SERVO-PROPORTIONAL VALVES

DIRECT OPERATED WITH INTEGRATED ELECTRONICS

D936 SERIES

ISO 4401 SIZE 03

Rev. -, September 2019

PROPORTIONAL SOLENOID OPERATED VALVE IN 4/4-WAY SLEEVE DESIGN FOR SERVO QUALITY PERFORMANCE OFFERING HIGH ROBUSTNESS AND RELIABILITY

WHAT MOVES YOUR WORLD

MOOG

Whenever the highest levels of motion control performance and design flexibility are required, you'll find Moog expertise at work. Through collaboration, creativity and world-class technological solutions, we help you overcome your toughest engineering obstacles. Enhance your machine's performance, and help take your thinking further than you ever thought possible.

All dimensions in mm (in)

PRODUCT OVERVIEW

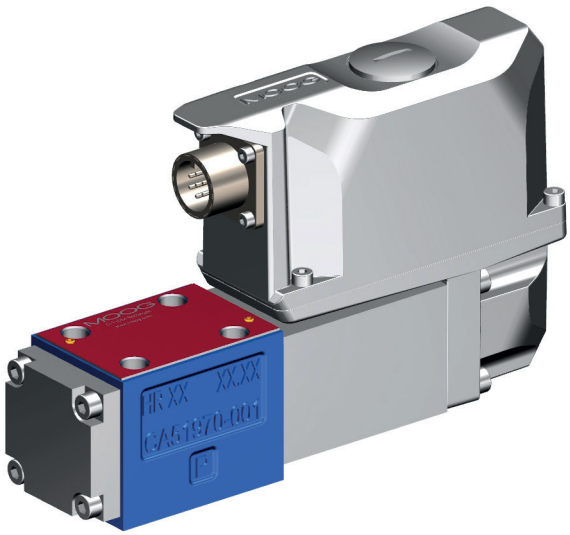
Moog D936 Series valves are direct operated Servo-Proportional Valves driven by a proportional solenoid. They are equipped with integrated electronics and closed-loop position control of the spool.

The valves are suitable for electrohydraulic control of position, speed, pressure and force in open and closed loop control systems.

This valve series is characterized by a compact design that allows a space-saving system design.

The robust design allows for a high resistance against harsh environmental conditions like high vibrations and temperature.

The valve offers analog interfaces for command signal and spool position feedback. It is, however, equipped with modern electronics with a digital core that offers high energy efficiency while delivering high static and dynamic control performance.



D936 Servo-Propotional Valve

D936 Servo-Propotional Valve	
Valve design	1-stage, with spool and bushing
Size according ISO 4401	03
Mounting pattern	ISO 4401-03-03-0-05 (with or without leakage oil connection Y)
Rated flow at Δp_N 35 bar (500 psi)/spool land	4 to 40 l/min (1.06 to 10.6 gpm)
Maximum operating pressure - port P, A, B	350 bar (5,000 psi)
Step response time for 0 to 100 % stroke	11 ms

FEATURES AND BENEFITS

Features	Benefits
4/4-way design including failsafe position	Reduces need for additional safety components
Servo valve design with fully hardened spool and bushing	High accuracy and wear resistance
Electronics mechnically uncoupled from housing	High vibration resistance for longer service life and less machine downtime
Next-generation electronics with digital core and energy efficient components	Low thermal stress and long electronics lifecycle
Optimized overlaps and clearances between spool and bushing	Low internal leakage and high contamination resistance
Electronics placed on the solenoid	Compact design for minimum installation space

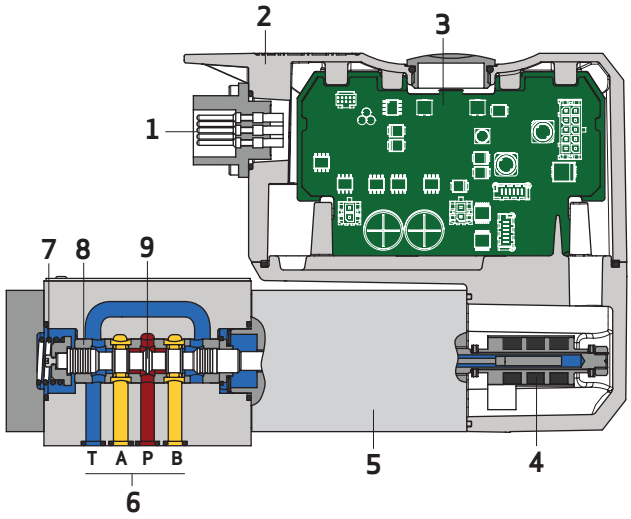
DESCRIPTION OF OPERATION

Valve Design

The Moog D936 Series Servo-Proportional Control Valves are closed-loop hydraulic products that are used in industrial applications. These valves are electrical feedback valves, which means that the position control loop for the spool is closed by a position transducer and the integrated valve electronics.

The spool (9) is mounted in a hardened steel bushing (8) that provides high control accuracy and superior wear resistance. The spool is deflected by the proportional solenoid (5) that operates against the return spring (7).

The onboard electronics (3) are mounted on top of the solenoid to create a compact and space-saving valve shape. The electronics are uncoupled from the electronics housing and provide a high resistance against vibrations and shocks.



1 Valve connector
2 Electronics housing
3 Valve electronics
4 Position transducer (LVDT)
5 Proportional solenoid
6 Ports
7 Spring
8 Bushing
9 Spool

Operation

An electric command signal (spool position set point) is applied to the valve electronics via the main connector (1). A position transducer (4) measures the actual position of the spool. The electronics compare the spool position and the command signal, and control the Pulse Width Modulated (PWM) current to the proportional solenoid. If a control deviation occurs, the PWM current is changed to move the spool to the desired position and the PWM current is kept at a level that holds the spool in this position.

Thus, the position of the spool is proportional to the electric command signal.

D936 SERIES SERVO-PROPORTIONAL VALVES

General Technical Data

Valve design	1-stage, with spool and bushing
Mounting pattern	ISO 4401-03-03-0-05 (with or without leakage oil connection Y)
Installation position	Any
Weight	2.9 kg (6.4 lb)
Storage temperature range	-40 to +80 °C (-40 to +176 °F)
Ambient temperature range	-20 to +60 °C (-4 to +140 °F)
Vibration resistance	30 g, 3 axis, 10 Hz to 2 kHz
Shock resistance	50 g, 6 directions, 3 ms
$MTTF_d$ value according to EN ISO 13849-1	150 years

Hydraulic Data

Maximum operating pressure				
Port P, A, B	350 bar (5,000 psi)			
Port T without Y	280 bar (4,000 psi) [1]			
Port T with Y	350 bar (5,000 psi)			
Port Y	Depressurized to tank[1]			
Rated flow at Δp_N 35 bar (500 psi)/spool land for linear flow characteristics (for others see ordering code)	4 l/min (1.06 gpm)	12 l/min (3.2 gpm)	24 l/min (6.3 gpm)	40 l/min (10.6 gpm)
Leakage flow (rate) (≈ zero lap)[2]	0.2 l/min (0.05 gpm)	0.4 l/min (0.11 gpm)	0.7 l/min (0.19 gpm)	1.3 l/min (0.34 gpm)
Maximum allowable pressure drop regarding the transition to the failsafe position[3]				
Failsafe options 1 and F	350 bar (5,000 psi)	350 bar (5,000 psi)	350 bar (5,000 psi)	160 bar (2,320 psi)
Failsafe option 2	350 bar (5,000 psi)	350 bar (5,000 psi)	260 bar (3,770 psi)	120 bar (1,740 psi)
Hydraulic fluid	Hydraulic oil as per DIN 51524 parts 1 to 3 and ISO 11158. Other fluids upon request.			
Temperature range	-20 to +80 °C (-4 to +176 °F)			
Viscosity range				
Recommended viscosity range at 38 °C (100 °F)	15 to 100 mm^2/s (cSt)			
Maximum permissible viscosity range at 38 °C (100 °F)	5 to 400 mm^2/s (cSt)			
Recommended cleanliness class as per ISO 4406				
For functional safety	19/16/13			
For longer service life	17/14/11			

1) In order to avoid an emptying of the return line, a back pressure of 2 bar (30 psi) should be maintained on the T and Y connections.

2) Measured at 140 bar (2,000 psi) system pressure, oil viscosity 32 mm2/s and oil temperature 40 °C (104 °F)

3) Values apply for 4-way operation, please refer also to the information given in the section “Failsafe Functions”.

D936 SERIES SERVO-PROPORTIONAL VALVES

Typical Static and Dynamic Data[1)]

Step response time for 0 to 100 % stroke	11 ms
Threshold	< 0.2 %
Hysteresis	< 0.2 %
Null shift at ΔT = 55 K (131 °F)	< 1.5 %
Sample deviation of rated flow	< 3 %

1) Measured at 140 bar (2,000 psi) system pressure, 32 mm^2/s (32 cSt) oil viscosity and +40 °C (+104 °F) oil temperature.

Electrical Data

Duty cycle	100 %
Degree of protection according to IEC/EN 60529	IP65 (with mounted mating connectors)
Supply voltage[2)]	24 V_{DC} (18 to 32 V_{DC})
Permissible ripple of supply voltage	2.5 V_{PP}
Maximum current consumption[3)]	1.4 A
Maximum power consumption	33.6 W (1.4 A at 24 V_{DC})
Fuse protection, external, per valve	2 A (slow)
EM compatibility	• Emitted interference as per DIN EN 61000-6-4 • Immunity to interference as per EN 61000-6-2 (evaluation criterion A)

2) All connected circuits must be isolated from the mains supply by „electrical separation“ in accordance with IEC/EN 61558-1 and IEC/EN 61558-2-6. Voltages must be limited to the safety extra-low voltage range in accordance with EN 60204-1. We recommend the use of SELV/PELV power packs.

3) Measured at +25 °C (+77 °F) ambient temperature and 24 V supply voltage

D936 SERIES SERVO-PROPORTIONAL VALVES

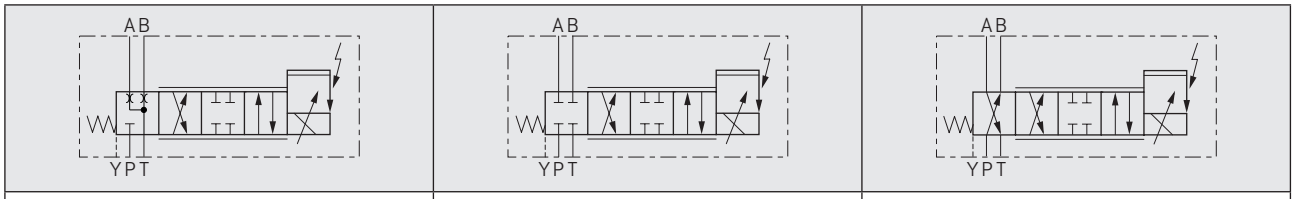
Failsafe functions

The D936 valve series offers three different fail-safe options. They can be chosen at position 6 of the ordering code.

For options 1 and 2, the spool is moved to the 4th position by spring force when the electrical supply of the valve is switched off. Option 1 connects ports A and B with port T and thus relieves the pressure from ports A and B. Option 2 blocks all valve ports, but there will still remain a small amount of internal leakage, so a cylinder or motor may creep when it is under load.

For option F, the spool is moved to a stroke of about 110% in the direction P→B and A→T when switching off the electrical power.

Hydraulic symbols for the different options are shown below:



Failsafe option 1	Failsafe option 2	Failsafe option F

Please note:

1) For both options 1 and 2 the spool is moved through the fully open Position P⟶B and A⟶T when travelling to the 4th position. That means there will be full flow for a short amount of time.

2) The switching force of the spring is limited, so there are limits concerning the maximum allowable pressure drop to reach the failsafe position. These limits depend on the rated flow and the failsafe option. Limits for reaching the failsafe position are given on page 6.

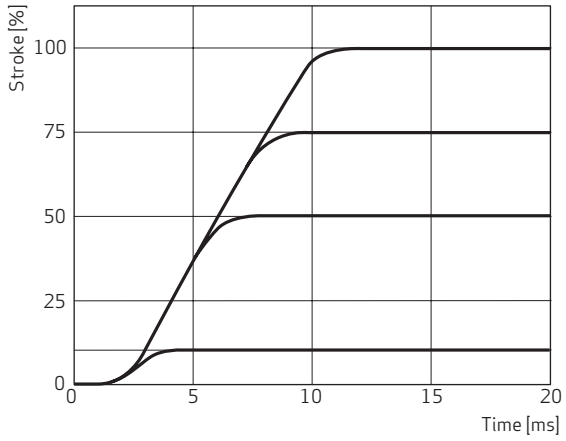
3) The maximum pressure drop for leaving the failsafe position is also limited. In some cases, those limits can be lower than the pressure drop limits to reach the failsafe position. Depending on the system configuration, it may be necessary to reduce or shut down the hydraulic supply pressure to leave the failsafe position.

4) For certain errors (e.g. power supply voltage too low), the valve electronics will switch off the solenoid power and the valve will move to the failsafe position. The solenoid power will be switched on again as soon as the error is no longer present.

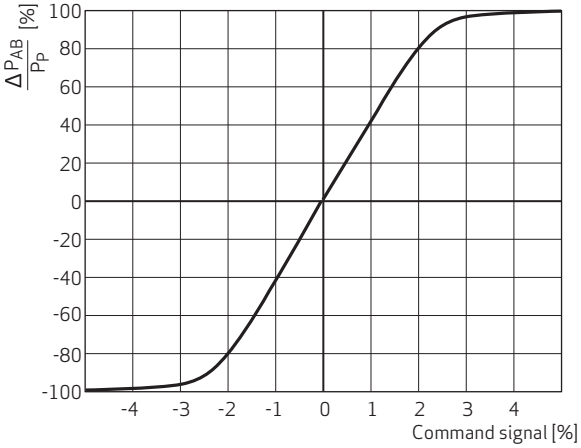
D936 SERIES SERVO-PROPORTIONAL VALVES

Typical Characteristic Curves

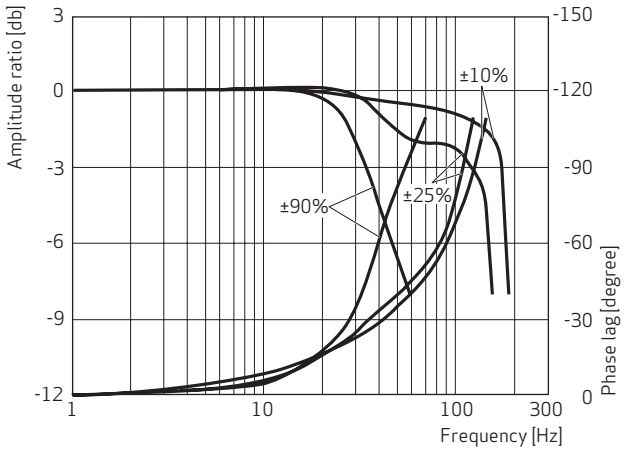
Step Response



Pressure Signal Characteristic



Frequency Response

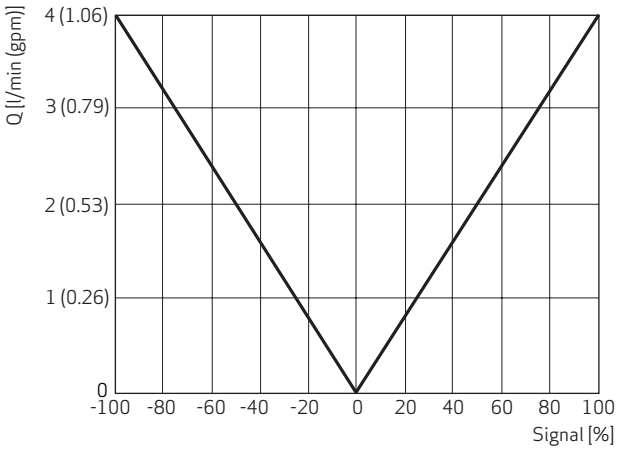


D936 SERIES SERVO-PROPORTIONAL VALVES

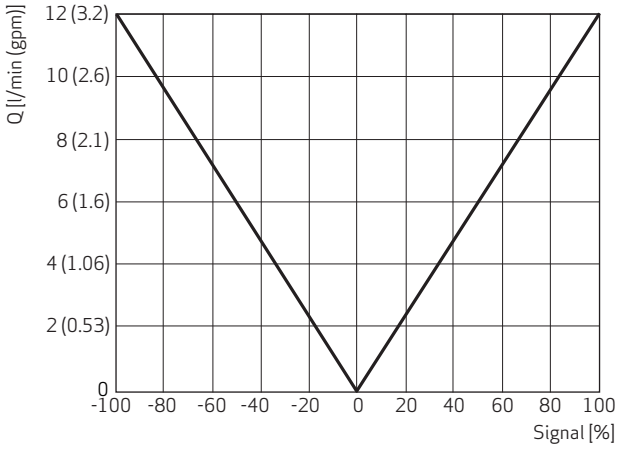
Rated flow at Δp_N 35 bar (500 psi)/spool land

Linear Flow Characteristics

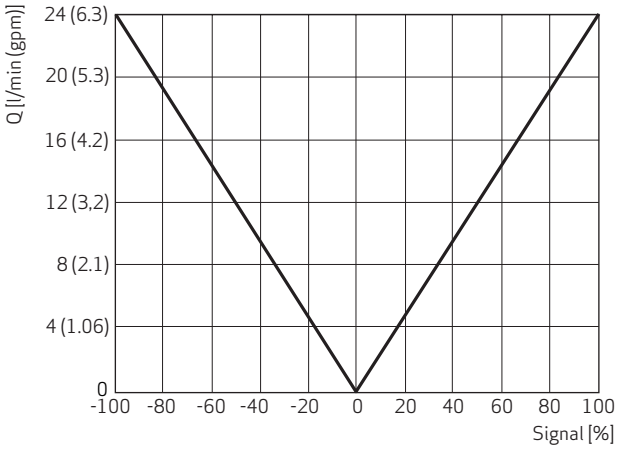
Rated flow 4 l/min



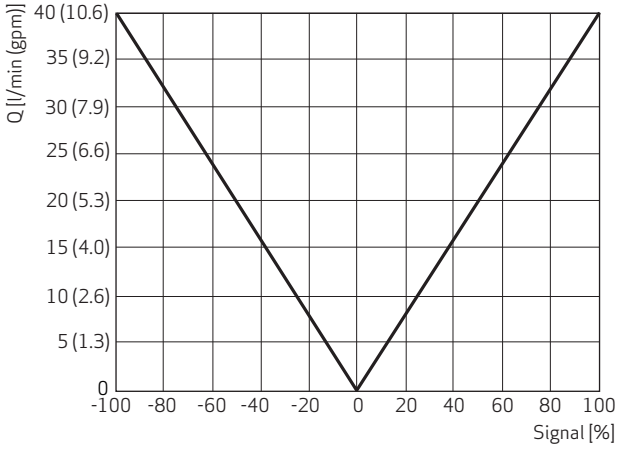
Rated flow 12 l/min



Rated flow 24 l/min



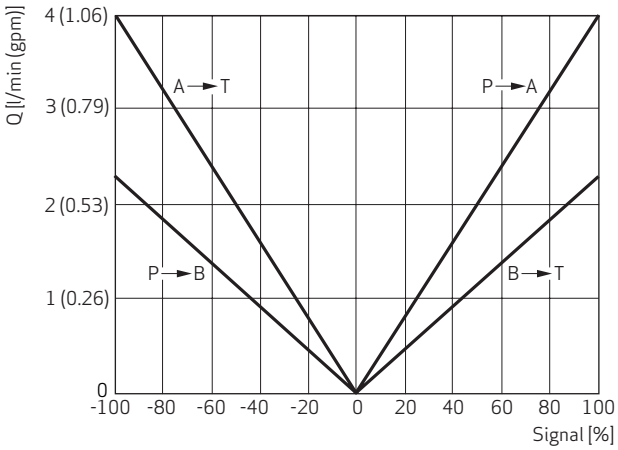
Rated flow 40 l/min



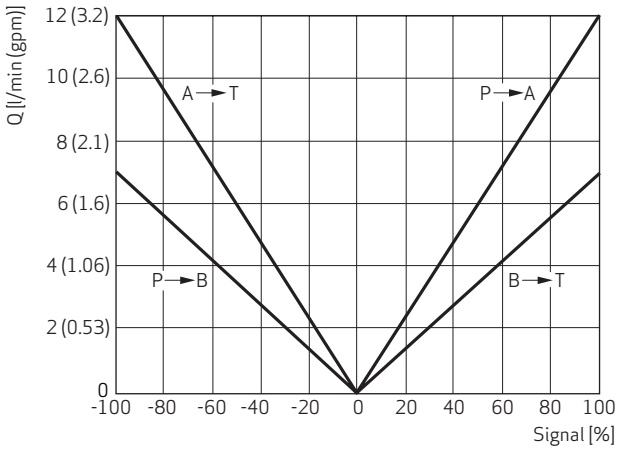
D936 SERIES SERVO-PROPORTIONAL VALVES

Linear Flow Characteristics for Differential Cylinders

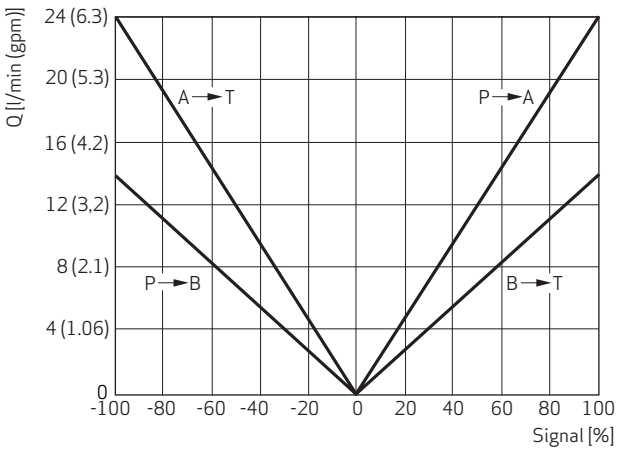
Rated flow 4 l/min



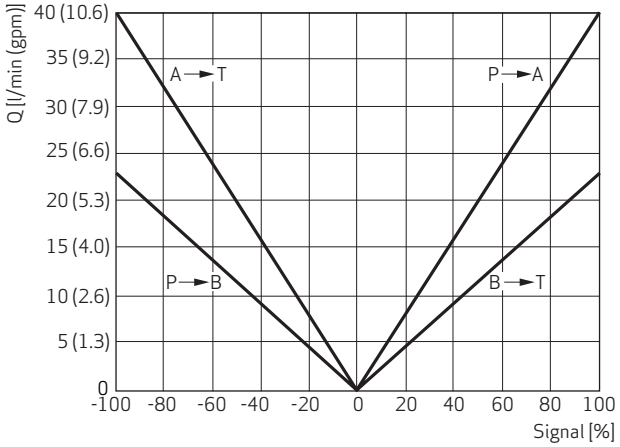
Rated flow 12 l/min



Rated flow 24 l/min



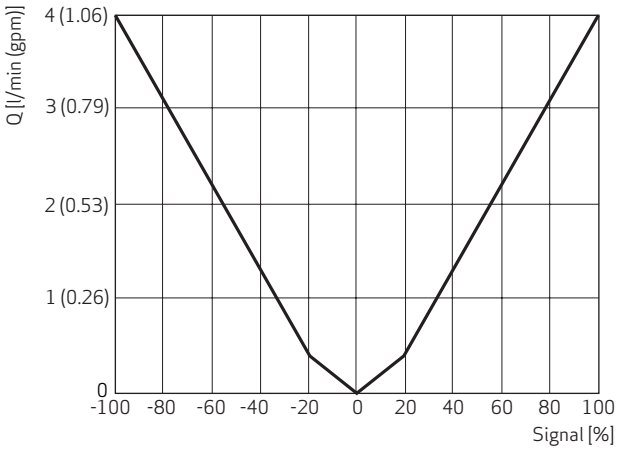
Rated flow 40 l/min



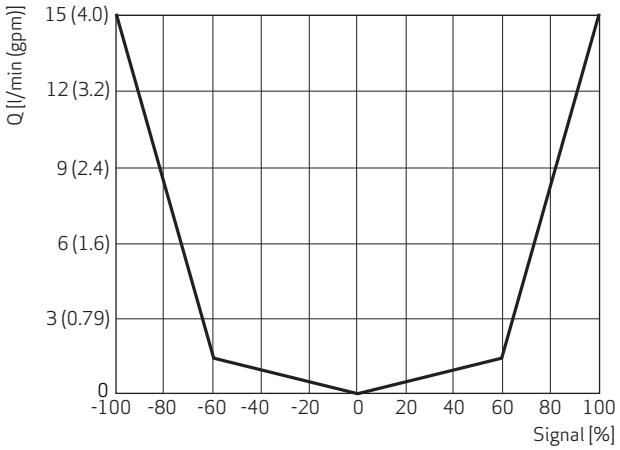
D936 SERIES SERVO-PROPORTIONAL VALVES

Dual Gain Flow Characteristics

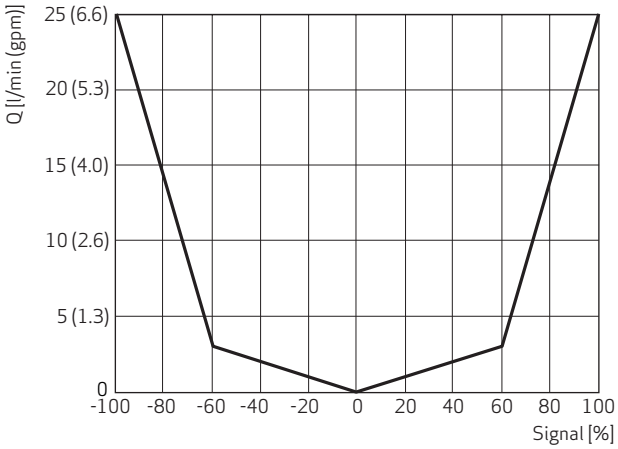
Rated flow 4 l/min



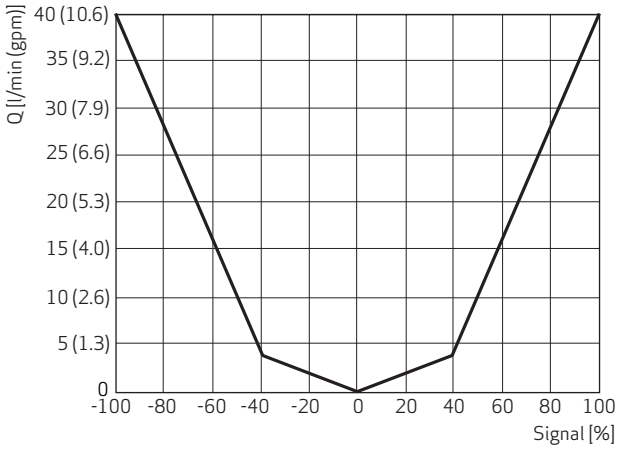
Rated flow 15 l/min



Rated flow 25 l/min



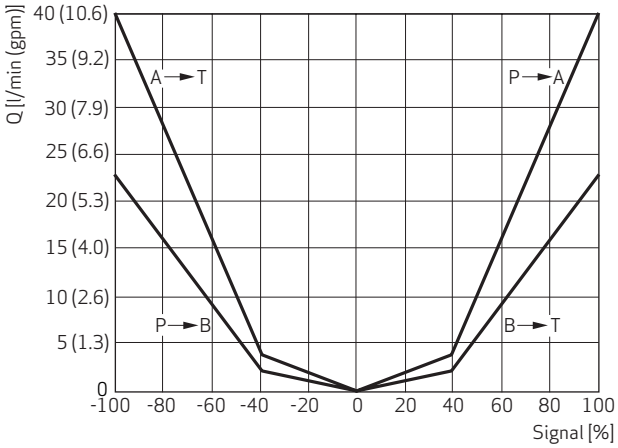
Rated flow 40 l/min



D936 SERIES SERVO-PROPORTIONAL VALVES

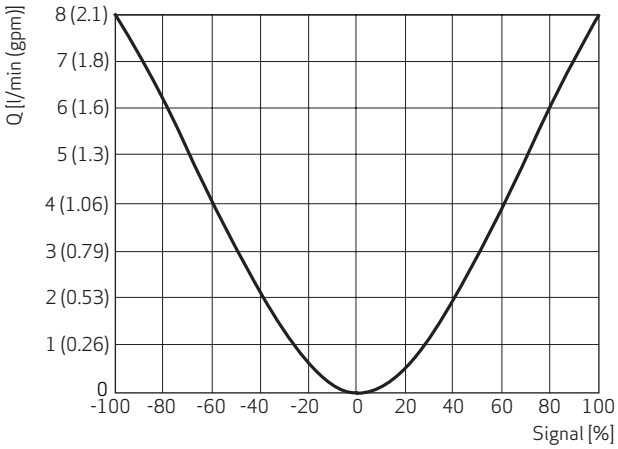
Dual Gain Flow Characteristics for Differential Cylinders

Rated flow 40 l/min

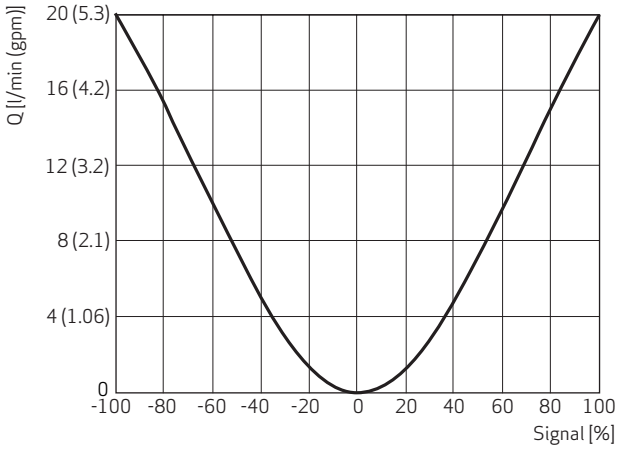


Progressive Flow Characteristics

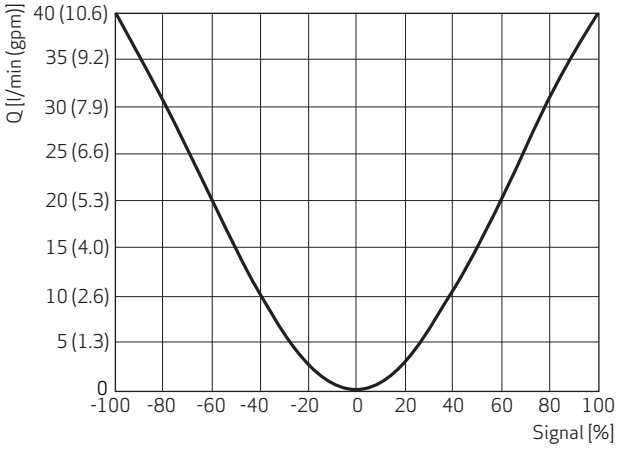
Rated flow 8 l/min



Rated flow 20 l/min



Rated flow 40 l/min



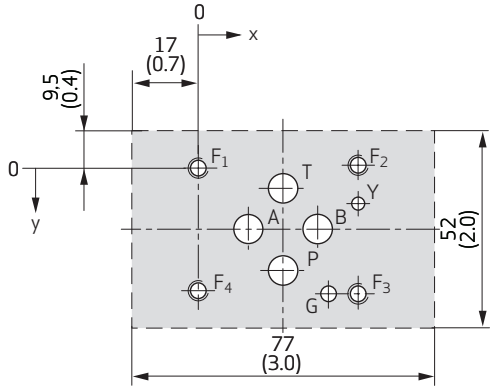
D936 SERIES SERVO-PROPORTIONAL VALVES

Port Pattern of Mounting Surface

The mounting surface must conform to ISO 4401-03-03-0-05. Please observe a mounting length of a minimum 77 mm (3.0 in) and O-ring recesses for Y.

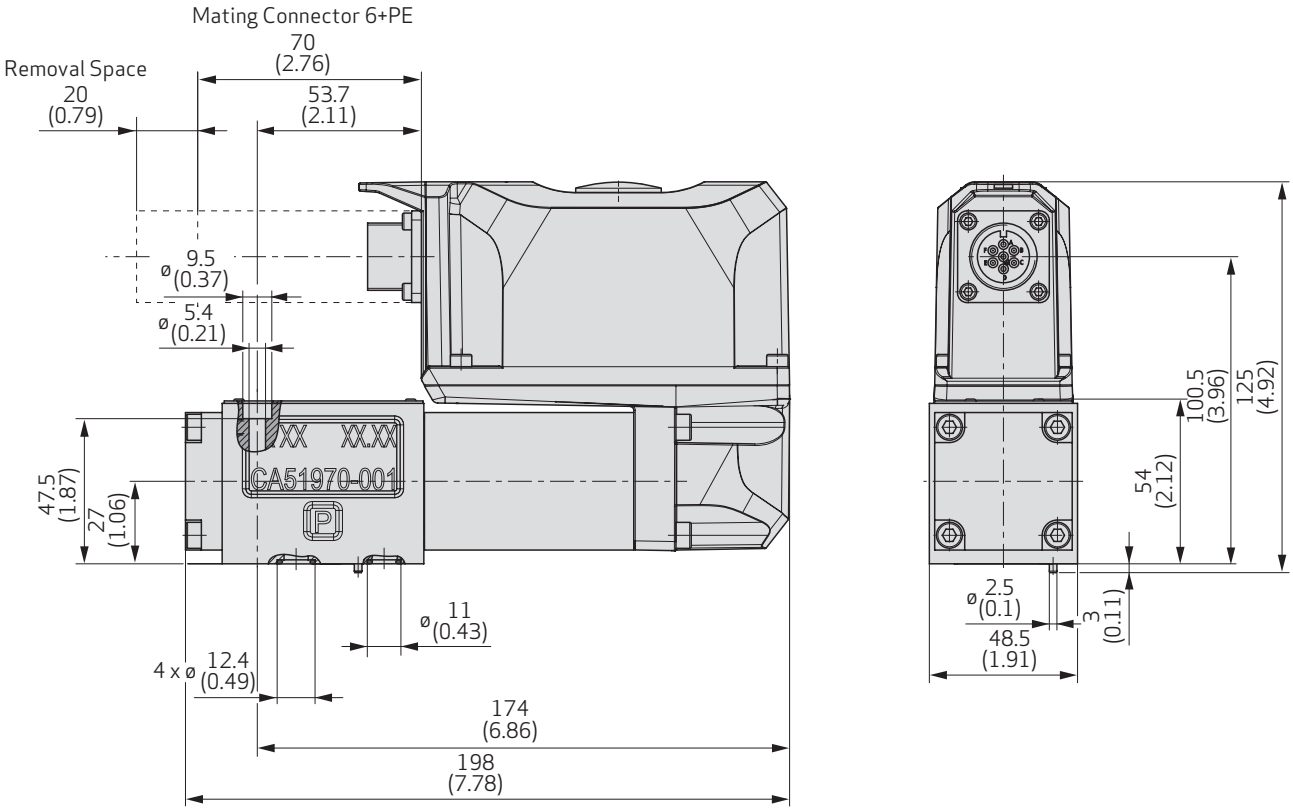
For maximum flow the ports for P, T, A and B must be designed with Ø 7.5 mm (0.3 in), not according to the standard.

The evenness of the connecting surface has to be 0.01 mm (0.0004 in) over 100 mm (3.94 in), and average surface finish R_a better than 0.8 µm (0.0000314 in).



Designation		P	A	B	T	Y	F_1	F_2	F_3	F_4	G
Size Ø	**mm**	7.5	7.5	7.5	7.5	3.3	M5	M5	M5	M5	4
	in	0.3	0.3	0.3	0.3	0.13	M5	M5	M5	M5	0.16
Position X	**mm**	21.5	12.7	30.2	21.5	40.5	0	40.5	40.5	0	33
	in	0.846	0.5	1.189	0.846	1.594	0	1.594	1.594	0	1.299
Position Y	**mm**	25.9	15.5	15.5	5.1	9	0	-0.75	31.75	31	31.75
	in	1.02	0.61	0.61	0.201	0.354	0	-0.03	1.25	1.22	1.25

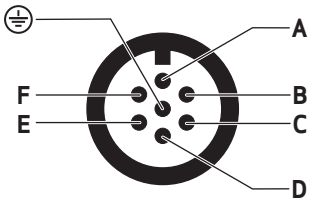
Installation Drawing



ELECTRONICS

Pin Assignment for Valves with 6-pole + PE Connector, Pin Contacts

According to EN 175201-804, mating connector (type R or S, metal) with leading protective earth pin (⏚)



Pin	Pin assignment	Signal type[1]	
		Voltage floating	Current floating[2]
A	**Supply voltage**	U_{A-B} = 24 V_{DC} (18 to 32 V_{DC}) referenced to GND (reverse polarity protected against GND)	
B	**GND**	Power ground/signal ground	
C	**Reference point actual value**	Reference for Pin F	
D	**Command signal - spool position**	$U_{in} = U_{D-E}$ R_{in} = 10 kΩ	$I_{in} = I_D = -I_E$ R_{in} = 200 Ω I_{max} = ±25 mA
E	**Reference point Input rated command**	Reference for pin D[2]	
F	**Actual value - spool position**	U_{F-C} = -10 to 10 V; U_{F-C} is proportional to the spool position; 0 V corresponds to the spool center position	I_{out} = 4 to 20 mA referenced to PIN C; I_{out} is proportional to the spool position; 12 mA corresponds to the spool center position; the output is short-circuit-proof; R_L = 0 to 500 Ω
⏚	**Protective earth (PE)**	Connected with valve body	

1) Signal ranges see next page.

2) The potential difference between pins D or E referenced to pin B must be between -15 and +32 V.

ELECTRONICS

Ordering Codes and Signals for Valves with 6-pole + PE Connector

Ordering code position 10	Command signal ±100% spool position		Actual value ±100 % spool position	
H	U_D - U_E	-10 to +10 V	U_F - U_C	-10 to +10 V
X	I_D	-10 to +10 mA	I_F	4 to 20 mA
E	I_D	4 to 20 mA	I_F	4 to 20 mA

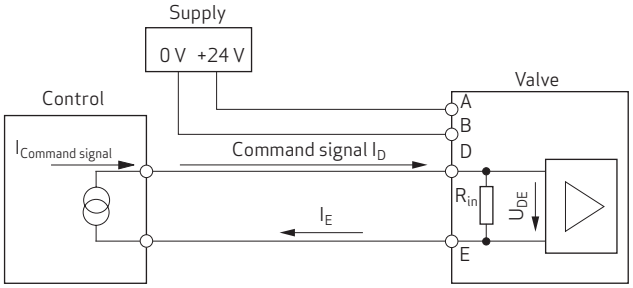
Note: See inside back cover for complete ordering information.

Command Signal Current Floating, Ordering Code X or E

The spool position is proportional to $I_D = - I_E$.

For a command signal I_D = 20 mA (code E) or +10 mA (code X) the spool moves to 100 % P → A and B → T.

For a command signal I_D = 12 mA (code E) or 0 mA (code X) the spool is in the defined center position.

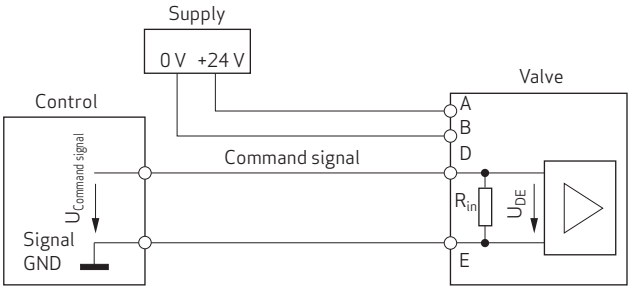


Command Signal Voltage Floating, Ordering Code H

The spool position is proportional to $U_D - U_E$.

For a command signal $U_D - U_E$ = +10 V the spool moves to 100 % P → A and B → T.

For a command signal $U_D - U_E$ = 0 V the spool is in the defined center position.

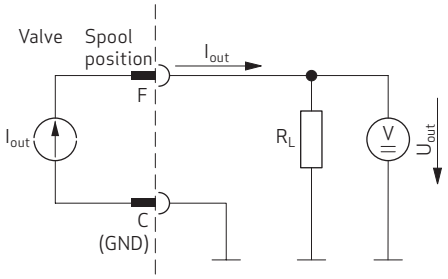


Actual Value 4 to 20 mA, Ordering Code X or E

The signal can be used for monitoring and fault detection purposes. The spool position is proportional to I_{out}. The spool position corresponds to 4 to 20 mA. At 12 mA the spool is in center position.

20 mA corresponds to 100 % valve opening P → A and B → T. A cable fault is detected by I_{out} = 0 mA.

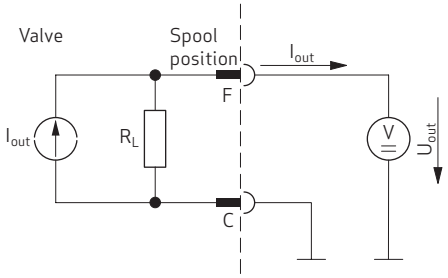
Actual value U_{out} = 2 to 10 V with resistor RL = 500 Ω (0.25 W) provided by the customer.



Actual Value -10 to +10 V, Ordering Code H

The spool position is proportional to Uout. The spool position corresponds to -10 to +10 V. At 0 V the spool is in center position.

+10 V corresponds to 100 % valve opening P → A and B → T.



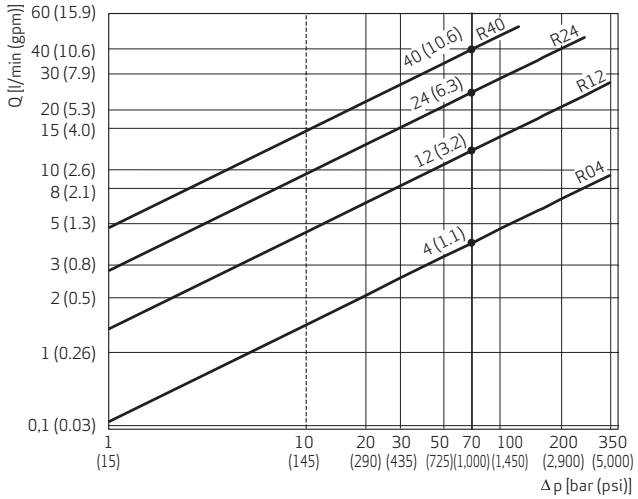
FLOW CALCULATION

When the valve is open the prevailing flow is dependent not only on the spool position, (i.e. the opening cross section of the valve), but also on the pressure drop at the individual lands. When the valve is deflected at 100 %, it delivers the rated flow with the rated pressure drop. The rated flow of a servo valve corresponds to a pressure drop of 35 bar (500 psi) per land, equating to 70 bar (1,000 psi) for two lands. When a valve is opened at 100 %, the flow can be calculated as a function of the actual pressure drop with the aid of the formula below, or it can be taken from the diagram.

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

Q [l/min (gpm)]	actual flow
Q_N [l/min (gpm)]	rated flow
Δp [bar (psi)]	actual pressure drop per spool land
Δp_N [bar (psi)]	rated pressure drop per spool land

Flow Chart



When operating the valves close to these application limits, it is necessary to drill the ports to the maximum possible diameters (see „Port Pattern of Mounting Surface“ on page 14).

ABOUT MOOG

Hydraulic Solutions

Since Bill Moog invented the first commercially viable servo valve in 1951, Moog has set the standard for world-class hydraulic technology. Today, Moog products are used in a variety of applications - providing high power, enhanced productivity and ever better performance for some of the worlds most demanding applications.

Electric Solutions

Clean operation, low noise generation, less maintenance and reduced power consumption make Moog electric solutions ideal for applications worldwide. Moog is the ideal partner for applications where transitioning technologies requires special expertise.

Hybrid Solutions

By incorporating the advantages of existing hydraulic and electric technologies - including modular flexibility, increased efficiency and cleanliness - into innovative hybrid solutions, Moog offers new performance potential in specialized applications.

Flight Simulation

Simulation Table

MOOG GLOBAL SUPPORT

Moog Global Support is our promise to offer world-class Repair and Maintenance Services delivered expertly by our trained technicians. With the reliability only available from a leading manufacturer with facilities around the world, Moog offers you service and expertise you can count on to keep your equipment operating as it should.

This promise offers many benefits to our customers including:

- Reduce your downtime by keeping critical machines running in peak performance
- Protect your investment by ensuring reliability, versatility and long-life of products
- Better plan your maintenance activities and make systematic upgrades
- Leverage our flexible programs to meet the unique service requirements of your facility

Look to Moog for global support including:

- Repair services using OEM parts are performed by trained technicians to the latest specifications
- Stock management of spare parts and products to prevent unplanned downtime
- Flexible programs, tailored to your needs such as upgrades, preventative maintenance and annual/ multiyear contracts
- On-site services bring the expertise to you, providing quicker commissioning, set-up and diagnostics
- Access to reliable services that are guaranteed to offer consistent quality anywhere in the world

For more information on Moog Global Support visit **www.moog.com**

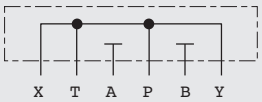
ACCESSORIES AND SPARE PARTS

Series-specific Accessories and Spare Parts

Spare Parts D936 Series Servo-Proportional Valves

Part name	Description	Material	Part number
Service sealing set	O-rings for ports P, T, A, B, Y, consisting of: 4 pieces inner Ø 9.25 mm (0.36 in) x Ø 1.8 mm (0.07 in) 1 piece inner Ø 7.65 mm (0.3 in) x Ø 1.8 mm (0.07 in)	FKM 90 Shore	B97215-V630F63
		HNBR 90 Shore	B97215-H630F61

Accessories D936 Series Servo-Proportional Valves

Part name	Description	Remark	Part number
Flushing plate	P, A, B, T, X, Y Mounting screws and O-rings included		B46634-002
Mating connector	Cable with straight mating connector 6-pole + PE	5, 10, 20 or 25 m, e.g. for 5 m specify 005, other length upon request	C21033-xxx-001
	Mating connector, elbow 6-pole + PE	In accordance with EN 175201-804, type S, metal, IP65, crimp contact Ø 0.75 to 1.5 mm^2 (0.0012 to 0.0023 in^2), conus Ø 12.2 mm (0.48 in), cable Ø 8 to 12 mm (0.31 to 0.47 in), sealing element Ø 9 to 13 mm (0.35 to 0.51 in)	B97069-061
	Mating connector, straight 6-pole + PE	In accordance with EN 175201-804, type R, metal, IP65, crimp contact Ø 0.75 to 1.5 mm^2 (0.0012 to 0.0023 in^2), conus Ø 12.2 mm (0.48 in), cable Ø 8 to 12 mm (0.31 to 0.47 in), sealing element Ø 9 to 13 mm (0.35 to 0.51 in)	B97007-061
Mounting screws	4 pieces M5x55, ISO 4762-10.9, tightening torque 6.8 Nm (60 lbf in)		A03665-050-055
Shipping plate	1 piece		B46035-001

ACCESSORIES AND SPARE PARTS

Documents D936 Series Servo-Proportional Valves

Part name	Description	Remark	Part number
Mounting and Installation Instruction D936 Series Valves	Installation Instructions	Visit www.moog.com to download a document using the part number in a search	B97072-936
Technical Note TN 353	Protective Grounding and Electrical Shielding of Hydraulic Valves with Integrated Electronics	Visit www.moog.com to download a document using the part number in a search	CA58437
Technical Note TN 494	Maximum Permissible Length of Electric Cables for Valves with Integrated Eletronics		CA48851

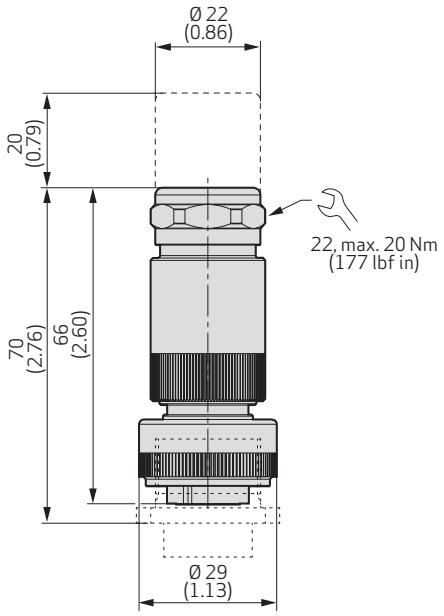
ACCESSORIES AND SPARE PARTS

Accessories - Installation Drawings

Mating Connector, Straight 6-pole + PE

In accordance with EN 175201-804, type R, metal, IP65, crimp contact Ø 0.75 to 1.5 mm² (0.0012 to 0.0023 in²), conus Ø 12.2 mm (0.48 in), cable Ø 8 to 12 mm (0.31 to 0.47 in), sealing element Ø 9 to 13 mm (0.35 to 0.51 in)

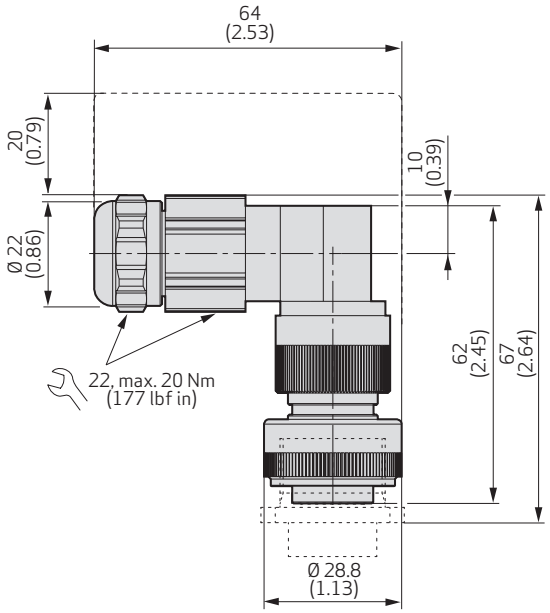
Part number B97007-061



Mating Connector, Elbow 6-pole + PE

In accordance with EN 175201-804, type S, metal, IP65, crimp contact Ø 0.75 to 1.5 mm² (0.0012 to 0.0023 in²), conus Ø 12.2 mm (0.48 in), cable Ø 8 to 12 mm (0.31 to 0.47 in), sealing element Ø 9 to 13 mm (0.35 to 0.51 in)

Part number B97069-061



NOTES

NOTES

NOTES

ORDERING CODE

Model number (assigned at the factory)

Type designation

1	2	3	4	5	6	7	
D936	-				-	**R**			**K**		**9**			...

Model designation

1	**Valve type**
R	Servo-Proportional Valve with integrated digital electronics

2	**Rated flow per spool land [l/min (gpm)]** [1]	
	For Δp_N = 35 bar (500 psi)	For Δp_N = 5 bar (75 psi)
04	4 (1.06)	1.5 (0.4)
08	8 (2.1)	3.0 (0.8)
12	12 (3.2)	4.5 (1.2)
15	15 (4.0)	5.7 (1.5)
20	20 (5.3)	7.6 (2.0)
24	24 (6.3)	9.1 (2.4)
25	25 (6.6)	9.5 (2.5)
40	**40 (10.6)**	**15.1 (4.0)**

3	**Pressure range [bar (psi)]**
	Maximum operating pressure
K	350 (5,000)

4	**Bushing/spool design** [1]
0	**4-way: zero lap, linear flow characteristic**
Y	4-way: zero lap, dual gain flow characteristic
L	4-way: zero lap, progressive flow characteristic
J	4-way: zero lap, linear flow characteristic, A:B = 2:1
E	4-way: zero lap, dual gain flow characteristic, A:B = 2:1

5	**Proportional solenoid**
9	Proportional solenoid on B side

6	**Spool position without electrical supply**
1	**Port P blocked, ports A and B connected to T**
2	**Ports P, A, B and T blocked**
F	P→B, A→T connected

7	**Y port**
0	**No Y port, p_{Tmax} = 280 bar (4,000 psi)**
3	With Y port, p_{Tmax} = 350 bar (5,000 psi)

ORDERING CODE

	8	9	10	11		13
...		**S**		**2**	**-**	**0**

13 Enable function	
0	No enable signal

11 Supply voltage	
2	24 V_{DC}, for more information, see section on "Electronics"

10 Command signals		
	Command signal	Actual value
H	**± 10 V**	**± 10 V**
E	4 to 20 mA	4 to 20 mA
X	± 10 mA	4 to 20 mA

9 Valve connector X1	
S	6-pole + PE EN 175201-804

8 Seal material	
H	**HNBR**
V	FKM

Note: Preferred options marked in bold.

1) Combinations of Rated Flows and Flow Characteristics

Rated Flow (Pos. 2)	**Flow Characteristics** (Pos. 4)			
	O, J	Y	E	L
04	X	X		
08				X
12	X			
15		X		
20				X
24	X			
25		X		
40	X	X	X	X

MORE PRODUCTS. MORE SUPPORT.

Moog designs a range of motion control products to complement those featured in this document. Moog also provides service and support for all of our products. For more information, contact the Moog facility closest to you.

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PIM/Rev. -, September 2019, CDL58904-en