CATALOG 762 578

KEEP FOR REFERENCE

A0 76

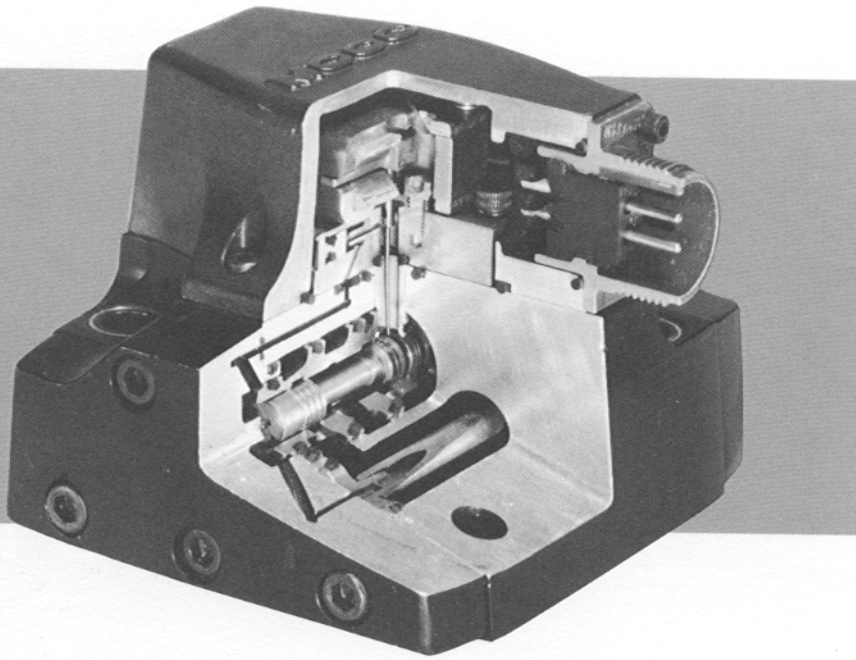
MOOG®

A0 76

TWO-STAGE FLOW CONTROL SERVOVALVE

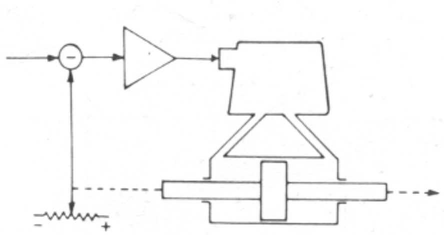
MOOG A076 SERVOVALVE

The A076 is the latest version of the famous 76 Series of Moog servovalves. This new design provides better flow linearity for high flow models, it significantly extends the high pressure and pressure impulse capabilities of the valve, it permits a 5th port option for separate pilot pressurization, and it incorporates changes that improve the integrity of the filter.



The A076 is a high performance, two-stage design that covers the range of rated flows from 1 to 15 gpm at 1000 psi (4 to 58 lit/min at 70 bars). The output stage is a closed center, four-way, sliding spool. The pilot stage is a symmetrical double-nozzle and flapper, 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.

The spool and sleeve assembly floats on o-rings in an aluminum alloy body. This isolates the spool from side loading that could be imposed by mounting the valve on a slightly uneven manifold. A convenient null adjustment is provided by an eccentric pin that locates the sleeve. The pilot stage is built-up as a separate subassembly that can be removed without upsetting careful spacing of the torque motor parts.



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.

OPERATION

Moog A076 Servovalves use an electrical torque motor, a double-nozzle pilot stage, and a sliding-spool second stage. Electrical current in the torque motor gives proportional displacement of the second stage spool; hence, proportional flow to the load.

TORQUE MOTOR

The torque motor includes coils, polepieces, magnets, and an armature. The armature is supported for limited pivotal movement by a flexure tube. The flexure tube also provides a fluid seal between the hydraulic and electromagnetic portions of the valve.

PILOT STAGE

The flapper attaches to the center of the armature and extends down, inside the flexure tube. A nozzle is located on each side of the flapper so that flapper motion varies the nozzle openings. Pressurized hydraulic fluid is supplied to each nozzle through a filter and inlet orifice. Differential pressures caused by flapper movement between the nozzles are applied to the ends of the valve spool.

DESIGN FEATURES*

- rugged forged aluminum alloy body
- o-ring floated, center pinned bushing with convenient null adjust
- dry torque motor in sealed compartment
- frictionless, flexure tube supported armature-flapper
- modular torque motor and pilot stage assembly
- balanced, double coil, double air gap torque motor
- mechanical feedback with simple cantilever spring
- spool-bushing diametral tolerances held within 35 microinches (1 micrometer)
- motor coils protected during thermal and vibration extremes by resilient potting
- filter surface flushed by 2nd stage fluid flow
- 5th port for separate pilot supply available on certain models
- alternate 90° locations of motor cap available on special order

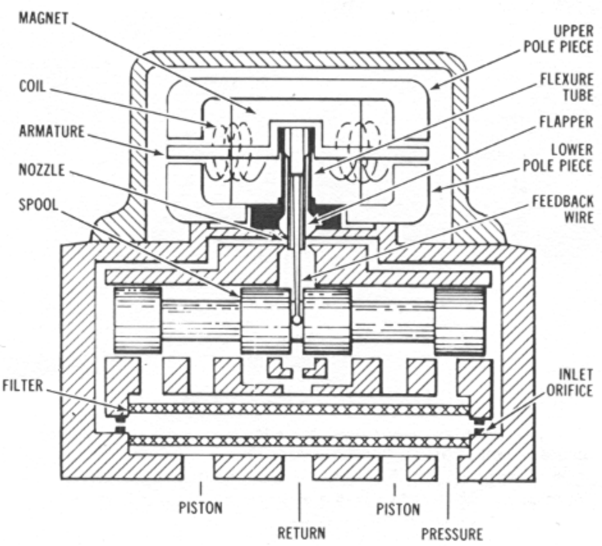
*Design features of AO76 Servovalves are covered by U.S. Patents 3,023,782 and 3,228,423 together with corresponding patents in several foreign countries.

VALVE SPOOL

The 4-way valve spool controls flow from the supply to either control port (C1 or C2). Simultaneously, the other control port is opened to fluid return. The spool fits in a sleeve that contains openings which are uncovered by spool motion to meter flow to the load. Various valve rated flows are provided by sizing these openings in the sleeve. Spool motion deflects a cantilever feedback wire that applies torque to the armature-flapper.

OPERATION

Electrical current in the torque motor coils causes either clockwise or counter-clockwise torque on the armature. This torque displaces the flapper between the two nozzles. The differential nozzle flow moves the spool to either the right or left. The spool continues to move until the feedback torque counteracts the electromagnetic torque. At this point the armature/flapper is returned to center, so the spool stops and remains displaced until the electrical input changes to a new level. Therefore, valve spool position is proportional to the electrical signal. The actual flow from the valve to the load will depend upon the supply and load pressures as described on page 5 under Rated Flow.



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 lit/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 bars.

VALVE PRESSURE DROP The sum of the differential pressures across the control orifices of the servovalve spool, expressed in psi or bars. 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 bars/ma throughout the range of load pressure between ± 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)	lit/min (lpm)	1 lpm/cis 3.8 lpm/gpm
fluid pressure	lbs/in^2 (psi)	bars	0.07 bars/psi
dimensions	inch (in)	millimeters (mm) micrometers (μm)	25.4 mm/in 25400 μm/in
weight	pounds (lb)	kilogram (kg)	0.45 kg/lb
force	pounds (lb)	deka Newtons (daN)	0.45 daN/lb
torque	in-lbs	deka Newton meters (daNm)	0.011 daNm/in-lb
temperature	degrees Fahrenheit (°F)	degrees Celsius (°C)	°C = 5/9(°F—32)

*useful approximations for about 2% accuracy.

HYDRAULIC CHARACTERISTICS

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

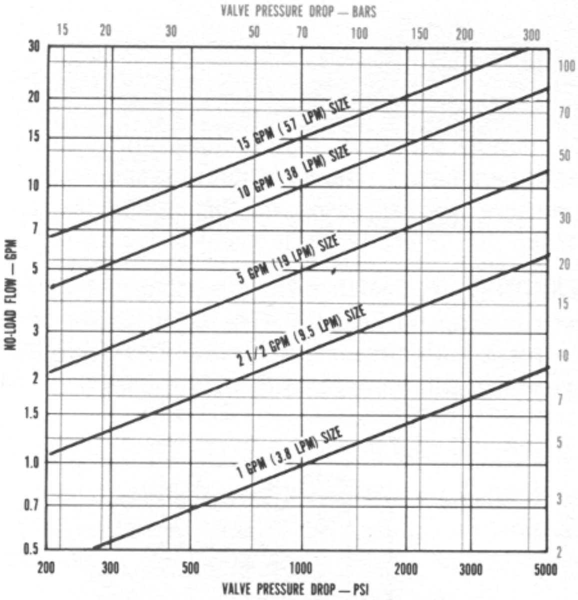


FIGURE 1 CHANGE IN RATED FLOW WITH PRESSURE

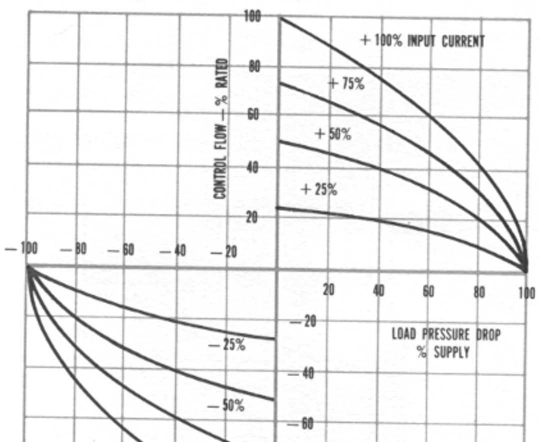


FIGURE 2 — CHANGE IN CONTROL FLOW WITH CURRENT AND LOAD PRESSURE

FLUID SUPPLY A076 Servovalves are intended to operate with constant supply pressure.

Supply Pressure	
minimum	200 psi (14 bars)
maximum standard	3000 psi (210 bars)
maximum special order	5000 psi (350 bars)
Proof Pressure	
at pressure port	150% supply
at return port	100% supply
NFPA static pressure rating* (test pressure 10,700 psi)	6900 psi
NFPA cyclic pressure rating (pressure port)* (cyclic test pressure 4350 psi for > 10^6 cycles)	3000 psi
Fluid†	petroleum base hydraulic fluids 60-450 SUS @ 100° F (10-97 cST @ 38° C)
Supply filtration required	10μm nominal (25μm absolute) or finer recommended
Operating temperature	
minimum	− 40° F (− 40° C)
maximum (unless limited by fluid)	+ 275° F (+ 135° C)

*Method of verifying static and fatigue pressure ratings per NFPA/T2.6.1-1974, category 3/90.

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

RATED FLOW Five standard sizes are available having rated flows of 1, 2½, 5, 10, and 15 gpm at 1000 psi valve drop (3.8, 9.5, 19, 38, and 57 lit/min at 70 bars). See plot at left for corresponding rated flows at other supply pressures.

Flow with various combinations of supply pressure and load pressure drop can be determined by calculating the valve pressure drop.

$$P_V = (P_S - P_R) - P_L$$

P_V = valve pressure drop
P_S = supply pressure
P_R = return pressure
P_L = load pressure drop

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 for each size servovalve is:

Flow with 1000 psi (70 bars) Supply

Rated Flow	Internal Leakage
1 gpm (3.8 lit/min)	< 0.17 gpm (0.66 lit/min)
2½ gpm (9.5 lit/min)	< 0.22 gpm (0.83 lit/min)
5 gpm (19 lit/min)	< 0.35 gpm (1.32 lit/min)
10 gpm (38 lit/min)	< 0.35 gpm (1.32 lit/min)
15 gpm (57 lit/min)	< 0.35 gpm (1.32 lit/min)

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

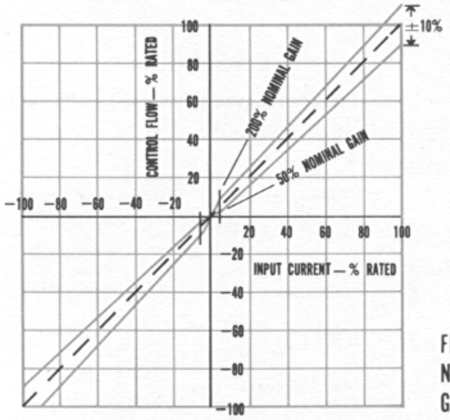


FIGURE 3
NO-LOAD FLOW
GAIN TOLERANCES

FLOW GAIN The no-load flow characteristics of AO76 Servovalves can be plotted to show flow gain, symmetry, and linearity. Typical limits (excluding hysteresis effects) are shown in Figure 3.

LINEARITY The nonlinearity of control flow to input current will be most severe in the null region due to variations in the spool null cut. With standard production tolerances valve flow gain about null (within ±5% of rated current input) may range from 50 to 200% of the normal flow gain.

RATED FLOW TOLERANCE ± 10%

SYMMETRY < 10%

HYSTERESIS < 3%

THRESHOLD < ½%

SPOOL DRIVING FORCES

The maximum hydraulic force available to drive the second-stage spool will depend upon the supply pressure, and the hydraulic amplifier pressure gradient. The normal first-stage configuration for AO76 Servovalves will produce a spool driving force gradient which exceeds 1 lb/% (0.4 daN/%) input current with a 3000 psi (210 bars) supply. This gradient will be reduced about 30% when operating on a 1000 psi (70 bars) supply. The maximum spool driving force with 3000 psi (210 bars) supply is 150 pounds (67 daN)

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 AO76 Servovalves exceeds 30% of supply pressure for 1% of rated current and can be as high as 80%.

NULL externally adjustable

NULL SHIFT

With Temperature	100°F variation (56°C)	<±2%
With Acceleration	to 10 g	<±2%
With Supply Pressure	80% to 110% nominal	<±2%
With Quiescent Current	50% to 100% rated current	<±2%
With Back Pressure	0% to 20% of supply	<±2%

FREQUENCY RESPONSE Typical response characteristics for AO76 Servovalves are shown in Figures 4 and 5. 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 6.

STEP RESPONSE Typical transient response of AO76 Servovalves is given in Figure 7. The straight-line portion of the response represents saturation flow from the pilot stage which will increase with higher supply pressures.

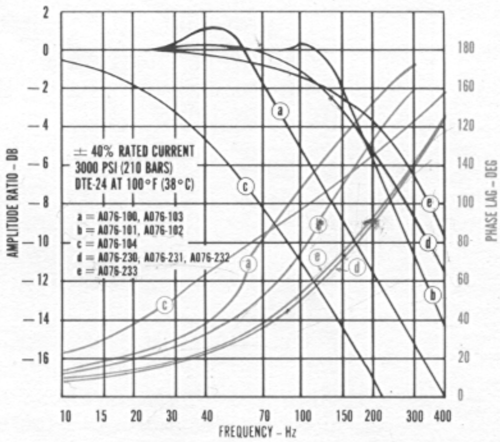


FIGURE 4 REDUCED AMPLITUDE FREQUENCY RESPONSE

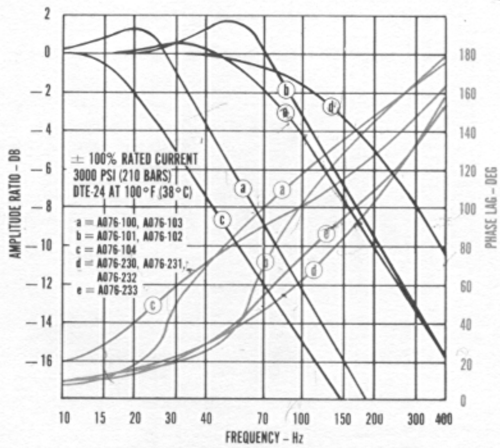


FIGURE 5 FULL AMPLITUDE FREQUENCY RESPONSE

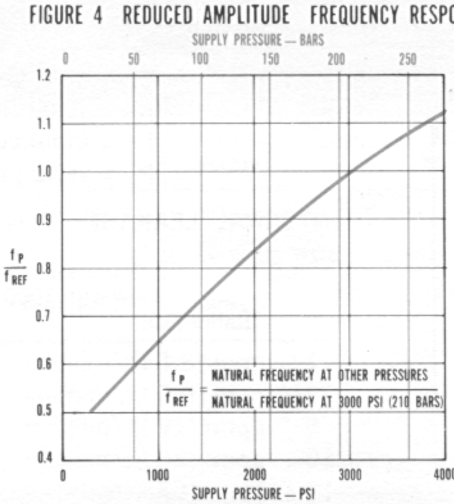


FIGURE 6 FREQUENCY RESPONSE CHANGE WITH PRESSURE

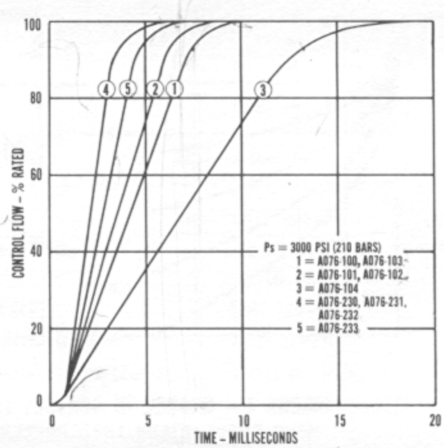


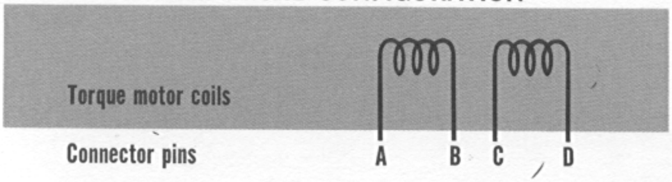
FIGURE 7 STEP RESPONSE

ELECTRICAL CHARACTERISTICS

RATED CURRENT & COIL RESISTANCE
A variety of coils are available for AO76 Servovalves, so there is a wide choice of rated current. See Table I. It is possible to derate a coil to give a lower rated current than listed, thus rated current may be 8 ma differential for a 1000 ohm/coil valve.

AO76 Servovalves can be supplied with internal resistors to give higher resistance for a given rated current. Thus 670 ohm resistors with 130 ohm coils will give 30 ma rated differential current with 800 ohm/coil.

STANDARD ELECTRICAL CONFIGURATION



External connections and electrical polarity for flow out C1 are

- single coils: B+, A–; or D+, C–
- series coils: tie B to C; D+, A–
- parallel coils: tie A to C and B to D; B & D+, A & C–
- differential coils: tie B to C
  - with B & C+, current B to A > C to D
  - with B & C–, current D to C > A to B

COIL CONNECTIONS A four-pin electrical connector (that mates with a 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.

AO76 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.

QUIESCENT CURRENT If used, it is recommended that quiescent current not exceed 100% rated current.

DITHER A small amplitude dither signal may be used to improve system performance. If used it is recommended that dither frequency be 200 to 400 Hz and less than 20% rated current amplitude.

COIL IMPEDANCE The resistance and inductance of standard coils are given in the Table below. 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. The apparent coil inductance values given are determined at 50 Hz.

Table I. Available Coils for AO76 Servovalves

NOMINAL RESISTANCE PER COIL AT 70° F (21° C) OHMS	RECOMMENDED RATED CURRENT—MA		APPROXIMATE COIL INDUCTANCE — HENRYS			
	Differential, Parallel or Single Coil Configuration	Series Coils	Single Coils	Differential* Coils	Series Coils	Parallel Coils
22	200	100	0.07	0.10	0.21	0.06
40	50	25	0.12	0.19	0.36	0.10
80	40	20	0.22	0.34	0.66	0.18
130	30	15	0.37	0.58	1.1	0.30
200	20	10	0.72	1.1	2.2	0.59
500	15	7.5	1.3	2.1	4.1	1.1
1000	10	5	3.2	5.0	9.7	2.6
1500	8	4	4.1	6.4	12.5	3.4

*Inductance per coil with differential operation (class A push-pull).

STANDARD MODELS

Moog maintains five different models of the A076 Servovalve in stock. Characteristics of these stock models are controlled for optimum system performance in usual applications.

These stock valves are made in production quantities, so each user gains the cost and technical advantages of an established production design.

STANDARD DESIGNS ARE AVAILABLE AS INDICATED BELOW

MODELS CARRIED IN STOCK 3000 psi (210 bars) Maximum Supply				STANDARD DESIGN MODELS					
RATED FLOW @ 1000 psi (70 bars) Valve Pressure Drop		ELECTRICAL RATING		3000 PSI (210 BARS) MAXIMUM SUPPLY PRESSURE					
				HIGH CURRENT	LOW CURRENT		HIGH RESPONSE	5th PORT	
Gpm	Lit/Min	200 Ω/Coil 15 ma Diff.	80 Ω/Coil 40 ma Diff.	22 Ω/Coil 200 ma Diff.	1000 Ω/Coil 8 ma Diff.	1000 Ω/Coil 10 ma Diff.	80 Ω/Coil 40 ma Diff.	200 Ω/Coil 15 ma Diff.	80 Ω/Coil 40 ma Diff.
1	3.8	A076-100		A076-177	A076-190		A076-230	A076-550	
2½	9.5	A076-101		A076-178	A076-191		A076-231	A076-551	
5	19	A076-102		A076-161	A076-192		A076-232	A076-552	
10	38	A076-103		A076-179	A076-193		A076-233	A076-553	
15	57		A076-104	A076-180		A076-194			A076-554

ACCESSORIES

ORDER PART NUMBER

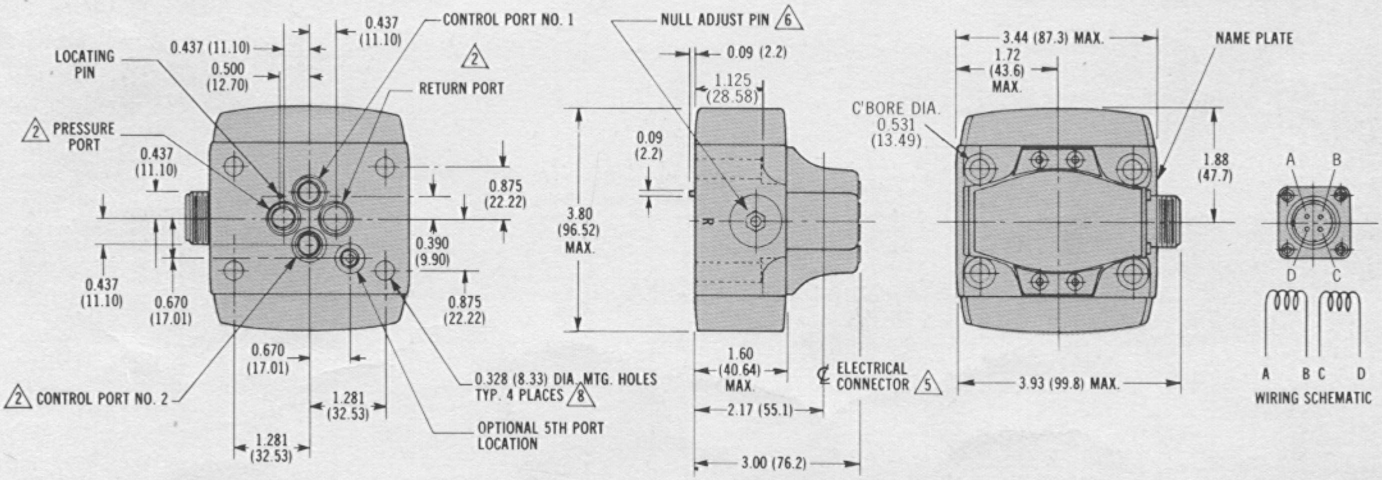
FLUSHING BLOCK 100-23718-1

ADAPTER MANIFOLDS for ¾-inch tubing,
(SAE industrial straight threads)
4 ports 100-43586-1
5 ports 100-43586-3

MATING ELECTRICAL CONNECTOR
(MS3106-14S-2S) 061-49054F14S-2S

1. Valve weight 2.3 lbs (1.03 kg)
2. (△) Ports: 0.343 (8.71) dia c'bored nominally 0.560 (14.22) O.D. x 0.055 (1.40) deep
3. Manifold O-Rings 0.070 (1.78) sect x 0.426 (10.82) I.D.
4. Surface to which valve is mounted requires 32/(▽▽▽) finish, flat within 0.001 (0.025)
5. (△) Electrical connector mates with MS3106-14S-2S or equivalent
6. (△) Null adjust: flow out of port No. 2 will increase with clockwise rotations of null adjust pin
7. Compressed oil volume for one control port: 0.229 in³ (3,75 cm³)
8. (△) Suggested mounting screws — 0.312-18 x 1.750 lg (M8 x 45) socket head screw (4 REQD)
9. Dimensions in parenthesis are in millimeters

INSTALLATION DETAILS



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