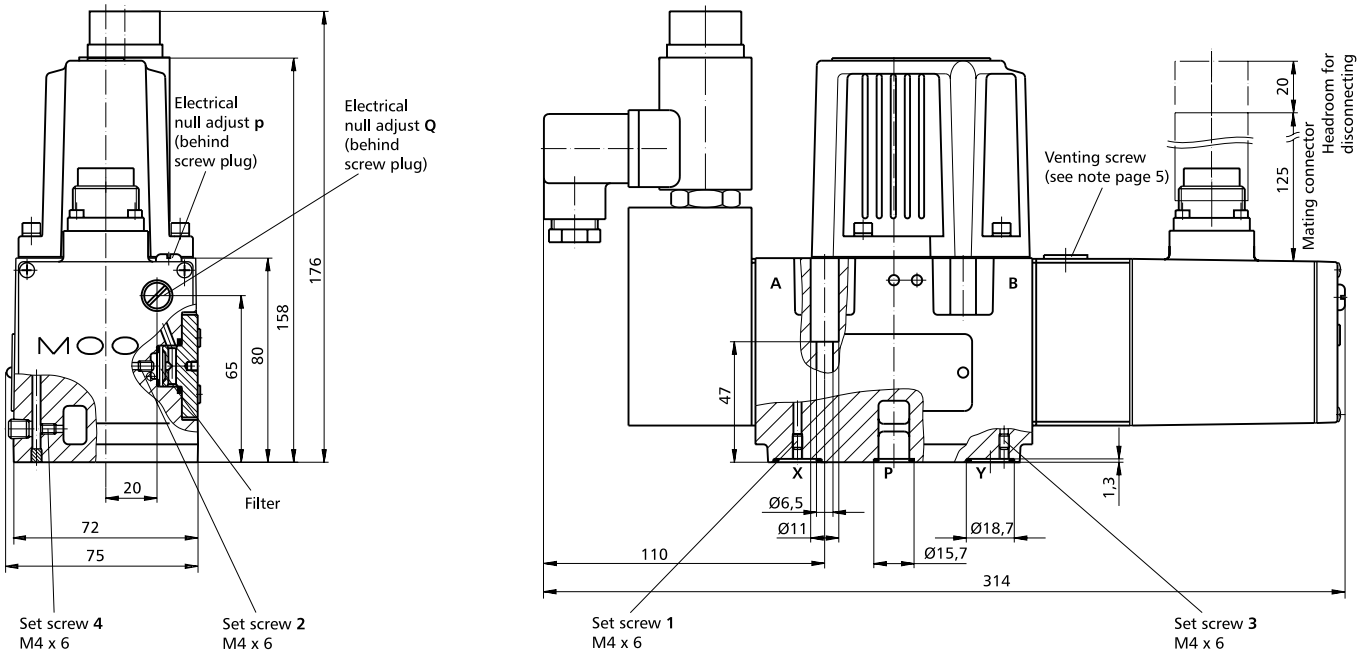
| | P | A | B | T | $T_2$ | X | Y | $F_1$ | $F_2$ | $F_3$ | $F_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Ø11,5** | **Ø11,5** | **Ø11,5** | **Ø11,5** | **Ø11,5** | Ø6,3 | Ø6,3 | M6 | M6 | M6 | M6 |
| x | 27 | 16,7 | 37,3 | 3,2 | 50,8 | -8 | 62 | 0 | 54 | 54 | 0 |
| y | 6,3 | 21,4 | 21,4 | 32,5 | 32,5 | 11 | 11 | 0 | 0 | 46 | 46 |

**Conversion instruction**

| for operation with internal or external pilot connection | Pilot flow supply | Set screw M4 x 6 bore **1** | bore **2** | Pilot flow return | Set screw M4 x 6 bore **3** | 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 12,4 x Ø 1,8 | | 45122 004 | 42082 004 |
| for X, Y | 2 pieces ID 15,6 x Ø 1,8 | | 45122 011 | 42082 011 |
| Mating connector, waterproof IP65 (not included in delivery) | | | for cable dia | |
| 11+PE pole | B97024 111 | DIN 43651 | min. Ø 11 mm, max. Ø 13 mm | |
| Flushing plates | for P, A, B, T, $T_2$, X, Y B67728 001 | for P, T, $T_2$ X, Y B67728 002 | for P, T, $T_2$, and X, Y B67728 003 | |
| Mounting manifolds | see special data sheet | | | |
| Mounting bolts (not included in delivery) | | required torque | required | |
| M6 x 60 DIN 912-10.9 | A03665 060 060 | 13 Nm | 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 13 x Ø 1,5 | — | 66117 013 015 | A25163 013 015 |
| filter cover | 1 piece ID 17 x Ø 2,0 | B97009 080 | — | 42082 080 |




**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 the 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.

**Electrical characteristics**

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

Nominal voltage $U_N$ 24 VDC
Nominal power $P_N$ 29 W

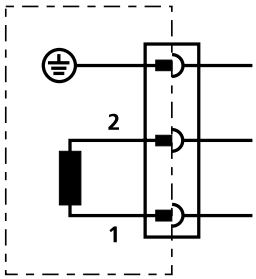
Hydraulically activated valves for the fail-safe version on request.

**Note:**

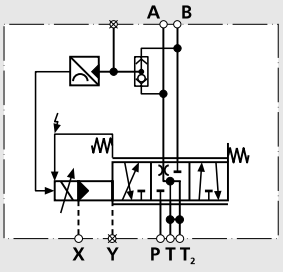
Detailed informations about safety requirements according to EN 954-1 see MOOG Application Note AM 391 E.

**Connector wiring**

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

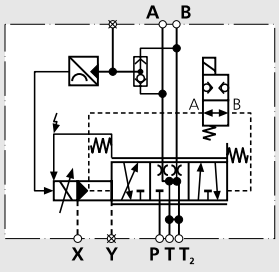



**Block diagrams**




Spring centred version (installation drawing see page 8)

only with X external




Version with poppet valve and spring centring

optional: X and Y external

# D691 Series
## 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,<br>2-stage with standard spool |
| **Pilot stage** | ServoJet | | Standard |
| **Pilot connection** | optional, internal or external | | X and Y (see pages 5 and 9) |
| **Installation options** | | | any position, fixed or movable<br>**Note:** consider air vent location |
| **Vibration** | | | 15 g, 3 axes |
| **Mass** | | [kg] | 6,3 |
| **Rated flow** | ±10 % at $\Delta p_N$ = 5 bar per land | [l/min] | **8 / 30 / 60 / 80 / 2 x 80** |
| **Operating pressure** | max. | | |
| Main stage: | port P, A, B | [bar] | 350 |
| | port T with Y internal | [bar] | 210 |
| | port T with Y external | [bar] | 350 |
| Pilot stage: | regular version | [bar] | 280 |
| | with dropping orifice (on request) | [bar] | 350 |
| **Temperature range** | Ambient | [°C] | –20 to +60 |
| | Fluid | [°C] | –20 to +80 |
| **Seal material** | | | NBR, FPM, others on request |
| **Operating fluid** | | | Mineral oil based hydraulic fluid (DIN 51524, part 1 to 3)<br>other fluids on request. |
| Viscosity | recommended | [mm²/s] | 15 to 45 |
| | allowable | [mm²/s] | 5 to 400 |
| **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: | | | $ß_{15} \geq 75$ (15 µm absolute) |
| for longer life: | | | $ß_{10} \geq 75$ (10 µm absolute) |
| **Response time** [1]) | for 0 to 100 % stroke | [ms] | **27** |
| **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. | | [l/min] | 3,5 |
| pilot stage only | | [l/min] | 1,7 |
| **Pilot flow** [1]) max. with 100 % Step input | | [l/min] | **1,7** |
| **Spool stroke** | | [mm] | ±3 |
| **Spool drive area** | | [cm²] | 2 |
| **Degree of protection** | | | EN 60529 class IP 65 with mating connector mounted |
| **Shipping plate** | | | Delivered with an oil sealed shipping plate under the mounting surface. |

[1]) measured at $p_x$ = 210 bar pilot or operating pressure, respectively, fluid viscosity of 32 mm²/s and fluid temperature of 40 °C.

**Model-Number** **Type designation**

**D691** . . . . . . . . . . . . . . . . .

**Specification status**

| | |
|---|---|
| – | Series specification |
| E | Preseries specification |
| Z | Special specification |

**Model designation**

| | |
|---|---|
| | assigned at the factory |

**Factory identification**

**Valve version**

| | |
|---|---|
| Q | Standard spool |

**Rated flow**

| | $Q_N$ [l/min] at $\Delta p_N$ = 5 bar per land |
|---|---|
| 08 | 8 |
| 30 | 30 |
| 60 | 60 |
| 80 | 80 |

**Pressure ranges**

| | Calibrated pressure for 100 % signal [bar] | typical non-linearity [%] | with reference to transducer type [bar] |
|---|---|---|---|
| C | 105 | < 0,35 | 160 |
| D | 140 | < 0,25 | 160 |
| F | 210 | < 0,21 | 250 |
| K | 350 | < 0,17 | 400 |
| X | Special version | | |

**Spool type**

| | | |
|---|---|---|
| B | 3-way: | P ◗ A, A ◗ T; ~critical lap, linear characteristic |
| U | 5-way: | P ◗ A, $P_2$ ◗ B, A ◗ T; ~critical lap, curvilinear characteristic |
| T | 4-way: | linear characteristic<br>P ◗ A and P ◗ B: 20 % overlap<br>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 [l/min] at $p_X$ = 140 bar |
|---|---|---|
| A | ServoJet | 1,30 |

**Valve version**

| | |
|---|---|
| N | Valve in main line, maximum pressure limiting control |
| K | Valve in main line, minimum press. limiting control |
| C | Valve in 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 (Buna) Standard |
| V | FPM (Viton) - optional<br>others on request |

**Pilot connections and pressure**

| | Pressure [bar] | Supply X | Return Y |
|---|---|---|---|
| A | 15 to 210 | internal | internal |
| B | 15 to 210 | external | external |
| C | 15 to 210 | external | internal |
| D | 15 to 210 | internal | external |
| E | 15 to 280 | internal | internal |
| F | 15 to 280 | external | external |
| G | 15 to 280 | external | internal |
| H | 15 to 280 | internal | external |
| J | 25 to 350 | internal | internal |
| K | 25 to 350 | external | external |
| L | 25 to 350 | external | internal |
| M | 25 to 350 | internal | external |

**Spool position without electrical supply**

| | **Mechanical fail-safe version**<br>Position | $p_P$ [bar] | $p_X$ extern [bar] |
|---|---|---|---|
| A | End position defined A ◗ T | | |
| B | End position defined P ◗ A | | |
| M | Mid position defined | ≥15 | <1 |
| | undefined | ≥15 | ≥15 |
| R | Mid position defined | ≥15 | <1 |
| | P ◗ B, A ◗ T | ≥15 | ≥15 |
| L | Mid position defined | ≥15 | <1 |
| | P ◗ A, B ◗ T | ≥15 | ≥15 |

| | **Electrically controlled fail-safe version**<br>Position | $p_P$ [bar] | $p_X$ | SV* | VE** |
|---|---|---|---|---|---|
| W | Mid position defined | ≥15 | ≥15 | off | on |
| | Mid position defined | ≥15 | <1 | on | on |

SV* = Solenoid valve
VE** = Valve electronics

**Preferred configurations are highlighted.**
**All combinations may not be available.**

**Options may increase price.**
**Technical changes are reserved.**

| | |
|---|---|
| **Australia** | Melbourne |
| **Austria** | Vienna |
| **Brazil** | São Paulo |
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| **Denmark** | Birkerød |
| **England** | Tewkesbury |
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| **Russia** | Pavlovo |
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