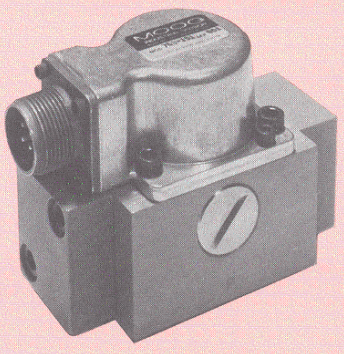
MOOG®

JET-PIPE

FLOW CONTROL SERVOVALVES

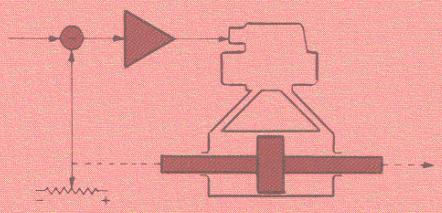
SERIES 750



CATALOG 751 585

MOOG SERIES 750 SERVOVALVE

The 750 Series is a high performance, two-stage design that can be supplied with rated flow up to 15 gpm at 1000 psi. The output stage is a closed center, four-way sliding spool. The jet-pipe pilot stage is driven by a double air gap, dry torque motor. Mechanical feedback of spool position is provided by a simple cantilever spring. The valve design is simple and rugged for dependable, long life operation.



In a conventional closed loop position control system, valve flow is applied to a hydraulic piston which drives the load. Load position is measured electrically and fed back for comparison with a signal representing the desired position. The resulting error signal is amplified, providing current input to the valve to control flow.

dry torque motor i
sealed compartmen

modular torque motor an
jet-pipe pilot stage assembl

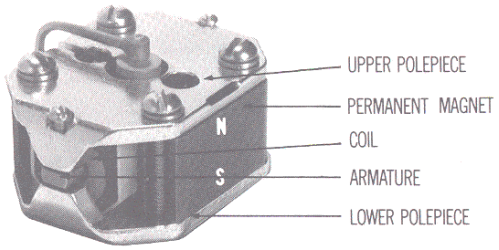
mechanical feedback wit
simple cantilever sprin

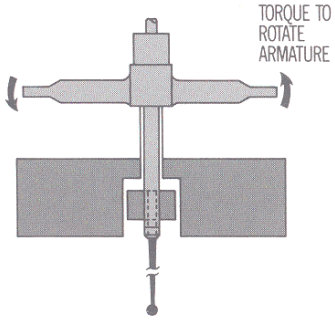
field replaceabl
100 μm absolut
filter for pilot stag

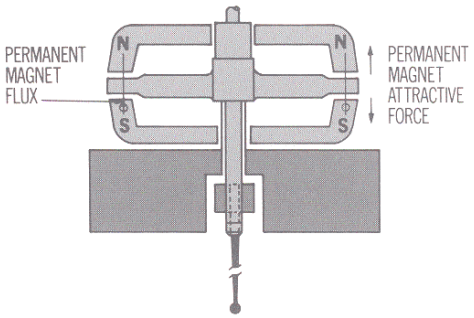
OPERATION

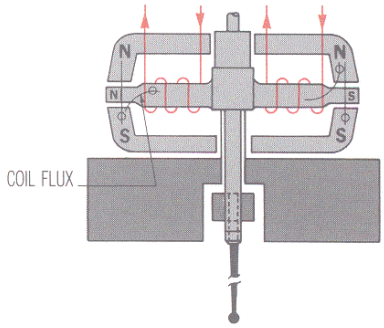
TORQUE MOTOR

- charged permanent magnets polarize polepieces
- dc current in coils causes increased force in diagonally opposite air gaps
- magnetic charge level sets magnitude of decentering force gradient on armature



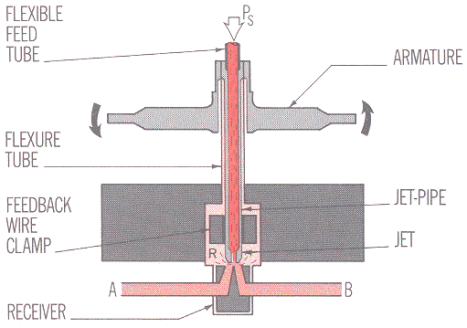


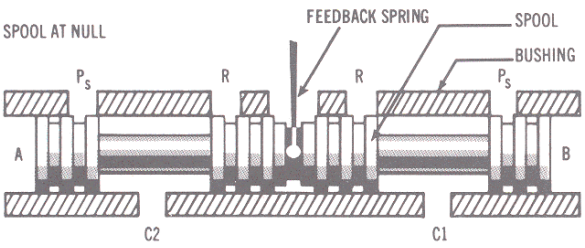


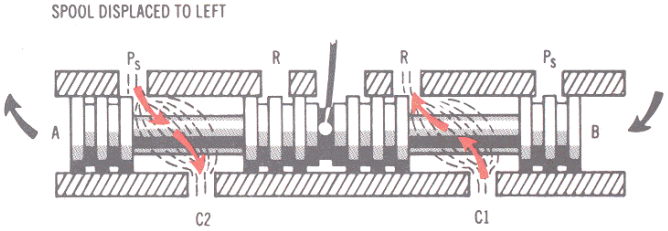


HYDRAULIC AMPLIFIER

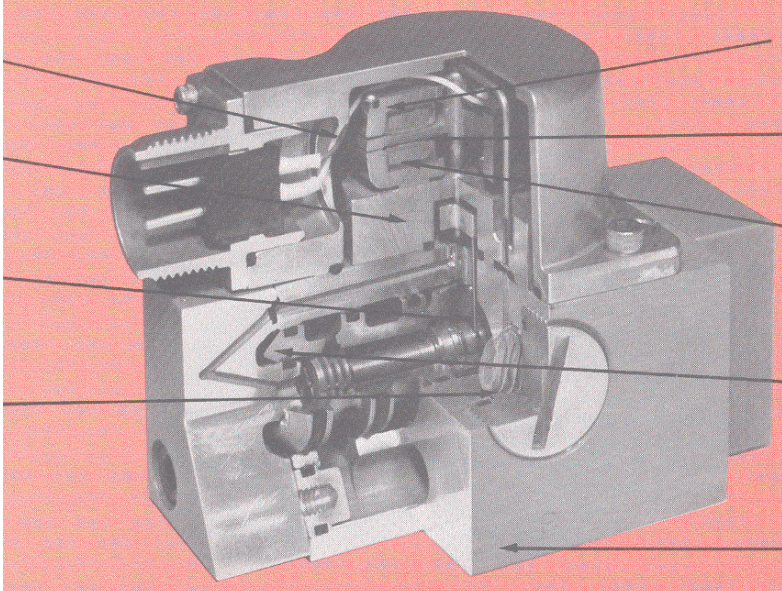
- armature and jet-pipe rigidly joined and supported by thin-wall flexure tube
- fluid continuously flows from supply pressure P_S through the first-stage filter, the flexible feed tube and the jet-pipe; exits at the jet; equally impinges upon the two receiver holes; and flows to return R through the cavity surrounding the jet
- rocking motion of armature/jet unbalances the amount of fluid impinging upon one receiver hole with respect to the other
- this causes a differential pressure and, therefore, affects fluid flow across A and B







DESIGN FEATURES*



balanced, double coil, double air gap torque motor

frictionless, flexure tube supported armature/jet-pipe

motor coils protected during thermal and vibration extremes by resilient potting

o-ring floated, center pinned bushing with convenient null adjust

rugged aluminum alloy body

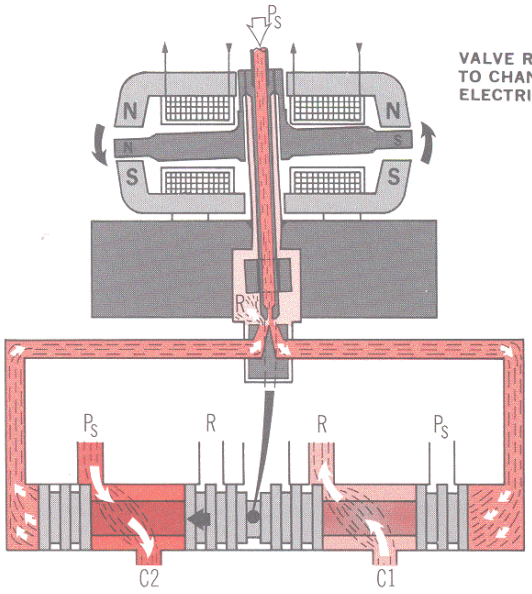
*Design features of 750 Series Servovalves are covered by U.S. Patents 3,023,782, 3,228,423 and 4,017,706 together with corresponding patents in several foreign countries.

VALVE SPOOL

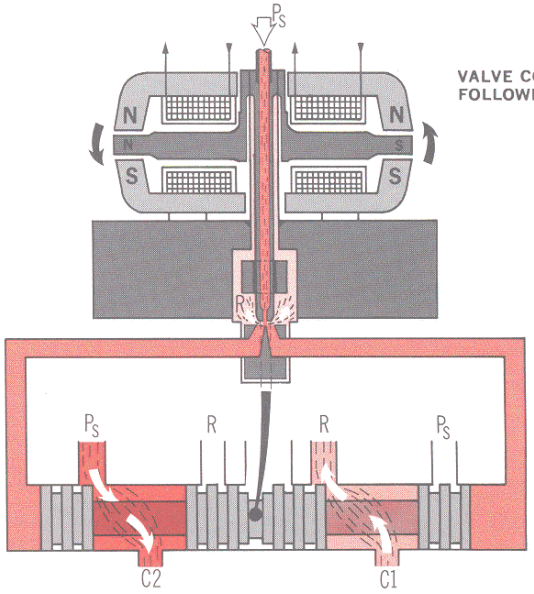
- 4-way spool slides in bushing (sleeve)
- bushing contains rectangular holes (slots) or annular grooves that connect to supply pressure P_S and return R
- at "null", spool is centered in bushing; spool lobes (lands) just cover P_S and R openings
- spool motion to either side of null allows fluid to flow from P_S to one control port, and from other control port to R

OPERATION

- electrical current in torque motor coils creates magnetic forces on ends of armature
- armature/jet-pipe assembly rotates about flexure tube support
- amount of fluid impinging upon one receiver hole increases with respect to the other and causes it to flow to that end of the spool
- spool moves and opens P_S to one control port; opens other control port to R
- spool pushes ball end of feedback spring, creating restoring torque on armature/jet-pipe
- as feedback torque becomes equal to torque from magnetic forces, armature/jet-pipe moves back to centered position
- spool stops at a position where feedback spring torque equals torque due to input current
- therefore, spool position is proportional to input current
- with constant pressures, flow to load is proportional to spool position



VALVE RESPONDING TO CHANGE IN ELECTRICAL INPUT



VALVE CONDITION FOLLOWING CHANGE

TERMINOLOGY

See Moog Technical Bulletin No. 117 for a complete discussion of servovalve terminology and test techniques.

ELECTRICAL

INPUT CURRENT The electrical current to the valve which commands control flow, expressed in milliamperes (ma).

RATED CURRENT The specified input current of either polarity to produce rated flow, expressed in milliamperes (ma). Rated current is specified for a particular coil connection (differential, series or parallel coils) and does not include null bias current.

QUIESCENT CURRENT A dc current that is present in each valve coil when using a differential coil connection. The polarity of the current in the two coils is reversed so that no signal input exists.

COIL IMPEDANCE The complex ratio of coil voltage to coil current. Coil impedance will vary with signal frequency, amplitude, and other operating conditions, but can be approximated by the dc coil resistance (ohms) and the apparent coil inductance (henrys) measured at a signal frequency.

DITHER An ac signal sometimes superimposed on the servovalve input to improve system resolution. Dither is expressed by the dither frequency (Hz) and the peak-to-peak dither current amplitude (ma).

HYDRAULIC

CONTROL FLOW The flow through the valve control ports to the load expressed in in^3/sec (cis), or gal/min (gpm), or liters/min (lpm).

RATED FLOW The specified control flow corresponding to rated current and given supply and load pressure conditions. Rated flow is normally specified as the no-load flow and is expressed in cis, or gpm, or lpm.

FLOW GAIN The nominal relationship of control flow to input current, expressed as cis/ma, or gpm/ma, or lpm/ma.

NO-LOAD FLOW The control flow with zero load pressure drop, expressed in cis, or gpm, or lpm.

INTERNAL LEAKAGE The total internal valve flow from pressure to return with zero control flow (usually measured with control ports blocked), expressed in cis, or gpm, or lpm. Leakage flow will vary with input current, generally being a maximum at the valve null (called NULL LEAKAGE).

LOAD PRESSURE DROP The differential pressure between the control ports (that is, across the load actuator), expressed in lbs/in^2 (psi), or bar.

VALVE PRESSURE DROP The sum of the differential pressures across the control orifices of the servovalve spool, expressed in psi or bar. Valve pressure drop will equal the supply pressure, minus the return pressure, minus the load pressure drop $[P_V = (P_S - P_R) - P_L]$.

PERFORMANCE

LINEARITY The maximum deviation of control flow from the best straight line of flow gain. Expressed as percent of rated current.

SYMMETRY The degree of equality between the flow gain of one polarity and that of reversed polarity, measured as the difference in flow gain for each polarity and expressed as percent of the greater.

HYSTERESIS The difference in valve input currents required to produce the same valve output as the valve is slowly cycled between plus and minus rated current. Expressed as percent of rated current.

THRESHOLD The increment of input current required to produce a change in valve output. Valve threshold is usually measured as the current increment required to change from an increasing output to a decreasing output. Expressed as percent of rated current.

LAP In a sliding spool valve, the relative axial position relationship between the fixed and movable flow-metering edges with the spool at null. Lap is measured as the total separation at zero flow of straight line extensions of the nearly straight portions of the flow curve, drawn separately for each polarity. Expressed as percent of rated current.

PRESSURE GAIN The change of load pressure drop with input current and zero control flow (control ports blocked). Expressed as the nominal psi/ma or bar/ma throughout the range of load pressure between $\pm 40\%$ supply pressure.

NULL The condition where the valve supplies zero control flow at zero load pressure drop.

NULL BIAS The input current required to bring the valve to null, excluding the effects of valve hysteresis. Expressed as percent of rated current.

NULL SHIFT The change in null bias resulting from changes in operating conditions or environment. Expressed as percent of rated current.

FREQUENCY RESPONSE The relationship of no-load control flow to input current when the current is made to vary sinusoidally at constant amplitude over a range of frequencies. Frequency response is expressed by the amplitude ratio (in decibels, or db), and phase angle (in degrees), over a specific frequency range.

UNITS

Recommended English and Metric (SI) units for expressing servovalve performance include the following:

	English	Metric	Conversion
fluid flow	in^3/sec (cis) gal/min (gpm)	liters/min (lpm)	0.98 lpm/cis 3.78 lpm/gpm
fluid pressure	lb/in^2 (psi)	bars	0.069 bars/psi
dimensions	inches (in)	millimeters (mm) micrometers (μm)	25.4 mm/in 25400 μm/in
weight	pounds (lb)	kilograms (kg)	0.454 kg/lb
force	pounds (lb)	Newtons (N)	4.45 N/lb
torque	in-lb	Newton-meters (N-m)	0.113 N-m/in-lb
temperature	degrees Fahrenheit (°F)	degrees Celsius (°C)	°C = 5/9 (°F − 32)

HYDRAULIC CHARACTERISTICS

Unless specified otherwise, all performance parameters are given for valve operation on Mobil DTE-24 fluid at 100°F (38°C).

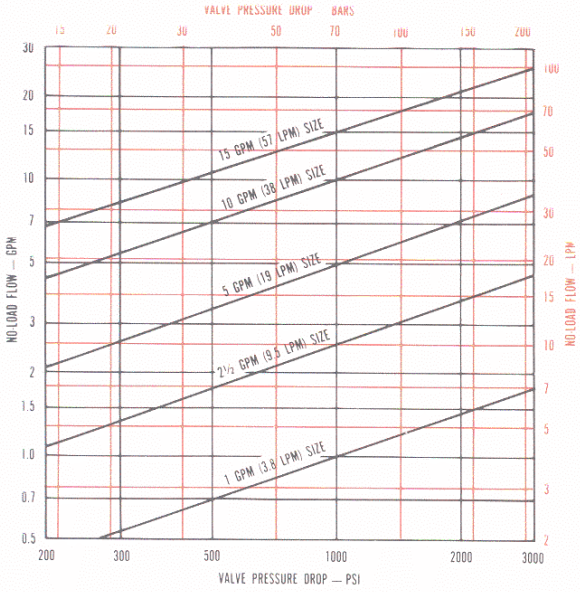


FIGURE 1 CHANGE IN RATED FLOW WITH PRESSURE

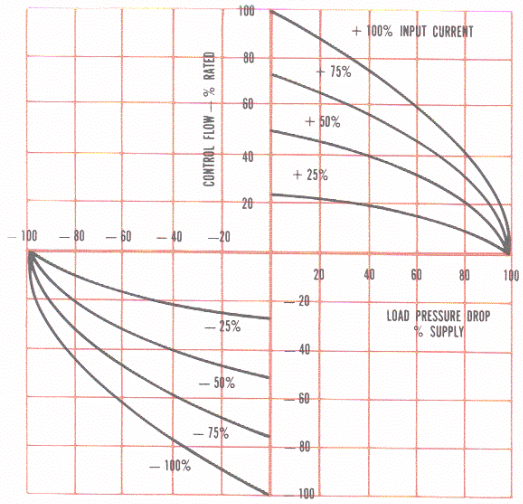


FIGURE 2 CHANGE IN CONTROL FLOW WITH CURRENT AND LOAD PRESSURE

FLUID SUPPLY 750 Servovalves are intended to operate with constant supply pressure.

Supply Pressure	
minimum	200 psi (14 bars)
maximum	3000 psi (210 bars)
Proof Pressure	
at pressure port	150% supply
at return port	100% supply
Fluid†	petroleum base hydraulic fluids 60-450 SUS @ 100°F (10-97 cSt @ 38°C)
Supply filtration	25μm absolute or finer ($\beta_{25} = 75$)
Operating temperature	
minimum (max. fluid viscosity 6000 SUS)	−40°F (−40°C)
maximum	+275°F (+135°C)

†Buna N seals are standard; Viton A and EPR available on special order.

RATED FLOW Rated flow is defined at a valve pressure drop of 1000 psi (70 bars). The change in rated flow with valve pressure drop is shown in Figure 1.

Rated flow of 750 Series Servovalves is limited by the porting size. Three port patterns are available:

Valve Series	Port Circle Diameter		Maximum Rated Flow 5% Nonlinearity		Maximum Rated Flow 10% Nonlinearity	
	in	mm	gpm	lpm	gpm	lpm
751-XXX	0.625	15.88	8	30	10	38
752-XXX	0.780	19.81	10	38	12	45
753-XXX	0.937	23.81	12	45	15	57

FLOW-LOAD CHARACTERISTICS Control flow to the load will change with load pressure drop and electrical input as shown in Figure 2. These characteristics follow closely the theoretical square-root relationship for sharp-edged orifices, which is

$$Q_L = K\, i \sqrt{P_V}$$

Q_L = control flow
K = valve sizing constant
i = input current
P_V = valve pressure drop

INTERNAL LEAKAGE Maximum internal leakage is determined by the valve rated flow. Figure 3 shows the maximum leakage at 1000 psi (70 bars) supply for typical 750 Series Servovalves.

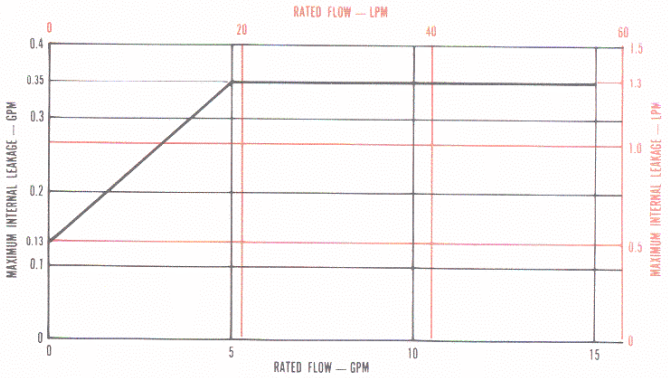


FIGURE 3 MAXIMUM INTERNAL LEAKAGE

PERFORMANCE CHARACTERISTICS

Unless specified otherwise, all performance parameters are given for valve operation on Mobil DTE-24 fluid at 100°F (38°C).

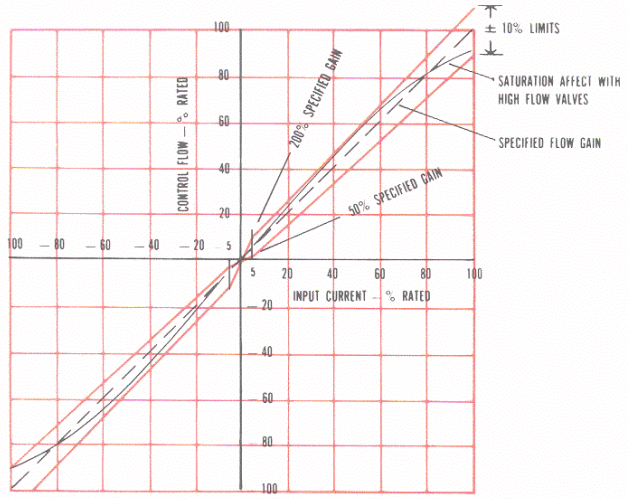


FIGURE 4 NO-LOAD FLOW GAIN TOLERANCES

FLOW GAIN The no-load flow characteristics of 750 Servovalves can be plotted to show flow gain, symmetry and linearity. Typical limits (excluding hysteresis effects) are shown in Figure 4.

NULL FLOW GAIN Nonlinearity of control flow to input current in the null region is due to variations in the spool cut. With standard production tolerances, valve flow gain about null (within ±5% of rated current input) may range from 50 to 200% of the specified flow gain. Special null cuts are available.

RATED FLOW TOLERANCE		±10%
SYMMETRY		<10%
HYSTERESIS		<3%
THRESHOLD		<½%
NULL SHIFT		
With Temperature	100°F variation (56°C)	<±2%
With Acceleration	to 10 g	<±2%
With Supply Pressure	1000 psi change (70 bars)	<±2%
With Back Pressure	0 to 500 psi (35 bars)	<±2%

SPOOL DRIVING FORCES
The maximum hydraulic force available to drive the second-stage spool will depend upon the supply pressure. The standard first-stage configuration for 750 Servovalves will typically produce a spool driving force gradient which exceeds 4 lb/% input current with 3000 psi supply. The maximum spool driving force with 3000 psi supply is 200 pounds. Servovalves with 50% higher spool driving force and gradient are available.

PRESSURE GAIN The blocked load differential pressure will change rapidly from one limit to the other as input current causes the valve spool to traverse the null region. Normally the pressure gain at null for 750 Servovalves exceeds 30% of supply pressure for 1% of rated current and can be as high as 100%.

NULL ..... externally adjustable

FREQUENCY RESPONSE Typical response characteristics for 750 Servovalves are shown in Figures 5, 6 and 7. Servovalve frequency response will vary with signal amplitude, supply pressure, temperature, and internal valve design parameters. The variation in response with supply pressure, as expressed by the change in frequency of the 90° phase point, is given in Figure 8.

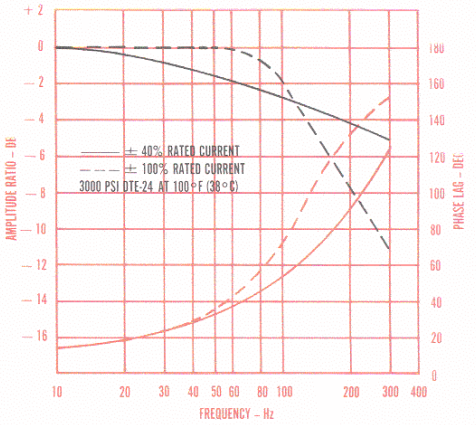


FIGURE 5 FREQUENCY RESPONSE OF 1 TO 5 GPM SERVOVALVES

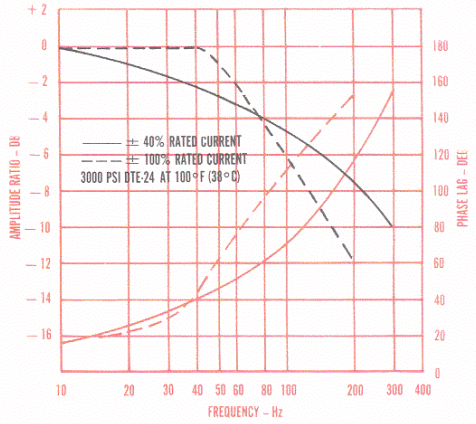


FIGURE 6 FREQUENCY RESPONSE OF 10 GPM SERVOVALVES

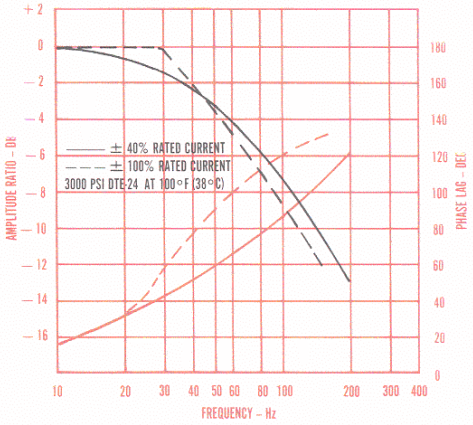


FIGURE 7 FREQUENCY RESPONSE OF 15 GPM SERVOVALVES

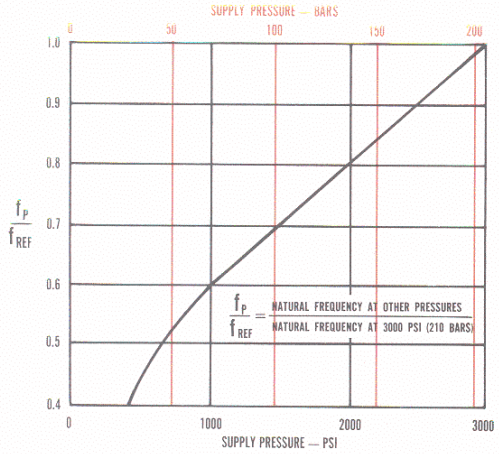


FIGURE 8 FREQUENCY RESPONSE CHANGE WITH PRESSURE

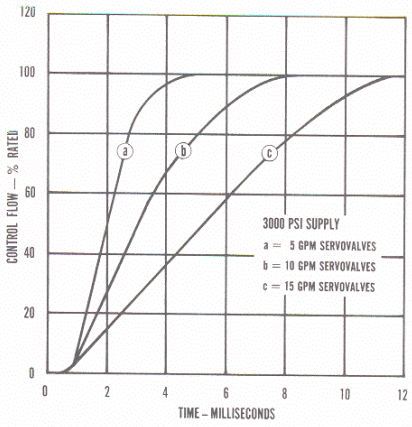


FIGURE 9 STEP RESPONSES

STEP RESPONSE

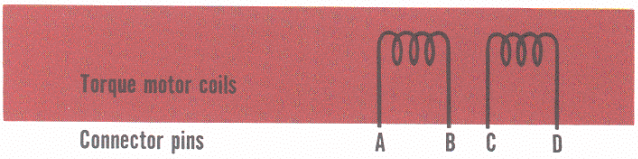
Typical transient response of 750 Servovalves is given in Figure 9. The straight-line portion of the response represents saturation flow from the pilot stage which will vary with the square root of the change in supply pressure.

ELECTRICAL CHARACTERISTICS

RATED CURRENT & COIL RESISTANCE

A wide variety of coils is available for 750 Servovalves. Table I lists some of the more popular configurations and their parameters. Contact the factory with other requirements.

STANDARD ELECTRICAL CONFIGURATION



External connections and electrical polarity for flow out C2 are

single coils: A+, B−; or C+, D−
series coils: tie B to C; A+, D−
parallel coils: tie A to C and B to D; A & C+, B & D−

NOMINAL RESISTANCE PER COIL AT 77°F (25°C) OHMS	RECOMMENDED RATED CURRENT—MA		APPROXIMATE COIL INDUCTANCE*—HENRYS		
	Parallel or Single Coil Operation	Series Coils	Single Coils	Series Coils	Parallel Coils
22	200	100	0.07	0.21	0.06
80	40	20	0.22	0.66	0.18
200	20	10	0.72	2.2	0.59
1000	10	5	3.2	9.7	2.6

*Measured at 50 Hz

Table I. Available Coils for 750 Servovalves

COIL CONNECTIONS A four-pin electrical connector (that mates with an MS3106-14S-2S) is standard. All four torque motor leads are available at the connector so external connections can be made for series, parallel, or differential operation.

750 Servovalves can be supplied on special order with other connectors or a pigtail. Also, the coils can be wired internally for 2- or 3-wire operation.

SERVOAMPLIFIER The servovalve responds to input current, so a servoamplifier that has high internal impedance (as obtained with current feedback) should be used. This will reduce the effects of coil inductance and will minimize changes due to coil resistance variations.

DITHER A small amplitude dither signal may be used to improve system performance. If used, it is recommended that dither frequency be 200 to 300 Hz and peak-to-peak amplitude be less than 20% of rated current.

COIL IMPEDANCE The resistance and inductance of standard coils are given in Table I. The two coils in each servovalve are wound for equal turns with a normal production tolerance on coil resistance of ±12%. Copper magnet wire is used so the coil resistance will vary significantly with temperature. The effects of coil resistance changes can be essentially eliminated through use of a current feedback servoamplifier having high output impedance.

Inductance is determined under pressurized operating conditions and is greatly influenced by back emf's of the torque motor. These effects vary with most operating conditions, and vary greatly with signal frequencies above 100 Hz.

ACCESSORIES

ORDER PART NUMBER

FLUSHING BLOCK

751-XXX & 752-XXX A01704-1
753-XXX A01704-2

MATING ELECTRICAL CONNECTOR

(MS3106-14S-2S) 061-49054F14S-2S

1 Valve weight 2.0 lbs (0.9 kg).

2 Surface to which valve is mounted requires $\frac{32}{\sqrt{}}$ (▽▽▽) finish, flat within 0.001 in (0.025 mm).

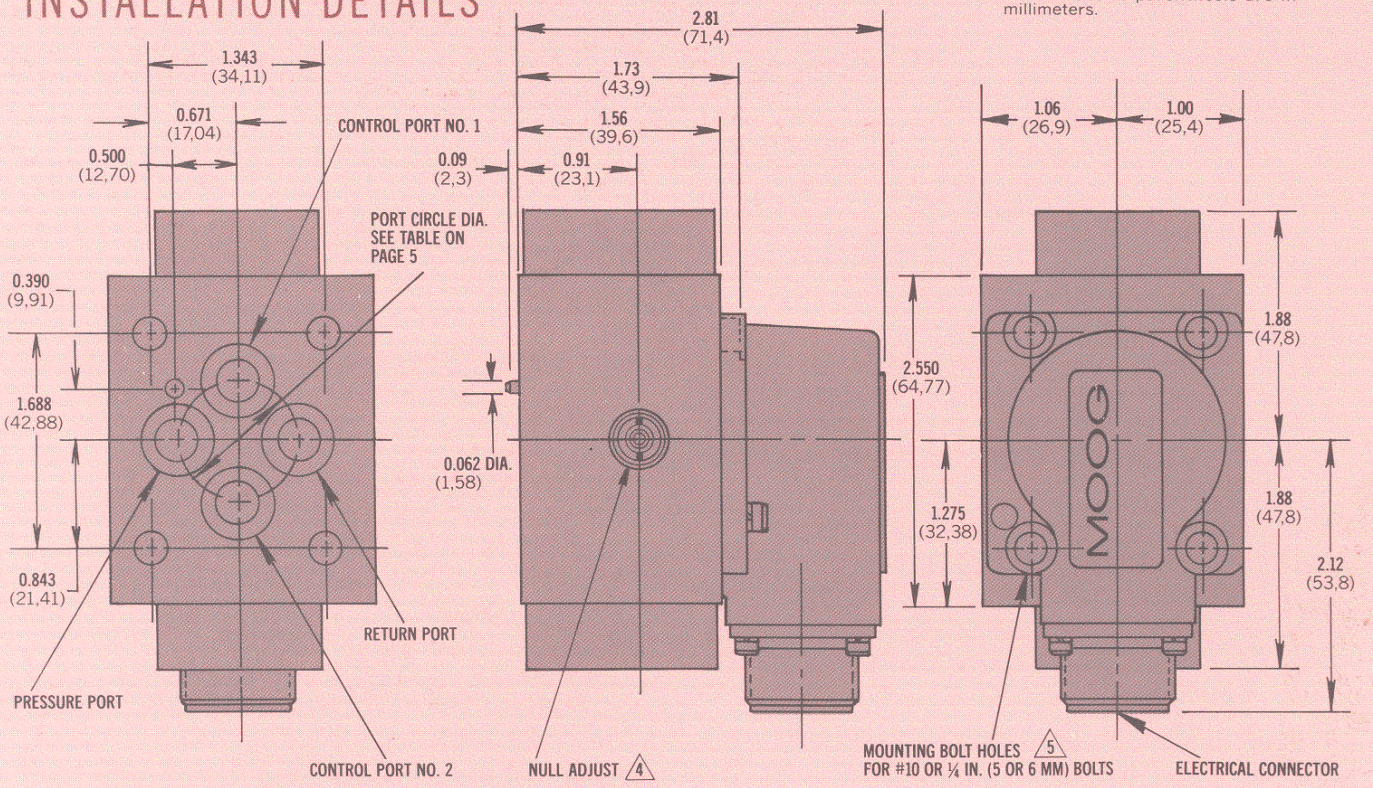
△3 Standard electrical connector mates with MS3106-14S-2S or equivalent.

△4 Null adjust: flow out of port No. 2 will increase with clockwise rotation of null adjustment.

△5 Mounting bolt size must be specified at time of order. Grade #5 bolts with 2.0 in (50 mm) minimum length recommended.

6 Dimensions in parenthesis are in millimeters.

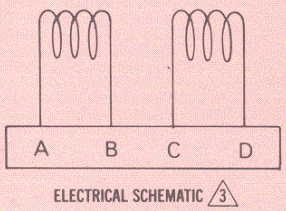
INSTALLATION DETAILS



STANDARD MODELS

3000 psi Max. Operating Pressure (210 bars)

Rated Flow @ 1000 psi (70 bars) Valve Pressure Drop		ELECTRICAL CHARACTERISTICS 200Ω/coil ±20 mA	80Ω/coil ±40 mA
gpm	lpm	parallel	parallel
1	3.8	753-100	—
2.5	9.5	753-101	—
5	19	753-102	—
10	38	753-103	—
15	57	—	753-104



ELECTRICAL SCHEMATIC △3