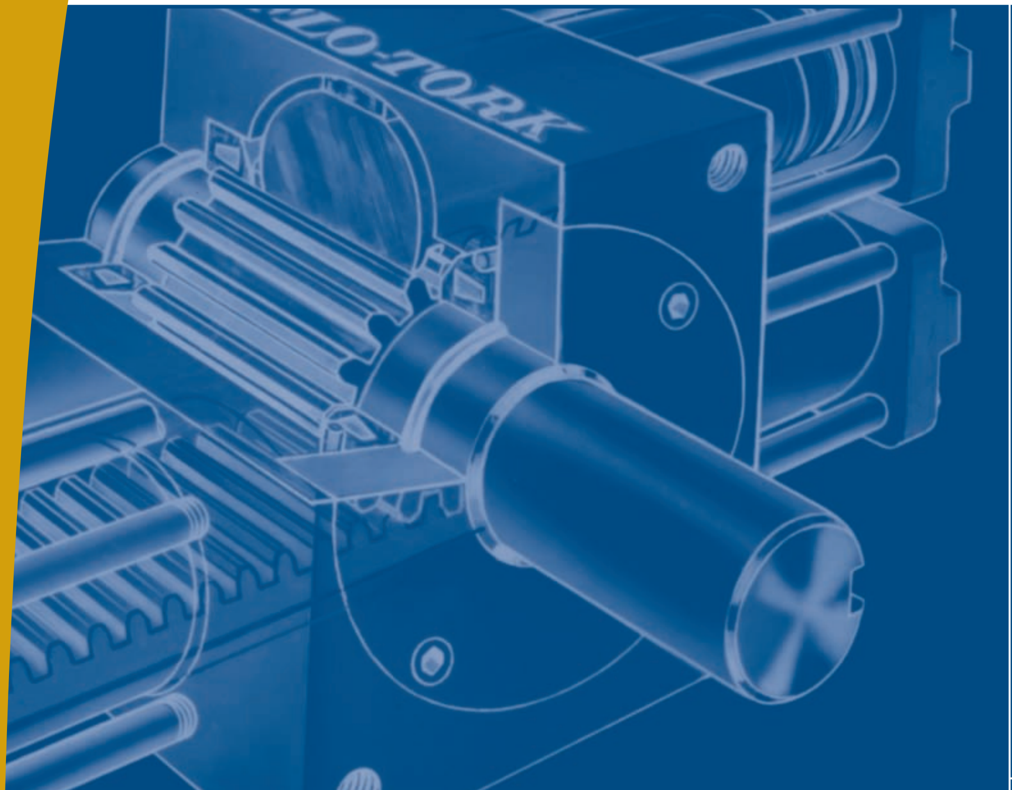
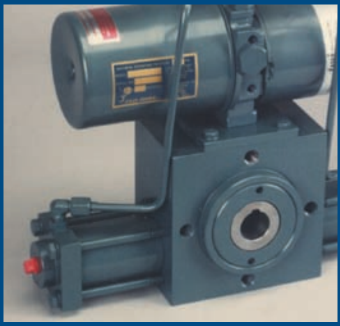
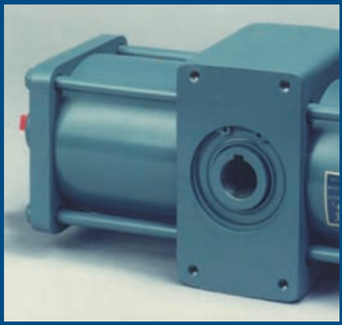
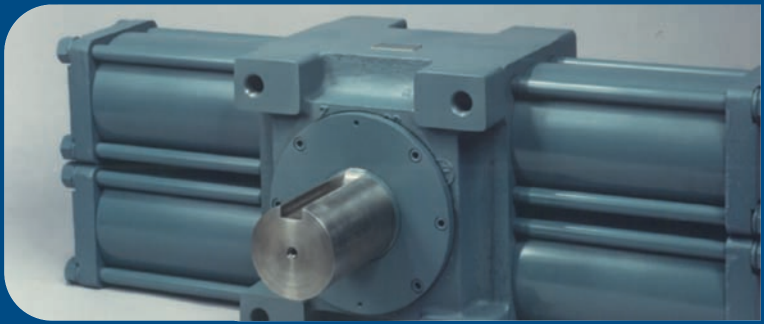


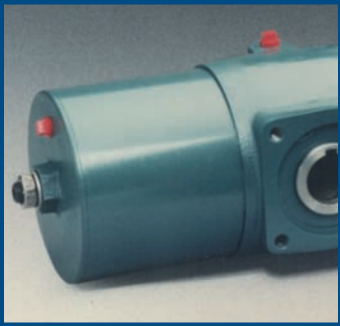
ROTARY ACTUATORS

IMAGINE A WORLD WHERE YOUR CRITICAL SERVICE ACTUATION PROBLEMS ARE SOLVED









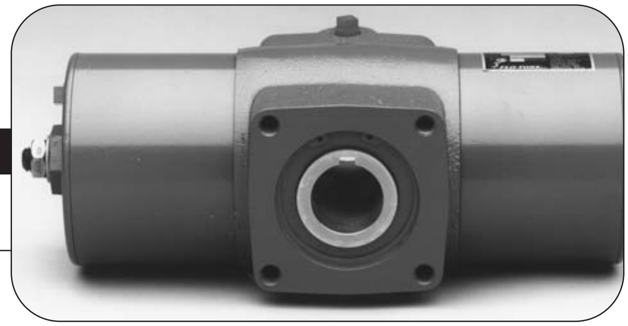
FLO-TORK,® INC.

A SERIES

Single rack, full feature pneumatic rotary actuators

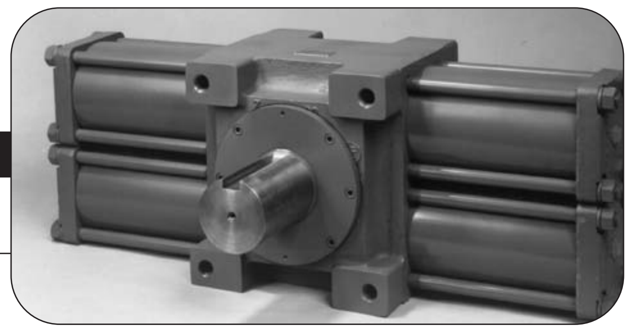
P SERIES

High torque, double rack pneumatic rotary actuators



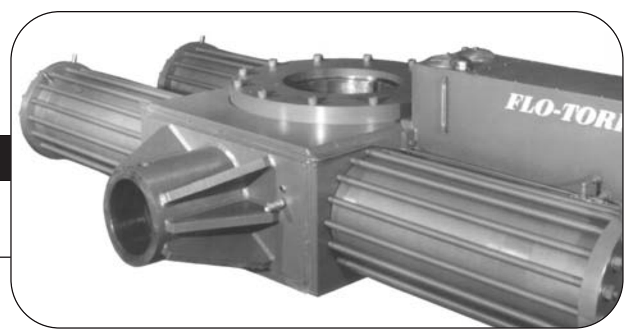
HYDRAULIC SERIES

Heavy duty, single and double rack hydraulic rotary actuators



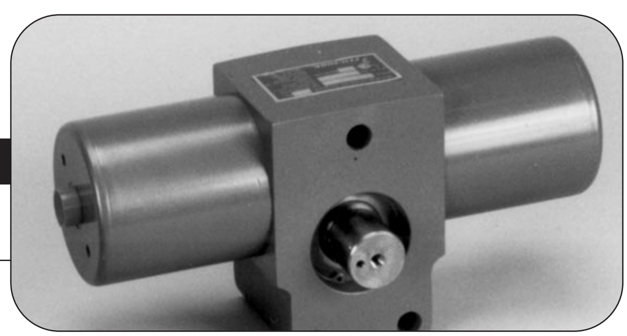
MEGATORK

Large hydraulic rotary actuators built to customer specifications



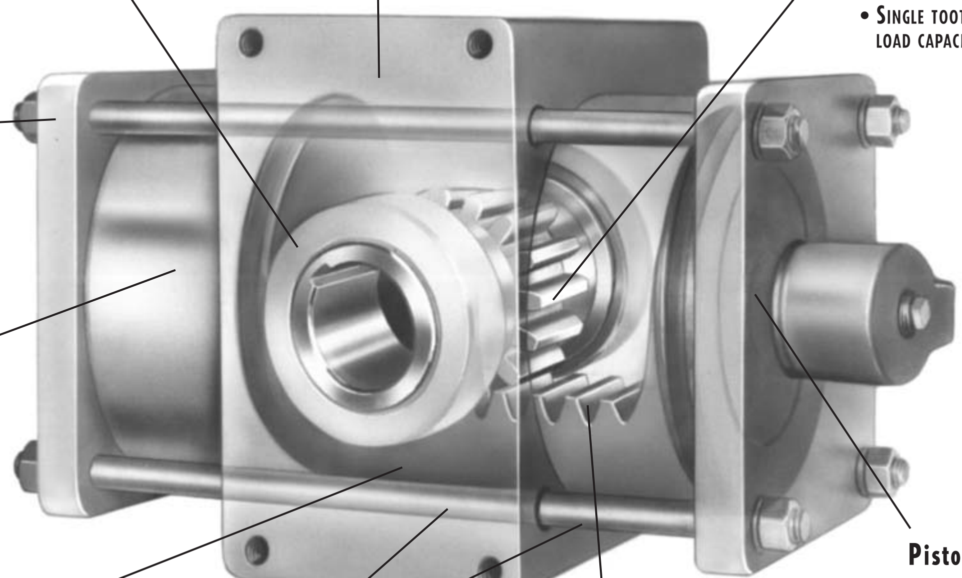
SPEC-TORK

Custom rotary actuators designed to OEM specifications



FLO-TORK, INC.

PNEUMATIC ROTARY ACTUATORS



A1000 TIE ROD DESIGN SHOWN

(Other models shown on page 5)

DESIGN FEATURES

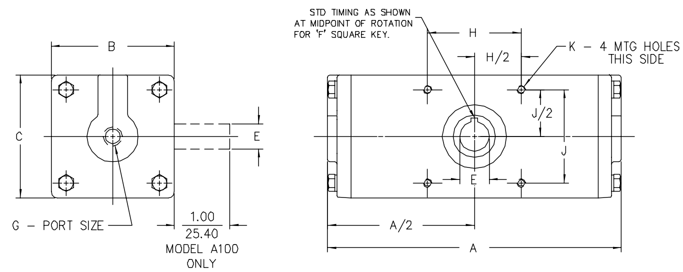
- High Pressure - 125 psi max.
- Torque Range - 100 to 10,000 lb. in. @ 100 psi
- Standard Rotations - 94, 184, 364 degrees
- Rack & Pinion - High Mechanical Efficiency
- Zero Leakage - High Volumetric Efficiency
- Precision Bearings - High Load Capacity, Low Friction
- Piston Seals - Block-V
- Gearing - Single Tooth Full Load Capacity
- Operating Temperature - 0 to 200 degrees F
- A100 & A500 - Extruded Aluminum Housing -Hard Coat Anodized

STANDARD OPTIONS

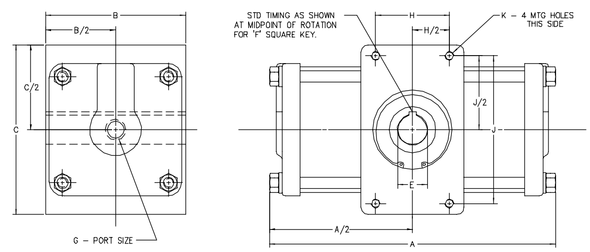
- Adjustable Cushions
- Stroke Adjustors
- NPT or SAE O-Ring Ports
- End Ports or Side Ports
- Mounting Variations
- Shafting Variations
- Customer Specified Rotations
- Custom Sealing Arrangements
- Special Coatings

ENVELOPE DIMENSIONS

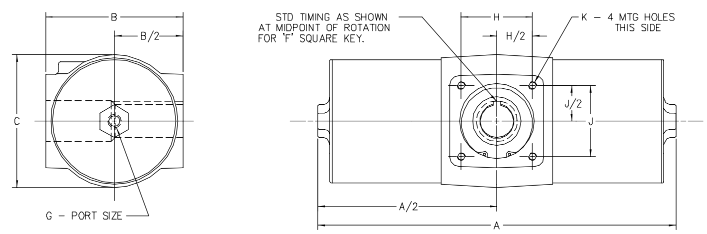
MODELS A100 AND A500



MODEL A1000



MODELS A4000 AND A10000

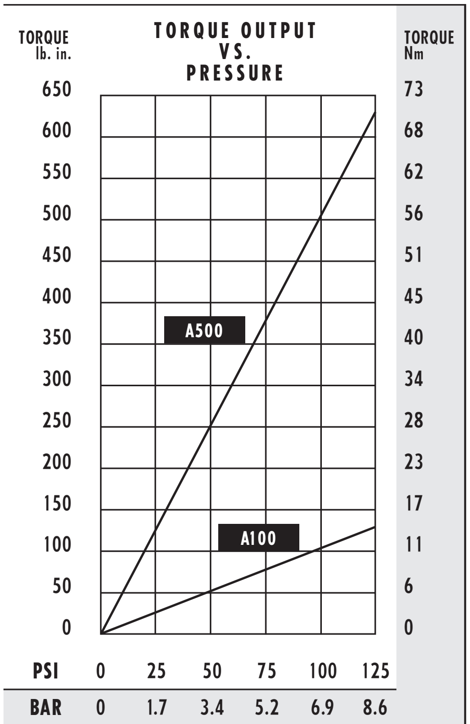


MODEL NO.	ROTATION DEGREES	A		B	C	E	F	G	H	J	K
		in	mm	in mm	in mm	in mm	in	in	in mm	in mm	in
	94°	4.37	111.00	2.50	2.50	.4985 .5000			1.75	1.75	1/4″ NC
A100	184°	5.55	140.97				1/8″ X 3/4″	1/4″ NPT			X
	364°	7.90	200.66	63.50	63.50	12.66 12.70			44.45	44.45	5/16″ DP
	94°	7.11	180.59	3.63	3.63	.875 .876			2.75	2.75	1/4″ NC
A500	184°	9.63	244.60				3/16" X 3-5/8"	1/4" NPT			X
	364°	14.65	372.11	92.20	92.20	22.23 22.25			69.85	69.85	1/2" DP
	94°	10.08	256.03	4.75	5.75†	1.000 1.002			2.50	5.00	5/16″ NC
A1000	184°	13.22	335.79				1/4″ X 4-3/4″	3/8″ NPT			X
	364°	18.44	468.38	120.65	146.05	25.40 25.45			63.50	127.00	5/8″ DP
	94°	13.95	354.33	7.25	7.00†	1.750 1.752			3.75	3.75	7/16″ NC
A4000	184°	18.96	481.58				3/8″ X 3-1/2″*	3/8″ NPT			X
	364°	29.11	739.39	184.15	177.80	44.45 44.50			95.25	95.25	3/4″ DP
	94°	18.54	470.92	9.38	9.25†	2.250 2.252			5.00	5.00	5/8″ NC
A10000	184°	25.57	649.48				1/2″ X 4″*	1/2″ NPT			X
	364°	39.70	1008.38	238.25	234.95	57.15 57.20			127.00	127.00	1″ DP

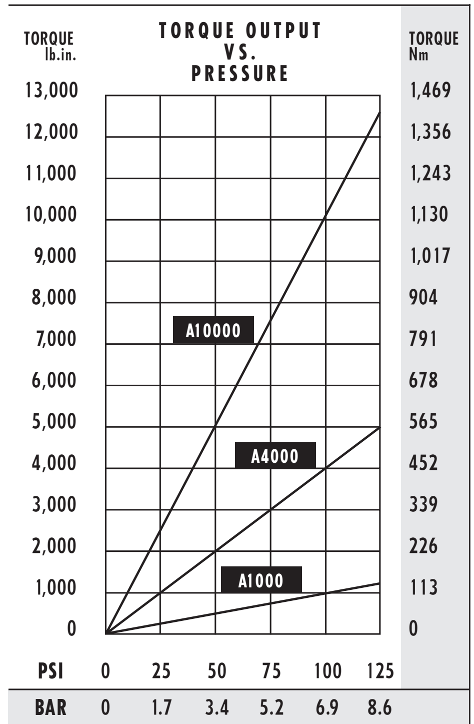
*Keyway engagement is measured from the front face.
† Dimensions shown are "As Cast" Dimensions.
(See Option pages 7-10 and Technical Data pages 24, 25 and 30-35 in ACT-125)

TYPICAL PERFORMANCE

A100 & A500



A1000 TO A10000

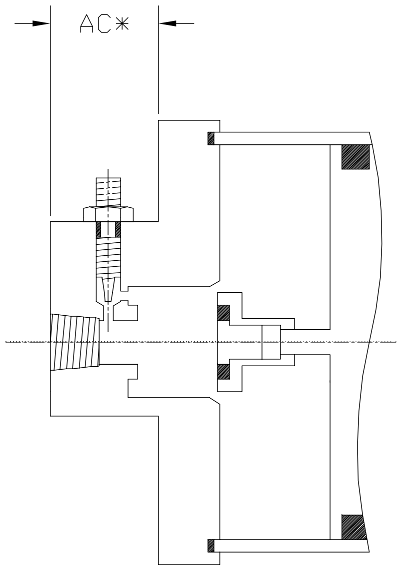


MODEL NUMBER	TORQUE* FACTOR	OUTPUT TORQUE (lb.in.) AT VARIOUS PRESSURES*			
		40 psi	60 psi	100 psi	125 psi
A100	1.0	40	60	100	125
A500	5.0	200	300	500	625
A1000	10.0	400	600	1,000	1,250
A4000	40.0	1,600	2,400	4,000	5,000
A10000	100.0	4,000	6,000	10,000	12,500

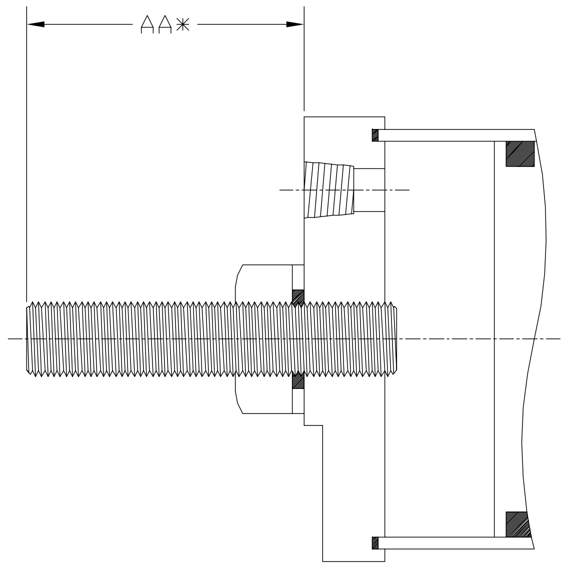
* Output torque (lb.in.) = Torque Factor x Operating Pressure (psi).
Example: Model A1000 @ 60 psi delivers (10.0x60=) 600 lb. in. torque.

MODEL NUMBER	DISPLACEMENT* FACTOR	DISPLACEMENT (in^3) PER STROKE*		
		94°	184°	364°
A100	.0206	1.94	3.79	7.50
A500	.1073	10.09	19.74	39.06
A1000	.2200	20.68	40.48	80.08
A4000	.7901	74.26	145.38	287.60
A10000	1.9749	185.64	363.38	718.86

*Displacement (in^3) = Displacement Factor x Rotational Arc (degrees).
Example: A500 x 184° displaces .1073 cu. in/degree x 184° = 19.74 in^3 displacement.



ADJUSTABLE CUSHION



0-20° EXTERNAL STROKE ADJUSTOR

Cushions

Cushions are designed to provide smooth deceleration, external energy absorption and noise reduction, over the last 15º of rotation. Cushions trap air at the end of stroke by blocking or restricting the discharge port. The trapped air is diverted through a small needle valve which generates a back pressure on the discharge side of the piston. This back pressure resists the forces exerted on the internal parts of the rotary actuator, thus causing a slowing of the external mass.

*Dimensions are shown on page 24.

Stroke Adjustors

Stroke adjustors are screw-type adjustable stops at end of rotation. They should be used when the exact final position of rotation is best determined on the assembled machinery or when final position requirements may vary with different machine set ups.

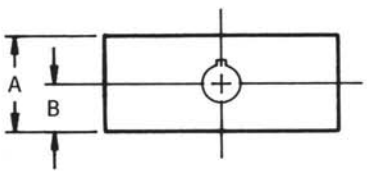
Caution: Cushion needles should be set between one half and one full turn from seated position. Setting should result in continuous speed reduction throughout the cushion length. Needle adjustment is set too far closed when there is an abrupt change in speed as the actuator enters the cushion. Never operate with needle in seated position or unscrewed beyond the point where the seal relief in the thread is visible.

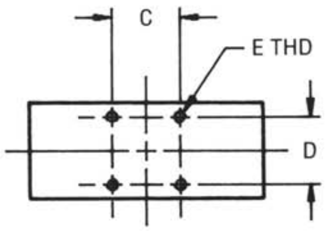
Caution: Cushion needle adjustment is a crucial factor in achieving optimum cushion performance. If the needle valve setting is too far open cushion capacity will be reduced or rendered ineffective; if set too far closed, cushion action will generate shock and pressure spikes in excess of actuator rating.

Note: Cushions and stroke adjustors are not available on the same cylinder end cap for standard models. Consult factory for special design considerations.

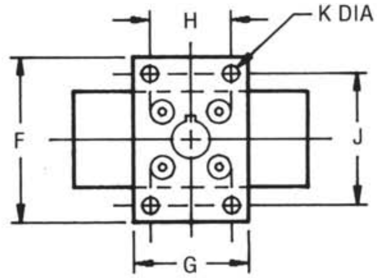
DIMENSIONS-MOUNTING OPTIONS

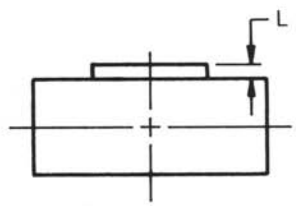
TOP & BOTTOM



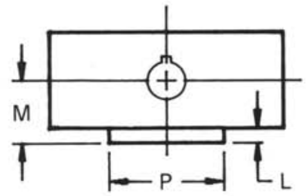


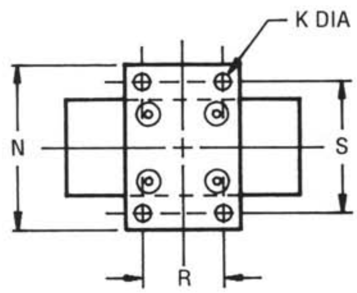
FACE FLANGE





BASE FLANGE



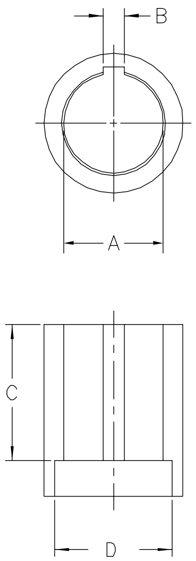


Model \ Dim.	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S
	in mm	in mm	in mm	in mm	in	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm
A100	2.50 63.50	1.25 31.75	1.75 44.45	1.75 44.45	1/4″ NC X 5/16″ DP	4.50 114.30	2.75 69.85	2.00 50.80	3.75 95.25	.28 7.11	.25 6.35	1.50 38.10	4.50 114.30	2.75 69.85	2.00 50.80	3.75 95.25
A500	3.63 92.20	1.81 45.97	2.75 69.85	2.75 69.85	1/4″ NC X 1/2″ DP	5.75 146.05	3.50 88.90	2.75 69.85	5.00 127.00	.28 7.11	.25 6.35	2.06 52.32	5.75 146.05	3.50 88.90	2.75 69.85	5.00 127.00
A1000	5.60 142.24	2.80 71.12	2.75 69.85	2.75 69.85	5/16″ NC X 5/8″ DP	8.00 203.20	3.50 88.90	2.50 63.50	7.00 177.80	.34 8.64	.38 9.65	3.18 80.77	7.25 184.15	3.75 95.25	2.75 69.85	6.25 158.75
A4000	NOT APPLICABLE					9.00 228.60	5.00 127.00	3.75 95.25	7.75 196.85	.47 11.94	.50 12.70	NOT APPLICABLE				
A10000	NOT APPLICABLE					11.75 298.45	6.25 158.75	5.00 127.00	10.50 266.70	.66 16.76	.75 19.05	NOT APPLICABLE				

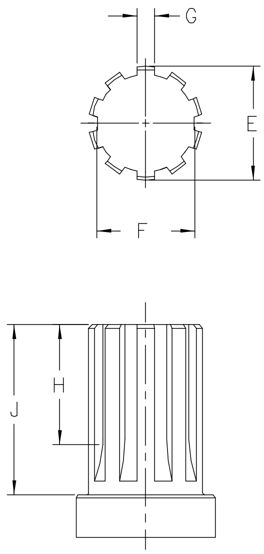
Dimensions are symmetrical about the centerline of the pinion.

SHAFT OPTIONS

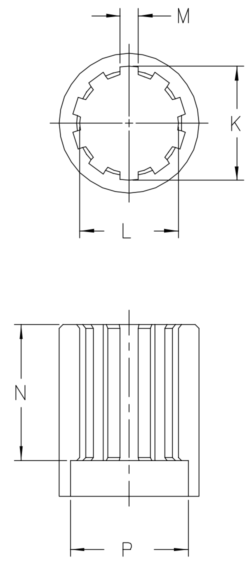
SINGLE END KEYED



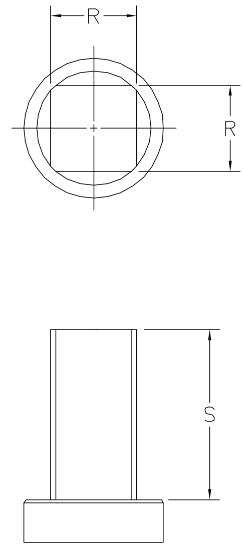
MALE SPLINE SAE 10B



FEMALE SPLINE SAE 10B



SQUARE



Model \ Dim.		A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S
		in	in	in	in	in	in	in	in	in	in	in	in	in	in	in	in
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
A100	in	.4985 .5000	.124 .125	.75	1.00	.497 .498	.419 .424	.074 .075	.75	1.31	NOT AVAILABLE					.374 .375	.97
	mm	12.66 12.70	3.15 3.18	19.05	25.40	12.62 12.65	10.64 10.77	1.88 1.91	19.05	33.27						9.50 9.53	24.64
A500	in	1.248 1.250	.311 .312	1.50	2.00	1.246 1.248	1.069 MAX	.190 .192	1.25	1.88	.874 .875	.752 .753	.135 .137	1.50	.881	.995 1.000	1.56
	mm	31.70 31.75	7.90 7.92	38.10	50.80	31.65 31.70	27.15	4.83 4.88	31.75	47.75	22.20 22.23	19.10 19.13	3.43 3.48	38.10	22.38	25.27 25.40	39.62
A1000	in	1.498 1.500	.374 .375	1.75	2.25	1.496 1.498	1.284 MAX	.230 .231	1.50	2.50	1.124 1.125	.967 .968	.174 .176	2.00	1.15	1.245 1.250	1.93
	mm	38.05 38.10	9.50 9.53	44.45	57.15	38.00 38.05	32.61	5.84 5.87	38.10	63.50	28.55 28.58	24.56 24.59	4.42 4.47	50.80	29.21	31.62 31.75	49.02
A4000	in	1.998 2.000	.499 .500	2.25	3.50	1.995 1.997	1.713 MAX	.307 .308	2.00	3.25	1.749 1.750	1.504 1.505	.271 .273	3.00	1.81	1.495 1.500	2.31
	mm	50.75 50.80	12.67 12.70	57.15	88.90	50.67 50.72	43.51	7.80 7.82	50.80	82.55	44.42 44.45	38.20 38.23	6.88 6.93	76.20	45.97	37.97 38.10	58.67
A10000	in	2.998 3.000	.749 .750	4.00	4.75	2.995 2.997	2.573 MAX	.462 .464	3.00	4.50	2.498 2.500	2.148 2.150	.387 .390	4.50	2.56	2.495 2.500	3.81
	mm	76.15 76.20	19.02 19.05	101.60	120.65	76.07 76.12	65.35	11.75 11.79	76.20	114.30	63.45 63.50	54.56 54.61	9.83 9.91	114.30	65.02	63.37 63.50	96.77

POSITION IDENTIFICATION PORTING

The following identification codes are used to specify the location of cushions, cushion adjustments, side ports, mountings, or other special requirements.

Surface Identification

MS1 - Front surface or face - bearing cap side

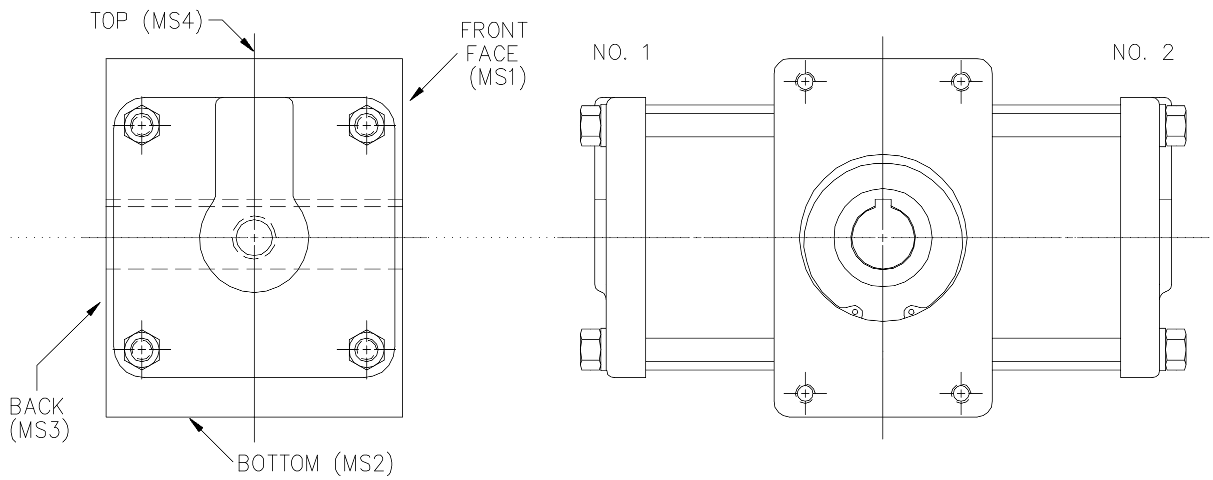
MS2 - Bottom surface - opposite keyway when actuator is at mid-rotation (applies to standard keyway location only). Available on models A100, A500 and A1000.

MS3 - Back surface - opposite of bearing cap side

MS4 - Top surface - opposite bottom surface. Available on models A100, A500 and A1000.

Cylinder End Identification

Cylinder ends are numerically identified as shown below. The left cylinder end is No. 1 and the right cylinder end is No. 2 when looking at the front face with the keyway at 12 o'clock and the rotary actuator at mid-rotation.



Ports - Air Rotary Actuators

Standard and optional port configuration for FLO-TORK pneumatic rotary actuators.

MODEL	STANDARD* NPT PORT	OPTIONAL* SAE PORT in. Dia.-Thd./in	RECOMMENDED TUBE SIZE in. O.D.	WHEN EXTERNAL STROKE ADJUSTORS ARE PROVIDED	SIDE PORTS
A100	1/4	1/2"-20	5/16	1/8" NPT	
A500	1/4	1/2"-20	5/16	Porting is relocated to endcap face above adjustor port. Sizing is as shown for standard ports.	Consult Factory
A1000	3/8	9/16"-18	1/2		
A4000	3/8	3/4"-16	1/2		
A10000	1/2	7/8"-14	5/8		

*Consult factory for special porting requirements.

HOW TO ORDER

A1000 - 184 - CB - ET - MS1 - RKH - N -

A SERIES

Model	Torque Output at 100 psi
A100	100 lb.in.
A500	500 lb.in.
A1000	1,000 lb.in.
A4000	4,000 lb.in.
A10000	10,000 lb.in.

ROTATIONAL ARC

94 — 94º
184 — 184º -0/+2º
364 — 364º
___ — Other specify

CUSHIONS

OO — Omit
CL — CCW stroke, right end cap
CR — CW stroke, left end cap
CB — Cushioned both directions
X — Special cushions*

Note: Cushion needle adjustment faces front in standard assembly. Refer to mounting surface call out to specify other orientation.

Example: Two cushions, back facing CB3.

STROKE ADJUSTORS

OO — Omit
AL — CCW stroke, right end cap
AR — CW stroke, left end cap
AB — Adjustors both directions
X — Special adjustors*

CUSHIONS & STROKE ADJUSTORS

Not Available on Same End

PORTING

ET — End ports, NPT threads (standard)
ST — Side ports, NPT threads
ES — End ports, SAE threads
SS — Side ports, SAE threads
X — Special porting*

Note: Side ports not available when cushions are specified.

SPECIAL MODIFICATIONS

XT — Special timing
XB — Special bearings
XM — Special materials
XC — Special coatings
X — Special features*

SEALS

N — Nitrile (Buna-N)-standard
NL — Nitrile (Buna-N)-Lip Seals
F — Fluoroelastomer (Viton)
X — Special seal*

SHAFT CONFIGURATION

RKS — Single end, keyed (standard on A100)
SBS — Single end, external spline
SQS — Single end, square
RKD — Double end, both keyed
SBH — Hollow, internal spline
RKH — Hollow keyed (standard on A500 up)
X — Special shaft*.

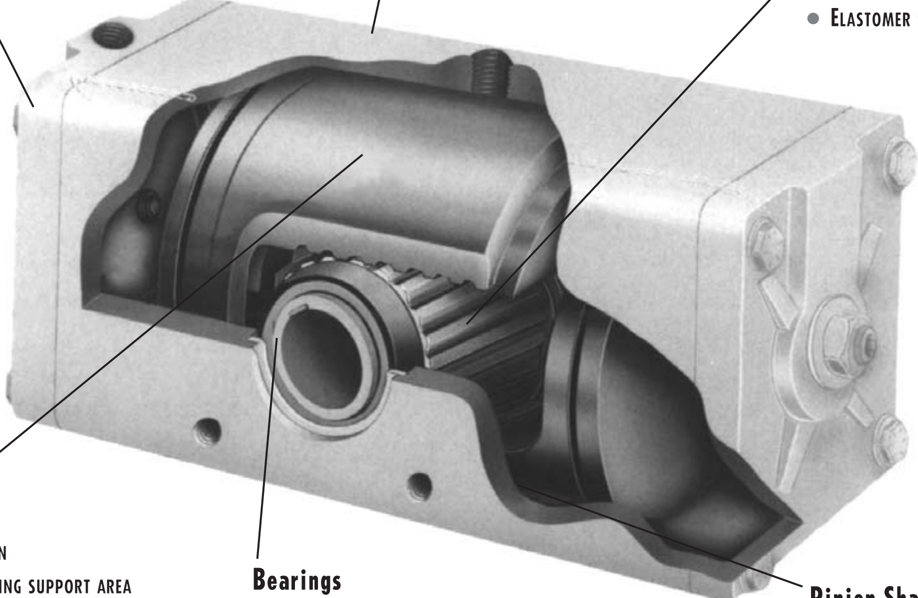
MOUNTING

MS1 — Front face mount (bearing cap side)-standard
MS2 — Bottom face mount
MS3 — Back face mount
MS4 — Top face mount
X — Special configuration*

Multiple mounting surfaces are designated by combining numerals (i.e., front and back is MS13). MS2 and MS4 mountings are available on models A100, A500 and A1000 only.

***Note:** The letter 'X' appearing as a suffix in the model code requires additional information or serial number for complete model identification.

PNEUMATIC ROTARY ACTUATORS



P300 THRU P2000 SHOWN

(Other models shown on page 13)

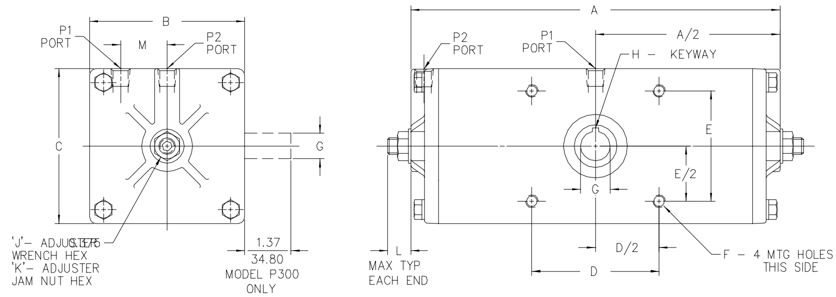
DESIGN FEATURES

- High Pressure Air - 125 psi max.
- Torque Range - 300 to 10,000 lb. in. @ 100 psi
- Standard Rotations - 94, 184 degrees
- Rack & Pinion - High Mechanical Efficiency
- Dual Rack Design - Doubles Torque Output
- Piston Seals - O-Ring
- Zero Leakage - High Volumetric Efficiency
- Operating Temperature - 0 to 200 degrees F
- (P300 thru P2000) Extruded Aluminum Housing - Hard Coat Anodized
- Gearing - Single Tooth Full Load Capacity

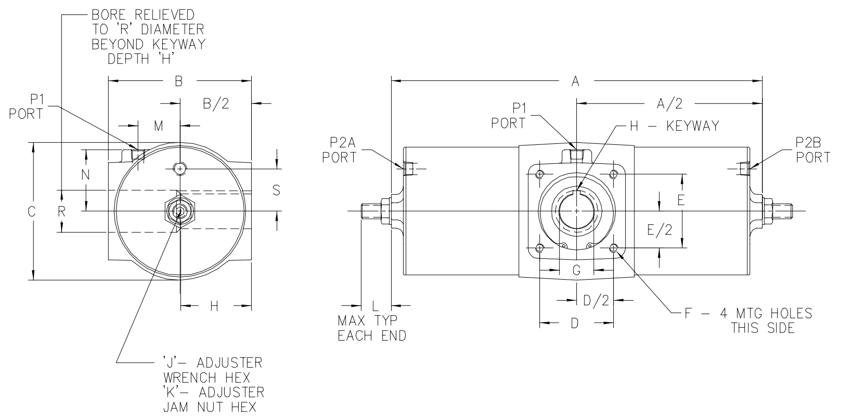
STANDARD OPTIONS

- Stroke Adjustors (One Direction Only)
- NPT or SAE O-Ring Ports
- Mounting Variations
- Shafting Variations
- Clockwise or Counterclockwise Rotations
- Customer Specified Rotations
- Custom Sealing Arrangements
- Special Coatings

MODEL P300, P1000 & P2000



MODEL P4000, P8000 & P10000

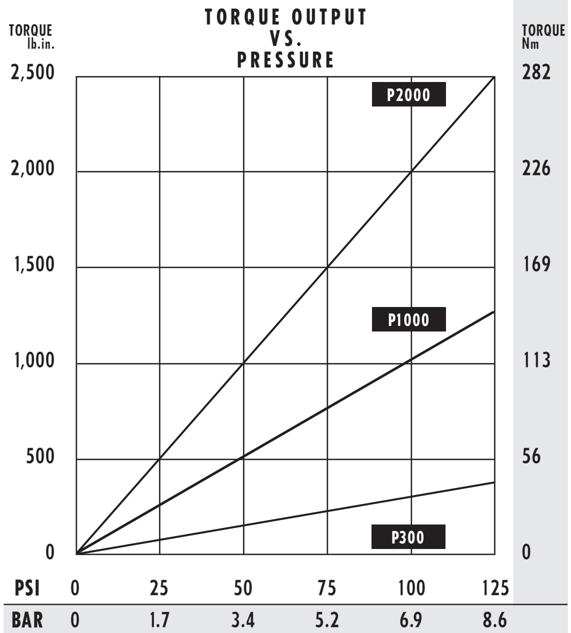


MODEL NO.	ROTATION DEGREES	A in	A mm	B in / mm	C in / mm	D in / mm	E in / mm	F in	G in / mm	H in	J in / mm	K in / mm	L in / mm	M in / mm	N in / mm	P in	R in / mm	S in / mm
	94°	6.61	167.89	2.50	2.50	1.75	1.75	1/4" NC	.748 .750		3/16"	9/16"	.60	.63				
P300								X		3/16" X 1"					N/A	1/8"NPT	N/A	N/A
	184°	10.22	259.59	63.50	63.50	44.45	44.45	5/16" DP	19.00 19.05		4.76	14.29	15.24	16.00				
	94°	8.40	213.36	3.62	3.62	2.75	2.75	1/4" NC	.875 .877		1/4"	3/4"	.69	1.25				
P1000								X		3/16" X 3-15/32"					N/A	1/4"NPT	N/A	N/A
	184°	13.11	332.99	91.95	91.95	69.85	69.85	1/2" DP	22.23 22.28		6.35	19.05	17.53	31.75				
	94°	10.87	276.10	4.56	4.56	3.75	3.25	3/8" NC	1.251 1.254		1/4"	3/4"	.66	1.37				
P2000								X		1/4" X 4-7/16"					N/A	1/4"NPT	N/A	N/A
	184°	17.68	449.07	115.82	115.82	95.25	82.55	3/4" DP	31.78 31.85		6.35	19.05	16.76	34.80				
	94°	15.76	400.30	6.38	5-3/4" AS CAST	3.75	3.75	1/2" NC	1.750 1.753		5/16"	15/16"	1.03	1.56	2-3/4"		2.13	1.63
P4000								X		3/8" X 2-31/32*"						3/8"NPT		
	184°	25.18	639.57	162.05	146.05	95.25	95.25	3/4" DP	44.45 44.53		7.94	23.81	26.16	39.62	69.85		54.10	41.40
	94°	17.20	435.10	7.25	7" AS CAST	3.75	3.75	1/2" NC	1.750 1.752		3/8"	1-1/8"	1.18	2.21	3-1/8"		2.16	2.13
P8000								X		3/8" X 3-19/32*"						3/8"NPT		
	184°	27.37	695.20	184.15	177.80	95.25	95.25	3/4" DP	44.45 44.50		9.53	28.58	29.97	56.13	79.38		54.86	54.10
	94°	18.49	469.65	7.62	7-7/16" AS CAST	5.00	5.00	5/8" NC	2.001 2.004		3/8"	1-1/8"	1.28	2.21	3-1/4"		2.50	2.25
P10000								X		1/2" X 3-3/4"*						3/8"NPT		
	184°	29.49	749.05	193.55	188.91	127.00	127.00	1" DP	50.83 50.90		9.53	28.58	32.51	56.13	82.55		63.50	57.15

NOTE: For Optional shaft configurations see A-Series options on page 9 and Technical Data pages 25 and 30-35.
*Keyway engagement is measured from the front face.

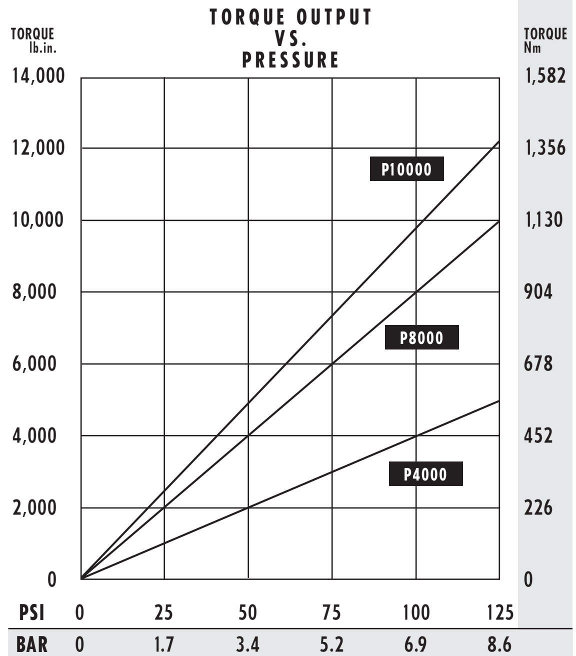
TYPICAL PERFORMANCE

P300 TO P2000



PRESSURE

P4000 TO P10000



PRESSURE

MODEL NUMBER	DISPLACEMENT FACTOR	DISPLACEMENT (in^3) PER STROKE*	
		94°	184°
P300	.0622	5.85	11.44
P1000	.2027	19.05	37.30
P2000	.3939	37.03	72.48
P4000	.9278	87.21	170.72
P8000	1.6470	154.82	303.05
P10000	1.9665	184.85	361.84

*Displacement (in^3) = Displacement Factor x Rotational Arc (degrees).
Example: P1000 x 184° displaces .2027 cu. in./degree x 184° = 37.30 in^3 displacement.

MODEL NUMBER	TORQUE FACTOR	OUTPUT TORQUE (lb.in.) AT VARIOUS PRESSURES*			
		40	60	90	100
P300	3.0	120	180	270	300
P1000	10.0	400	600	900	1,000
P2000	20.0	800	1,200	1,800	2,000
P4000	40.0	1,600	2,400	3,600	4,000
P8000	80.0	3,200	4,800	7,200	8,000
P10000	100.0	4,000	6,000	9,000	10,000

*Output Torque (lb.in.) = Torque factor x Operating Pressure (psi).
Example: Model P2000 @ 60 psi delivers (20.0 x 60) 1,200 lb.in. torque.

HOW TO ORDER

P4000 - 94 - AL - ET - MS13 - RKH - N - CW - ____

P SERIES

Model	Torque Output at 100 psi
P300	300 lb.in.
P1000	1,000 lb.in.
P2000	2,000 lb.in.
P4000	4,000 lb.in.
P8000	8,000 lb.in.
P10000	10,000 lb.in.

ROTATIONAL ARC

94 — 94º } -0/+2º
184 — 184º } -0/+2º
___ — Other specify
Maximum rotation of dual rack rotary actuators is 184º

CUSHIONS

Not Available

STROKE ADJUSTORS

OO — Omit
AL — Left end cap (0-6º)
AR — Right end cap (0-6º)
AB — Both end caps (0-6º)
X — Special adjustors*

Stroke adjustment affects only the outward piston stroke.

PORTING

ET — NPT Ports (standard)
ES — SAE O-ring ports
X — Special porting*

MOUNTING

MS1 — Front face (bearing cap side) - standard
MS2 — Bottom surface
MS3 — Back surface
MS4 — Top surface
X — Special configuration*

Multiple mounting surfaces are designated by combining numerals (i.e., front and back is MS13).

MS2 and MS4 mountings are not available on P4000 To P10000.

SHAFT CONFIGURATION

RKS — Single end, keyed (standard on P300)
RKD — Double end, keyed both ends of shaft
RKH — Hollow, keyed (standard on P1000 to P10000)
X — Special shaft*

SEALS

N — Nitrile (Buna-N) - standard
F — Fluoroelastomer (Viton)
X — Special seal*

ROTATION DIRECTION

CW — Clockwise rotation (standard)
CCW — Counter-clockwise rotation

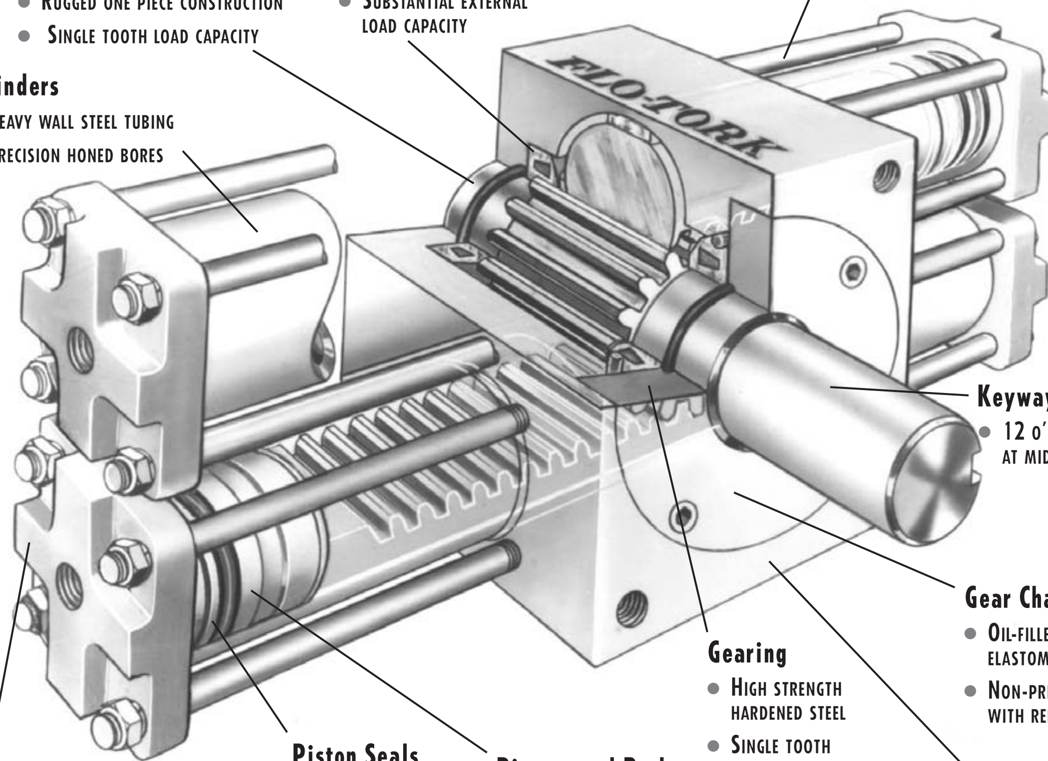
SPECIAL MODIFICATIONS

XT — Special timing of keyway
XM — Special materials
XC — Special coatings
SR — Spring return
X — Special features*

*NOTE: The letter 'X' appearing as a suffix in the model code requires additional information or serial number for complete model identification.

NOTE: Clockwise rotation is with keyway rotating from 12 o'clock position to 3 o'clock position when facing the snap ring side with the pressure ports on top. For counter-clockwise rotation the keyway rotates from 12 o'clock position to the 9 o'clock position.

HYDRAULIC ROTARY ACTUATORS



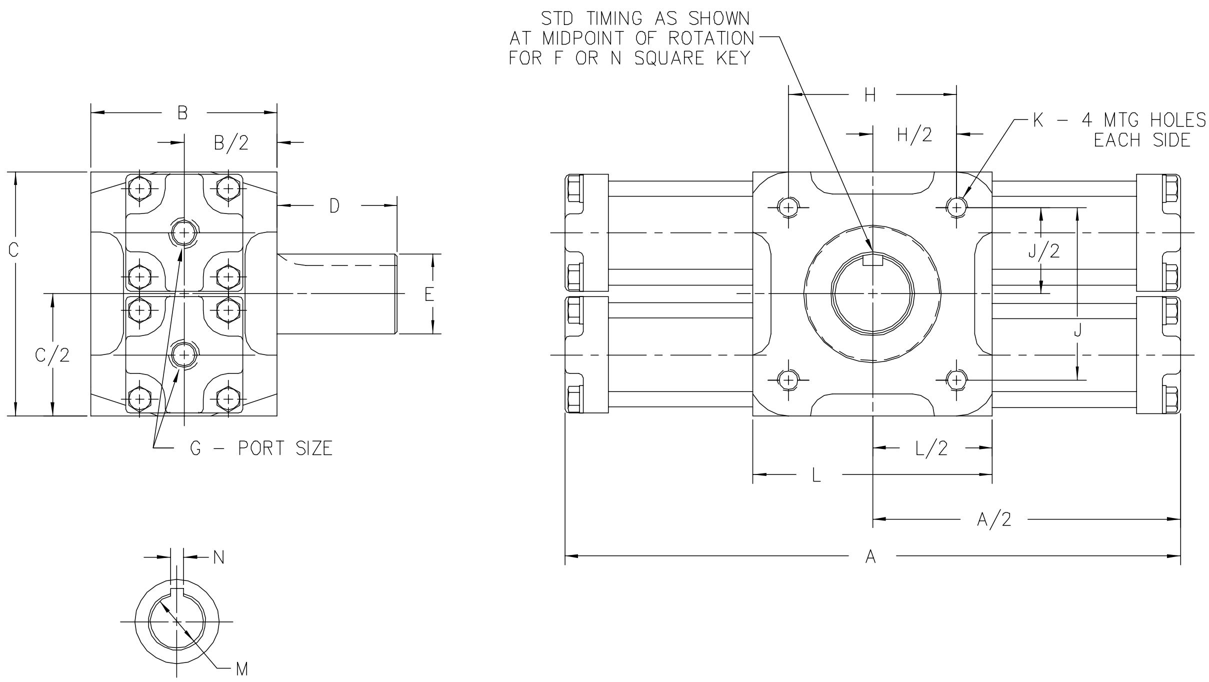
DESIGN FEATURES

- Heavy Duty Hydraulic - 3000 psi max.
- Torque Range - 900 to 600000 lb.in. @ 3,000 psi
- Standard Rotations - 90, 180, 360 degrees
- Rack & Pinion - High Mechanical Efficiency
- Zero Leakage - High Volumetric Efficiency
- Anti-Friction Bearings - High External Load Capability
- Gearing - Single Tooth Full Load Capacity
- Through Shaft - Position Readout Source
- Minimum Breakaway Pressure - 50 psi
- Operating Temperature - 0 to 200 degrees F

STANDARD OPTIONS

- Decelerating Cushions
- Stroke Adjustors
- Cushions & Stroke Adjustors
- NPT or SAE O-Ring Ports
- End Ports or Side Ports
- Mounting Variations
- Shafting Variations
- Customer Specified Rotations
- Custom Sealing Arrangements
- Air Bleeds
- Special Coatings

ENVELOPE DIMENSIONS



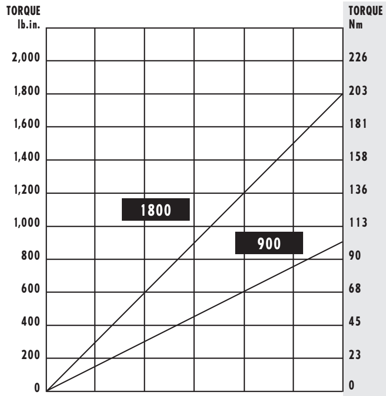
HOLLOW SHAFT OPTION

MODEL NO.	NO. RACKS	ROTATION DEGREES	A in	A mm	B in/mm	C in/mm	D in/mm	E in/mm	F in	G in	H in/mm	J in/mm	K in	L in/mm	M in/mm	N in/mm
900	1	90° 180° 360°	6.31 8.19 11.96	160.27 208.03 303.78	2.98	3.00	1.31	.8735 .8750	1/4" X 1"	1/4" NPT	2.63	2.38	5/16" NC	3.38	.625 .627	.187 .188
1800	2	90° 180° 360°	6.31 8.19 11.96	160.27 208.03 303.78	75.69	76.20	33.27	22.19 22.23		Optional SAE 1/2"-20	66.80	60.45	X 1/2" DP	85.85	15.88 15.93	4.75 4.78
3700	1	90° 180° 360°	8.49 11.24 16.73	215.65 285.50 424.94	3.94	4.50	1.88	1.248 1.250	5/16" X 1-1/2"	1/4" NPT	3.00	3.63	3/8" NC	3.82	.875 .877	.187 .188
7500	2	90° 180° 360°	8.49 11.24 16.73	215.65 285.50 424.94	100.08	114.30	47.75	31.70 31.75		Optional SAE 1/2"-20	76.20	92.20	X 5/8" DP	97.03	22.23 22.28	4.75 4.78
15000	1	90° 180° 360°	12.79 17.19 25.99	324.87 436.63 660.15	5.25	6.88	3.38	2.248 2.250	9/16" X 2-3/8"	1/2" NPT	4.75	4.88	3/4" NC	6.75	1.500 1.503	.375 .376
30000	2	90° 180° 360°	12.79 17.19 25.99	324.87 436.63 660.15	133.35	174.75	85.85	57.10 57.15		Optional SAE 7/8"-14	120.65	123.95	X 13/16" DP	171.45	38.10 38.18	9.53 9.55
75000	1	90° 180° 360°	24.60 33.39 50.99	624.84 848.11 1295.15	8.63	11.50	4.50	2.998 3.000	3/4" X 3-3/8"	3/4" NPT	7.38	9.13	1" NC	9.63	2.750 2.752	.625 .626
150000	2	90° 180° 360°	24.60 33.39 50.99	624.84 848.11 1295.15	219.20	292.10	114.30	76.15 76.20		Optional SAE 1-1/16"-12	187.45	231.90	X 1-5/8" DP	244.60	69.85 69.90	15.88 15.90
300000	1	90° 180° 360°	34.93 45.93 67.93	887.20 1166.60 1725.40	14.50	16.50	7.50	4.998 5.000	1-1/4" X 6"	1" NPT	13.00	13.50	1-1/4" NC	15.88	3.750 3.754	.750 .751
600000	2	90° 180° 360°	34.93 45.93 67.93	887.20 1166.60 1725.40	368.30	419.10	190.50	126.95 127.00		Optional SAE 1-5/16"-12	330.20	342.90	X 1-3/4" DP	403.35	95.25 95.35	19.05 19.08

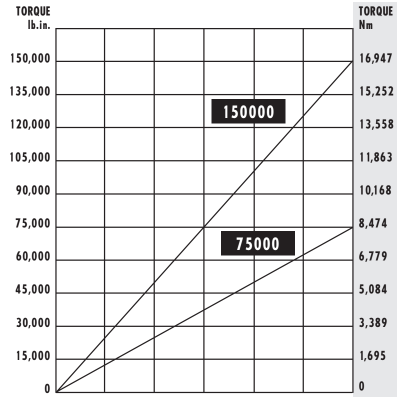
"A" Dimensions increase .84" per cushion end for Models 900 and 1800.
(See Options pages 19-22 and Technical Data pages 24, 25 and 30-35.)

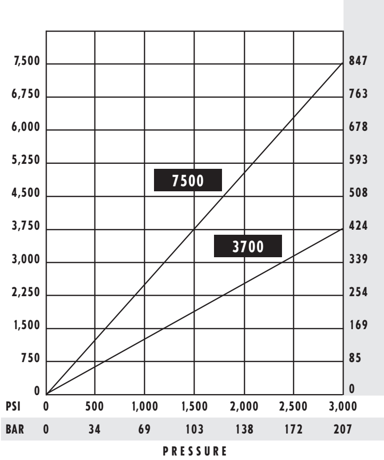
"C" Dimensions are "As Cast".
(See Options page 22 when optional mounting configurations are used.)

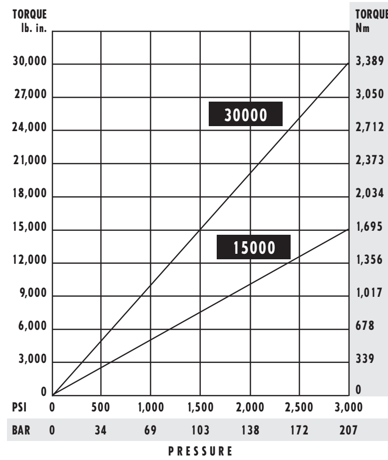
TYPICAL PERFORMANCE

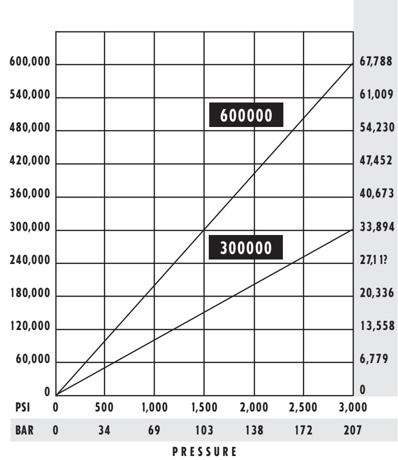


TORQUE OUTPUT VS. PRESSURE









MODEL NO.	TORQUE FACTOR*	OUTPUT TORQUE (lb.in.) @ VARIOUS PRESSURE*				
		500	750	1,500	2,500	3,000
900	.30	150	225	450	750	900
1800	.60	300	450	900	1,500	1,800
3700	1.23	615	923	1,845	3,075	3,700
7500	2.50	1,250	1,875	3,750	6,250	7,500
15000	5.00	2,500	3,750	7,500	12,500	15,000
30000	10.00	5,000	7,500	15,000	25,000	30,000
75000	25.00	12,500	18,750	37,500	62,500	75,000
150000	50.00	25,000	37,500	75,000	125,000	150,000
300000	100.00	50,000	75,000	150,000	250,000	300,000
600000	200.00	100,000	150,000	300,000	500,000	600,000

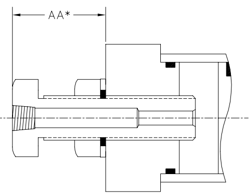
*Output Torque (lb.in.) = Torque Factor x Operating Pressure (psi). Example: Model 30000 @ 1,500 psi delivers (10.0x1,500=) 15,000 lb. in. torque.

MODEL NUMBER	DISPLACEMENT FACTOR*	DISPLACEMENT (in^3) STROKE*		
		90	180	360
900	.0063	.57	1.13	2.27
1800	.0126	1.13	2.27	4.54
3700	.0252	2.27	4.54	9.07
7500	.0504	4.54	9.07	18.14
15000	.0973	8.76	17.51	35.03
30000	.1946	17.51	35.03	70.06
75000	.4762	42.84	85.68	171.36
150000	.9520	85.68	171.36	342.72
300000	1.9051	171.46	342.92	685.84
600000	3.8102	342.92	685.84	1,371.67

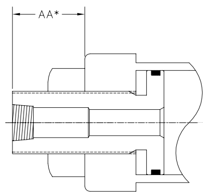
*Displacement (in^3)=Displacement Factor x Rotational Arc (degrees). Example: 15000 x 180º displaces .0973 cu. in./degrees x 180º=17.51 in^3.

External Stroke Adjustors

External stroke adjustors permit 0-30º of adjustment at the end of rotation. The adjustor stop, which contains the port, is set in position with a wrench on external flats and locked in place with a jam nut against a thread seal.



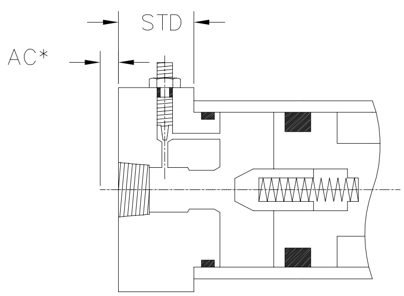
MODELS 900 TO 7500



MODELS 15000 AND UP

Cushions

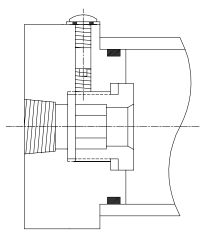
Cushions are designed to provide smooth deceleration, external energy absorption and noise reduction, over the last 15º of rotation. Cushions trap fluid at the end of stroke by locking or restricting the discharge port. The trapped fluid is diverted through a small needle valve which generates a back pressure on the discharge side of the piston. This back pressure resists the forces exerted on the internal parts of the rotary actuator, thus causing a slowing of the external mass.



ADJUSTABLE CUSHION

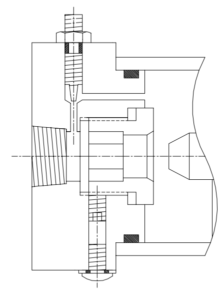
Internal Stroke Adjustors

Internal stroke adjustors permit 0-5º of adjustment. A threaded bushing within the end cap is set in position by a hex wrench inserted through the port and locked in place with a set screw.



Internal Stroke Adjustor & Adjustable Cushion

The 0-5º internal stroke adjustor and the adjustable cushion are combined into a single option. This design permits the full cushioning effect at any stroke adjustment setting.



Caution: Cushion needles should be set between one half and one full turn from seated position. Setting should result in continuous speed reduction throughout the cushion length. Needle adjustment is set too far closed when there is an abrupt change in speed as the actuator enters the cushion. Never operate with needle in seated position or unscrewed beyond the point where the seal relief in the thread is visible.

Caution: Cushion needle adjustment is a crucial factor in achieving optimum cushion performance. If the needle valve setting is too far open, cushion capacity will be reduced, or rendered ineffective; if set too far closed, cushion action will generate shock and pressure spikes in excess of actuator rating.

***Note:** When ordering a double rack model with stroke adjustors it is necessary to order end of stroke adjustors for both cylinders. When only one stroke adjustor is used for end of stroke adjustment on a double rack model the maximum operating pressure must be limited to 1500 psi.

***Note:** Cushions and external stroke adjustors are not available on the same cylinder end cap for standard models. Consult factory for special design considerations.

***Note:** Add on dimensions shown on page 24.

POSITION IDENTIFICATION AND PORTING

The following identification codes are used to specify the location of cushions, cushion adjustments, side ports and mountings.

Surface Identification

MS1 - Front surface or face - bearing cap side

MS2 - Bottom surface - opposite keyway when actuator is at mid-rotation (applies to standard keyway location only)

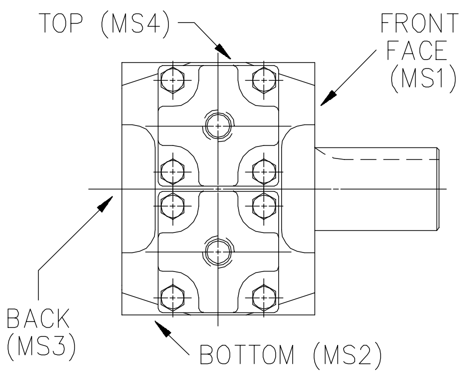
MS3 - Back surface - opposite of bearing cap side

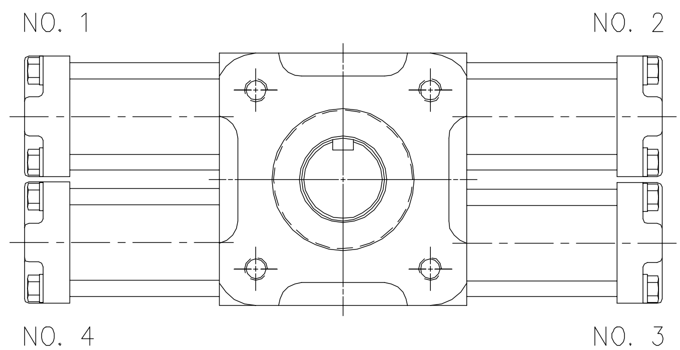
MS4 - Top surface - opposite bottom surface

Cylinder End Identification

Cylinder ends are numerically identified as shown below. On double rack units the upper left hand cylinder end is designated as No. 1. Continuing clockwise, the upper right hand cylinder is No. 2, the lower right hand cylinder end is No. 3, and the lower left hand cylinder end is No. 4.

On single rack Hydraulic units the lower rack is used. The right cylinder end is No. 3 and the left cylinder end is No. 4.





PORTS - HYDRAULIC ROTARY ACTUATORS

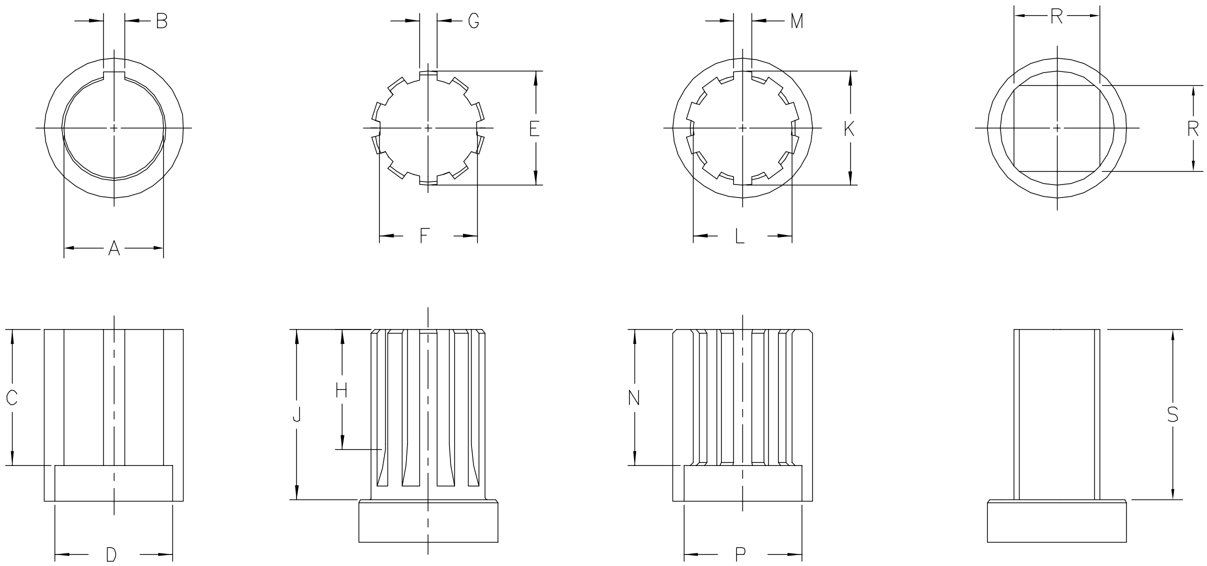
Standard and optional port configurations for Flo-Tork hydraulic rotary actuators.

MODEL	STANDARD NPT PORT	OPTIONAL* SAE PORT Dia. - Thd./in	RECOMMENDED TUBE SIZE O.D.	EXTERNAL STROKE ADJUSTORS MAXIMUM PORT SIZE*		SIDE PORT MAXIMUM PORT SIZE*	
				NPT	SAE	NPT	SAE
900	1/4"	1/2"-20	5/16"	1/8"	3/8"-24	1/4"	7/16"-20
1800	1/4"						
3700	1/4"	1/2"-20	5/16"	1/4"	9/16"-18	1/4"	7/16"-20
7500	1/4"						
15000	1/2"	7/8"-14	5/8"	1/2"	7/8"-14	3/8"	9/16"-18
30000	1/2"						
75000	3/4"	1 1/16"-12	3/4"	3/4"	1 1/16"-12	1/2"	7/8"-14
150000	3/4"						
300000	1"	1 5/16"-12	1"	1"	1 5/16"-12	3/4"	1 1/16"-12
600000	1"						

*Consult factory for special porting requirements. Sizes shown for external stroke adjustors and side ports are maximum standard port sizes.

SHAFT OPTIONS

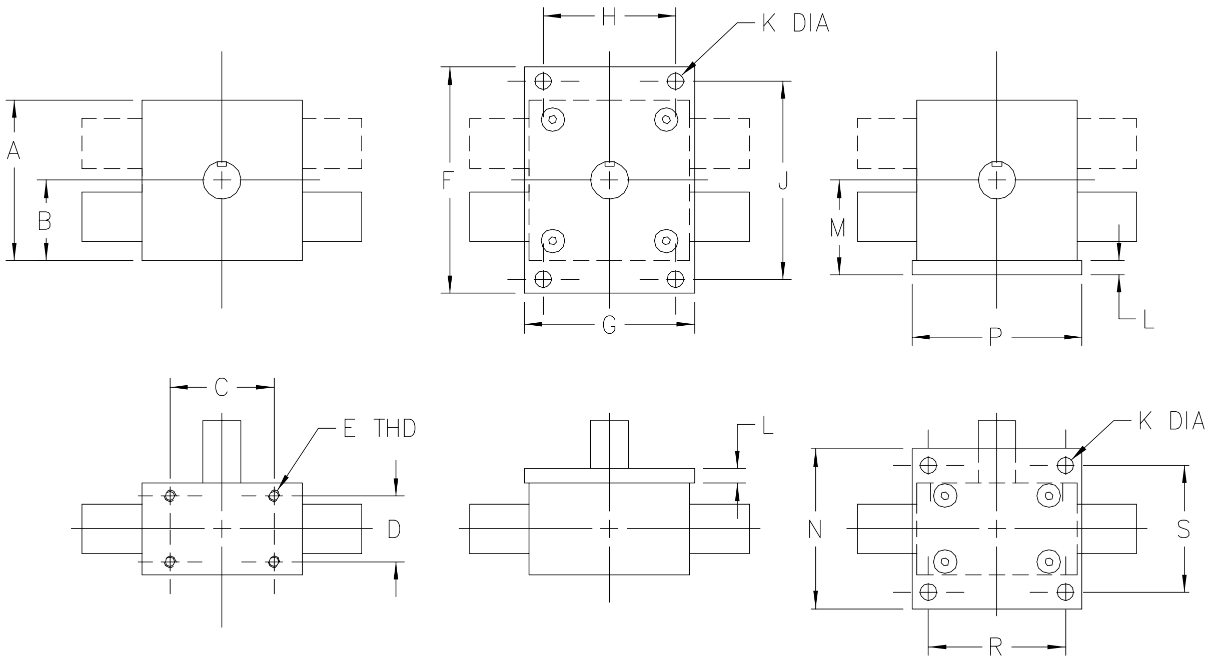
HOLLOW KEYED | **MALE SPLINE SAE 10B** | **FEMALE SPLINE SAE 10B** | **SQUARE**



MODEL NO.	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S
	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm
900	.625 .627	.187 .188	2.90	NO INTERNAL RELIEF DIAMETER	.872 .873	.742 .747	.132 .134	.87	1.31	.749 .750	.682 .683	.115 .117	1.25	.750	.623 .625	1.25
1800	15.88 15.93	4.75 4.78	73.66		22.15 22.17	18.85 18.97	3.35 3.40	22.10	33.27	19.02 19.05	17.32 17.35	2.92 2.97	31.75	19.05	15.82 15.88	31.75
3700	.875 .877	.187 .188	3.85		1.246 1.248	1.069 MAX	.190 .192	1.25	1.88	.874 .875	.752 .753	.135 .137	1.50	.881	.995 1.000	1.88
7500	22.23 22.28	4.75 4.78	97.79		31.65 31.70	27.15	4.83 4.88	31.75	47.75	22.20 22.23	19.10 19.13	3.43 3.48	38.10	22.38	25.27 25.40	47.75
15000	1.500 1.503	.375 .376	5.19		2.245 2.247	1.928 MAX	.345 .347	2.25	3.38	1.750 1.755	1.504 1.509	.271 .273	1.75	1.81	1.745 1.750	3.38
30000	38.10 38.18	9.53 9.55	131.83		57.02 57.07	48.97	8.76 8.81	57.15	85.85	44.45 44.58	38.20 38.33	6.88 6.93	44.45	45.97	44.32 44.45	85.85
75000	2.750 2.752	.625 .626	8.56		2.995 2.997	2.573 MAX	.462 .464	3.00	4.50	3.000 3.004	2.583 2.588	.465 .468	3.00	3.03	2.495 2.499	3.75
150000	69.85 69.90	15.88 15.90	217.42		76.07 76.12	65.35	11.73 11.79	76.20	114.30	76.20 76.30	65.61 65.74	11.81 11.89	76.20	76.96	63.37 63.47	95.25
300000	3.750 3.754	.750 .751	14.44		4.992 4.994	4.290 MAX	.774 .776	5.00	7.50	3.997 4.000	3.430 3.437	.621 .624	4.00	4.06	3.995 4.000	7.38
600000	95.25 95.35	19.05 19.08	366.78		126.80 126.85	108.97	19.66 19.71	127.00	190.50	101.52 101.60	87.12 87.30	15.77 15.85	101.60	103.12	101.47 101.60	187.45

MOUNTING OPTIONS

TOP AND BOTTOM | **FACE FLANGE** | **BASE FLANGE**



NOTE: Consult factory for dowelling recommendations

DIM. / MODEL	A	B	C	D	E	F	G	H	J	K	L	M	N	P	R	S
	in mm	in mm	in mm	in mm	in	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm	in mm
900	2.98	1.48	2.63	2.38	5/16" NC X	4.75	3.50	2.50	4.00	.44	.38	1.88	4.75	3.50	2.50	4.00
1800	75.69	37.59	66.80	60.45	1/2" DP	120.65	88.90	63.50	101.60	11.18	9.65	47.75	120.65	88.90	63.50	101.60
3700	4.50	2.25	3.00	3.00	3/8" NC X	7.25	4.38	3.00	5.75	.56	.50	2.75	6.50	4.38	3.00	5.00
7500	114.30	57.15	76.20	76.20	5/8" DP	184.15	111.25	76.20	146.05	14.22	12.70	69.85	165.10	111.25	76.20	127.00
15000	6.76	3.38	4.75	3.75	3/4" NC X	9.50	6.75	4.75	8.25	.69	.63	4.00	7.75	6.75	5.25	6.75
30000	171.70	85.85	120.65	95.25	13/16" DP	241.30	171.45	120.65	209.55	17.53	16.00	101.60	196.85	171.45	133.35	171.45
75000	11.31	5.66	7.38	6.25	1" NC X	14.75	11.25	9.25	13.38	.81	1.00	6.66	11.75	11.25	9.25	10.50
150000	287.27	143.76	187.45	158.75	1-3/4" DP	374.65	285.75	234.95	339.85	20.57	25.40	169.16	298.45	285.75	234.95	266.70
300000	16.26	8.13	10.00	11.50	1-1/4" NC X	23.25	18.00	15.00	21.25	1.06	1.25	9.38	19.50	18.00	12.00	16.50
600000	413.00	206.50	254.00	292.10	1-3/4" DP	590.55	457.20	381.00	539.75	26.92	31.75	238.25	495.30	457.20	304.80	419.10

NOTE: Dimensions are symmetrical about the centerline of the pinion.

HOW TO ORDER

15000- 180 - AICQ - ET - MS13 - RKS - N -

HYDRAULIC SERIES

Model	Torque Output at 3,000 psi	Number Of Racks
900	900 lb.in.	1
1800	1,800 lb.in.	2
3700	3,700 lb.in.	1
7500	7,500 lb.in.	2
15000	15,000 lb.in.	1
30000	30,000 lb.in.	2
75000	75,000 lb.in.	1
150000	150,000 lb.in.	2
300000	300,000 lb.in.	1
600000	600,000 lb.in.	2

ROTATIONAL ARC

90 — 90º ⎤
180 — 180º ⎬ -0/+2º
360 — 360º ⎦
___ — Other specify

CUSHIONS**

OO — Omit
CL — Counter-clockwise stroke
CR — Clockwise stroke
CB — Both ends of stroke
CQ — Four cushions (two rack units only)
X — Special cushions*

NOTE: Cushion needle adjustment faces front (bearing retainer side) in standard assembly. Refer to mounting surface call out to specify other orientation.
Example 1: two cushions, back facing — CB3;
Example 2: four cushions, top and bottom facing — CQ24.

STROKE ADJUSTOR**

OO — Omit
AIL — Counter-clockwise stroke (0-5º internal)
AIR — Clockwise stroke (0-5º internal)
AIB — Both ends of stroke (0-5º internal)
AIQ — Four internal adjustors (two rack units only)
AEL — Counter-clockwise stroke (0-30º external)
AER — Clockwise stroke (0-30º external)
AEB — Both ends of stroke (0-30º external)
AEQ — Four external adjustors (two rack units only)
X — Special adjustors

CUSHIONS & INTERNAL ADJUSTORS**

OO — Omit
AICL — Counter-clockwise stroke (0-5º internal)
AICR — Clockwise stroke (0-5º internal)
AICB — Both ends of stroke (0-5º internal)
AICQ — Four internal adjustors & cushions (two rack units only)
X — Special cushions & adjustors*

CUSHIONS & EXTERNAL ADJUSTORS

Not available on same end

SPECIAL MODIFICATIONS

AB — Air bleeds
LS — Limit switch
XT — Special timing
XB — Special bearings
XM — Special materials
XP — Special coating
PT — Position transducer drive
SR — Spring return
X — Special features*

SEALS

N — Nitrile (Buna-N) - standard
F — Fluoroelastomer (Viton)
NL — Nitrile (Buna-N) Lip Seals Standard 3700 & 7500
X — Special seals*

SHAFT CONFIGURATION

RKS — Single end, keyed (standard)
SBS — Single end, external spline
SQS — Single end, square
RKD — Double end, both ends keyed
SBD — Double end, both external spline
SQD — Double end, both square
SQH — Hollow, internal square
SBH — Hollow, internal spline
RKH — Hollow, keyed
X — Special shaft*

MOUNTING

MS1 — Front face mount (bearing cap side) - standard
MS2 — Bottom face mount
MS3 — Back face mount - standard
MS4 — Top face mount
MF1 — Front flange mount
MF2 — Bottom flange mount
MF3 — Back flange mount
MF4 — Top flange mount
MXF — Foot mount
X — Special configuration*

PORTING

ET — End ports, NPT threads (standard)
ST — Side ports, NPT threads
ES — End ports, SAE threads
SS — Side ports, SAE threads
X — Special porting*

NOTE: Side ports not available when cushions are specified.

***NOTE:** The letter “x” appearing as a suffix in each field of the model code requires additional information or a serial number for complete model identification, i.e. CBX on a double rack model would require identification as to which two cylinders include the cushions.

***NOTE:** When ordering a double rack model with stroke adjustors it is necessary to order end of stroke adjustors for both cylinders. When only one stroke adjustor is used for end of stroke adjustment on a double rack model the maximum operating pressure must be limited to 1500 psi.

**When ordering double rack units with cushions and adjustors, specify location by cylinder number.

DIMENSIONS-CUSHIONS AND STROKE ADJUSTORS

A SERIES PNEUMATIC - ENVELOPE DIMENSIONS - CUSHIONS AND STROKE ADJUSTORS

MODEL NUMBER	STANDARD 'A' DIM			"AA" ADJUSTOR*	"AC" CUSHION*
	94°	184°	364°	ADD-ON	ADD-ON
	in mm	in mm	in mm	in mm	in mm
A100	4.52 114.81	5.50 139.70	7.85 199.39	1.01 25.65	1.16 29.46
A500	7.11 180.59	9.63 244.60	14.65 372.11	.89 22.61	1.04 26.42
A1000	10.08 256.03	13.22 335.79	18.44 468.38	1.32 33.53	.66 16.76
A4000	13.95 354.33	18.96 481.58	29.11 739.39	1.48 37.59	.96 24.38
A10000	18.54 470.92	25.57 649.48	39.70 1008.38	2.09 53.09	.96 24.38

*"AA" (Adjustor) and "AC" (Cushion) dimensions are individual dimensions and are to be added to the standard 'A' dimension for each adjustor or cushion.

HYDRAULIC SERIES - ENVELOPE DIMENSIONS - CUSHIONS AND STROKE ADJUSTORS

MODEL NUMBER	STANDARD 'A' DIM			"AA" ADJUSTOR*	"AC" CUSHION*
	90°	180°	360°	ADD-ON	ADD-ON
	in	in	in	in	in
900 1800	6.31	8.19	11.96	1.01	.84
3700 7500	8.49	11.24	16.73	1.81	THESE DIM ARE THE SAME AS STANDARD 'A' DIM.
15000 30000	12.79	17.19	25.99	2.39	
75000 150000	24.60	33.39	50.99	1.87	
300000 600000	34.93	45.93	67.93	2.34	

*"AA" (Adjustor) and "AC" (Cushion) dimensions are individual dimensions and are to be added to the standard 'A' dimension for each adjustor or cushion.

UNIT WEIGHTS

A SERIES PNEUMATIC

MODEL NO.	94°		184°		364°	
	LB	KG	LB	KG	LB	KG
A100	3	1.36	3	1.36	4	1.81
A500	8	3.63	9	4.08	12	5.44
A1000	14	6.35	16	7.26	22	9.98
A4000	47	21.32	55	24.95	73	33.11
A10000	95	43.09	108	48.99	136	61.69

P SERIES PNEUMATIC

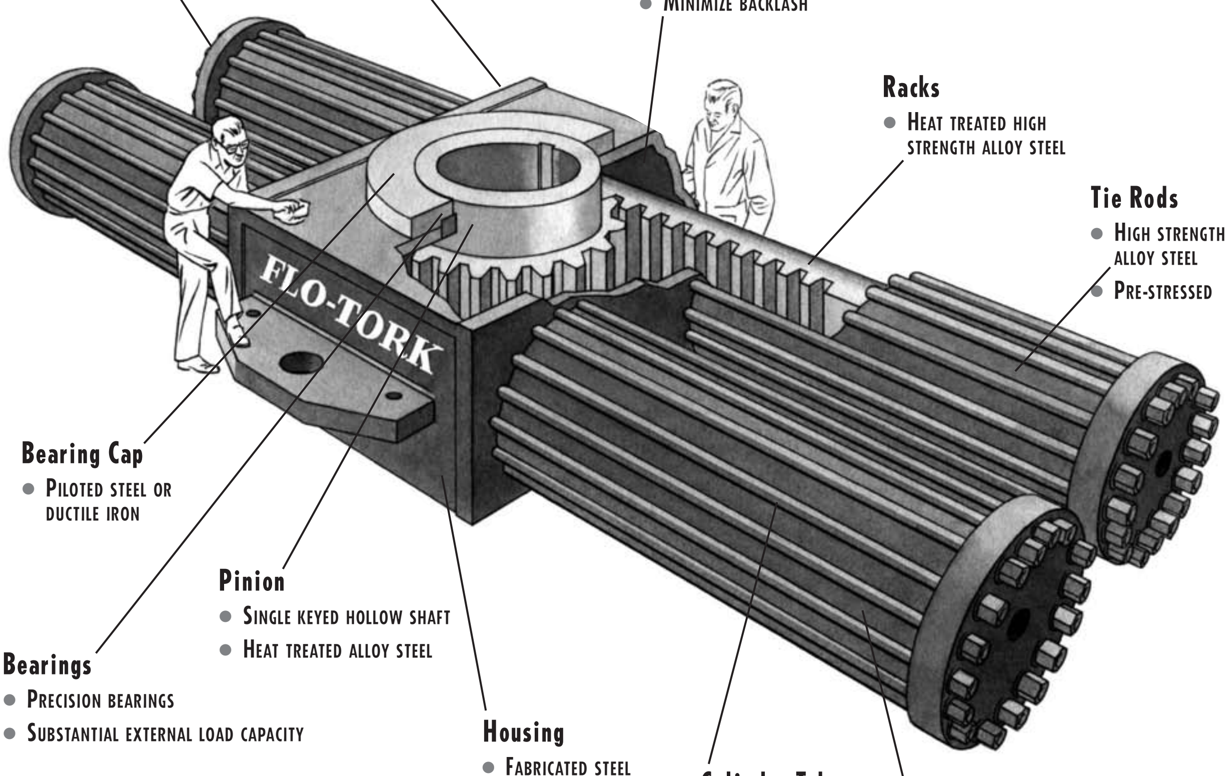
MODEL NO.	94°		184°	
	LB	KG	LB	KG
P300	4	1.81	5	2.27
P1000	9	4.08	13	5.90
P2000	17	7.71	25	11.34
P4000	42	19.05	55	24.95
P8000	59	26.76	76	34.47
P10000	71	32.21	92	41.73

HYDRAULIC SERIES

MODEL NO.	90°		180°		360°	
	LB	KG	LB	KG	LB	KG
900	8	3.63	10	4.54	11	4.99
1800	9	4.08	11	4.99	12	5.44
3700	18	8.16	20	9.07	26	11.79
7500	22	9.98	24	10.89	28	12.70
15000	61	27.67	64	29.03	74	33.57
30000	78	35.38	81	36.74	97	44.0
75000	270	122.47	288	130.64	323	146.51
150000	330	149.69	361	163.75	397	180.08
300000	943	427.74	1013	459.50	1162	527.08
600000	1144	518.92	1286	583.33	1582	717.60

NOTE: Approximate weights shown above are based on standard models.

HYDRAULIC ROTARY ACTUATOR



DESIGN FEATURES

- Heavy Duty Hydraulic - 3,000 psi max.
- Torque Range - 1,000,000-50,000,000 lb.-in.
- Standard Rotations - 90, 180, 360 degrees
- Rack & Pinion - High Mechanical Efficiency
- Zero Leakage - High Volumetric Efficiency
- Piston Seals - Pre-Loaded Lip Seals
- Gearing - Single Tooth Full Load Capacity
- Hollow Shaft - Eliminates costly coupling
- Compact Design - Highest torque per cu. ft. of space
- Temperature Range - 0 to 200 degrees F

OPTIONAL FEATURES

- Adjustable Cushions
- Tie Rod or Mill Type Cylinders
- Custom Rotational Arcs
- Custom Mounting Arrangements
- Custom End Cap Valves and Ports
- Self Contained Hydraulic Power Units
- Custom mountings
- Custom Shaft Configuration
- Custom Designs for pressure, torque, and dimensional requirements
- Custom Corrosion protection
- Designs for 4:1 pressure vessel safety factor

FLO-TORK Megatork actuators are designed to meet the needs of each individual application. Because of this we have included the following information sheet to help us in assisting you in sizing the correct actuator for your application. Please fill in the data sheet and forward it to us for review. We will contact you to discuss the specifics of your application.

COMPANY:

ADDRESS:

CITY: STATE: ZIP:

PHONE NUMBER: FAX NUMBER:

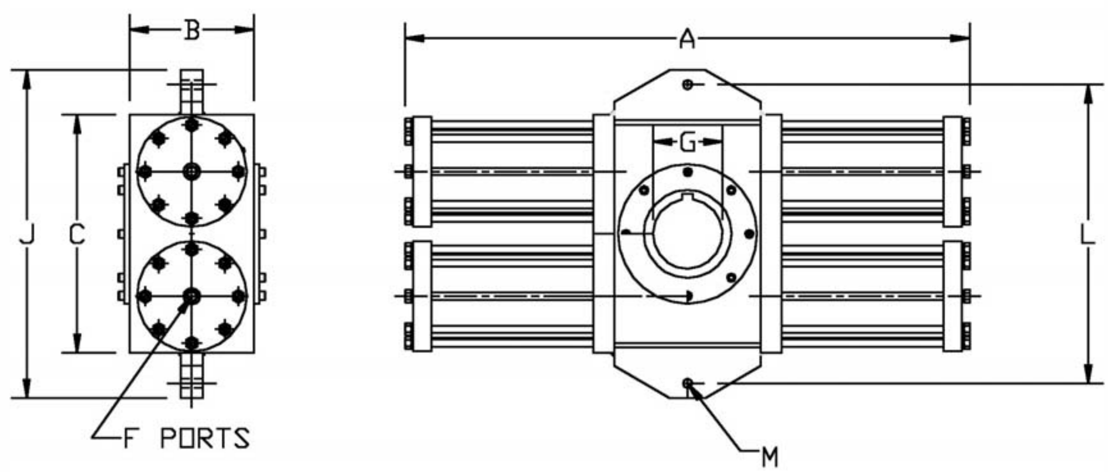
NAME: E-MAIL:

APPLICATION INFORMATION:

TORQUE REQUIRED:

ROTATION REQUIRED:

OPERATING PRESSURE (PSI):



DIMENSIONAL DATA: UNITS OF MEASURE: METRIC:

A: B: C:

F: G: J:

L: M:

Please fill in the envelope dimensions that you require for your specific application to assist us in sizing your actuator.

APPLICATION DISCRIPTION:

MEGATORK

TYPICAL PERFORMANCE

MODEL NUMBER	TORQUE FACTOR*	OUTPUT TORQUE (lb.-in.) @ VARIOUS PRESSURES*				
		1,000 psi	1,500 psi	2,000 psi	2,500 psi	3,000 psi
1M	333	333,000	499,500	666,000	832,500	1,000,000
1.5M	500	500,000	750,000	1,000,000	1,250,000	1,500,000
2M	667	667,000	1,000,500	1,334,000	1,667.500	2,000,000
3M	1,000	1,000,000	1,500,000	2,000,000	2,500,000	3,000,000
4M	1,333	1,333,000	1,999,500	2,666,000	3,332,500	4,000,000
5M	1,667	1,667,000	2,500,500	3,334,000	4,167,500	5,000,000
6M	2,000	2,000,000	3,000,000	4,000,000	5,000,000	6,000,000
7M	2,333	2,333,000	3,499,500	4,666,000	5,832,500	7,000,000
8M	2,667	2,667,000	4,000,500	5,334,000	6,667,500	8,000,000
9M	3,000	3,000,000	4,500,000	6,000,000	7,500,000	9,000,000
10M	3,333	3,333,000	4,999,500	6,666,000	8,332,500	10,000,000
15M	5,000	5,000,000	7,500,000	10,000,000	12,500,000	15,000,000
20M	6,667	6,667,000	10,000,500	13,334,000	16,667,500	20,000,000
25M	8,333	8,333,000	12,499,500	16,666,000	20,832,500	25,000,000
30M	10,000	10,000,000	15,000,000	20,000,000	25,000,000	30,000,000
40M	13,333	13,333,000	19,999,500	26,666,000	33,332,500	40,000,000
50M	16,667	16,667,000	25,000,500	33,334,000	41,667,500	50,000,000

*Output Torque (lb.in.) = Torque Factor x Operating Pressure (psi) Example: Model 9M @ 2,500 psi delivers (3,000 x 2,500=) 7,500,000 lb-in torque.

MODEL NUMBER	DISPLACEMENT FACTOR*	MODEL DISPLACEMENT DISPLACEMENT (gal.) PER STROKE*			
		90°	180°	270°	360°
	gal/degree	gal.	gal.	gal.	gal.
1M	0.03	2.52	5.04	7.56	10.08
1.5M	0.04	3.60	7.20	10.80	14.40
2M	0.05	4.82	9.65	14.47	19.30
3M	0.08	7.20	14.40	21.60	28.80
4M	0.11	9.90	19.80	29.70	39.60
5M	0.14	12.33	24.66	36.99	49.32
6M	0.16	14.76	29.52	44.28	59.04
7M	0.19	17.10	34.20	51.30	68.40
8M	0.23	20.34	40.68	61.02	81.36
9M	0.25	22.23	44.46	66.69	88.92
10M	0.28	25.29	50.58	75.87	101.16
15M	0.39	34.74	69.48	104.22	138.96
20M	0.58	51.84	103.68	155.52	207.36
25M	0.67	60.03	120.06	180.09	240.12
30M	0.79	71.19	142.38	213.57	284.76
40M	1.18	106.29	212.58	318.87	425.16
50M	1.37	123.03	246.06	369.09	492.12

*Displacement (gal) = Displacement Factor x Rotational Arc (degrees). Example: 10M x 270° displaces 0.281 gal./degree x 270°= 75.9 gal.

PERFORMANCE

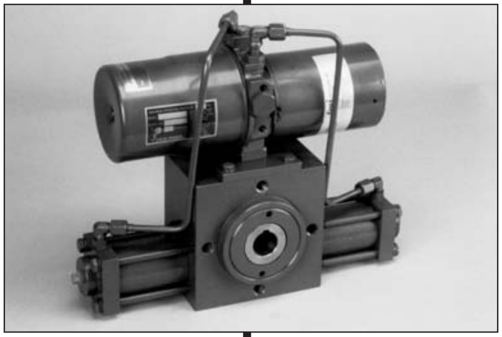
CUSTOM DESIGNS TO MEET PERFORMANCE CRITERIA

- TORQUE OUTPUT
- SPEED REGULATION
- HIGH CAPACITY CUSHIONS
- SPECIAL ROTATIONS
- MULTIPLE POSITIONS
- AIR/OIL TANDEM
- HIGH CYCLE

EQUIPMENT INTEGRATION

CUSTOM ENGINEERED TO MEET SPECIFIC MACHINERY REQUIREMENTS

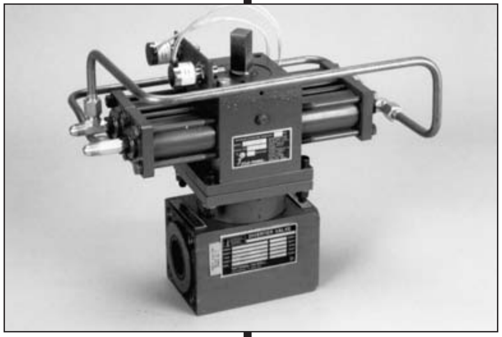
- TRUNION DRIVE
- BASKET ROTATION
- SWING GATE
- POWER HINGE
- POWER STEERING
- ELECTRO-HYDRAULIC
- REMOTE OPERATION



SPECIAL CONFIGURATIONS

CUSTOM DESIGNS FOR ACTUATOR DIMENSIONAL REQUIREMENTS

- COMPACT SIZES
- MOUNTING FLANGES
- SPECIAL SHAFTING
- MILL-TYPE CYLINDERS
- DUAL CONCENTRIC SHAFTS
- INTEGRAL VALVING



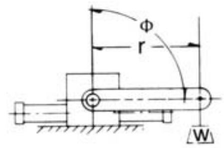
FOR ASSISTANCE IN MEETING YOUR SPECIFIC NEEDS, PLEASE FORWARD A COMPLETED APPLICATION SPECIFICATION GUIDE (PAGE 38 OF THIS CATALOG) TO FLO-TORK, INC.

The torque required to put a load into motion by a rotary actuator is the sum of the static torque, the dynamic torque and the gravitational torque. Static torque is the torque of friction, dynamic torque is the torque required to accelerate to desired speed and gravitational torque is the torque necessary to lift a weight against gravity. It is suggested that an actuator with reserve capacity of at least 20 percent be selected to accommodate variations within the system.

Rotation In Vertical Plane

The maximum torque required to rotate the weight (W) thru an angle Ø in a vertical plane will occur when the arm is horizontal. This torque is determined by the equation: $T = Wr$. If the arm mass is significant its' effect on the torque required must be calculated.

As the arm approaches vertical the required torque becomes less because the arm length (r) becomes shorter as a function of the sine of the angle. The torque required at any position can be determined by:

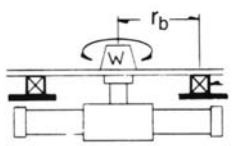


$T = Wr \sin Ø$

Horizontal Rotation of Supported Weight

The previous example does not include any considerations for friction. Friction Torque (T_f) can be determined by the product of the weight (W), the coefficient of friction (C_f) and the bearing radius (r_b).

$T_f = W\, C_f\, r_b$

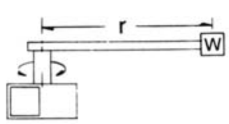


Bearing

Note: (W) should include the weight of the turntable as well as the load. Torque (T_f) required to overcome friction must be added to the acceleration torque (T_a) prior to selecting the proper rotary actuator model. The friction torque can be subtracted from the deceleration torque if desired.

Horizontal Rotation of Unsupported Weight

The torque (T_a) required to accelerate (rotate) unsupported weight in a horizontal plane can be determined by:



$T_a = J_\alpha$

Where $J = \dfrac{Wr^2}{g}$

Angular acceleration (α) is usually uniform and can be determined by:

$\alpha = \dfrac{(\omega_2 - \omega_1)}{(t_2 - t_1)}$ Where $\omega = \dfrac{(\theta_2 - \theta_1)}{(t_2 - t_1)}$

Caution: See Caution note on Page 31.

Deceleration

Deceleration torque is often the least understood and in many cases the most important requirement to be considered.

The time required to decelerate the load within a given angle of rotation should usually be longer than the time required to accelerate the same load to a required speed.

This is important because energy built up during uniform acceleration must be absorbed during deceleration by a build up of back pressure in the actuator cylinder.

Since energy in must equal the energy out, if the rotary actuator is used to decelerate the load, any reduction in deceleration time will result in increased back pressure which may be damaging to the rotary actuator and other system components. In all circuits this back pressure must be absorbed into the existing system.

Consider that acceleration energy equals torque times the angle of acceleration ($T_a\theta_a$). In terms of kinetic energy it is:

$$E_k = \frac{J\omega^2}{2}$$

The deceleration torque required to stop the load is kinetic energy divided by the same angle of deceleration:

$$T_d = \frac{J\omega^2}{2\theta_d}$$

Since deceleration energy must equal acceleration energy ($T_d\theta_d = T_d\theta_a$) and actuator pressure is proportional to torque, we can set up a simple example of angular travel and pressure.

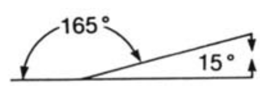
Example: If a load is uniformly accelerated thru 100° rotation at 1,000 psi., you can determine the deceleration pressure to stop the load in 80° by the following:

$\dfrac{100°}{80°}$ x 1,000=Pressure to decelerate=1,250 psi

Another Example: Uniformly accelerate a load thru 165° rotation at 500 psi., then stop the motion within the last 15° of rotation:

$\dfrac{165°}{15°}$ x 500=Pressure to decelerate=5,500 psi

Accel.@ 500 psi



Decel.
@ 5,500 psi

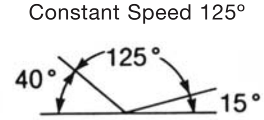
Deceleration pressure of 5,500 psi to dissipate the kinetic energy during the last 15° of rotation may prove to be destructive to the system.

Another example illustrates the use of flow control valves to control output flow. A mass accelerated through 40° at 2,000 psi, then moving at constant speed for 125°, will generate a destructive deceleration pressure of 5,333 psi to dissipate the kinetic energy within the last 15° of rotation.

$\dfrac{40°}{15°}$ x 2,000=Pressure to decelerate=5,333 psi

Constant Speed 125°

Accel.
@ 2,000 psi



Decel.
@ 5,333 psi

In addition, since it is difficult and in many cases impractical to remove system pressure during deceleration, one must consider the torque developed by the system pressure while driving the load through the deceleration distance (rotation) in addition to the kinetic energy already existing.

The optional FLO-TORK built-in cushions are designed to help decelerate the load during the last 15° of rotation. The deceleration pressure should not exceed the rated pressure of the rotary actuator model selected.

QUANTITIES AND FORMULAS FOR ROTARY MOTION

TORQUE is a force that produces rotation of a shaft. It is measured by the product of the force (F) and the perpendicular distance from the line of action of the force to the centerline of rotation (r).

$$T = F\,r$$

ROTATION results when an unbalanced torque acts on a body producing an angular acceleration. The torque to accelerate is the product of the body's moment of inertia about its axis of rotation (J) and the angular acceleration (α).

$$T = J\,\alpha$$

MOMENT OF INTERIA of a body is determined by the distribution of its mass about the axis of rotation. It tends to resist any change in angular velocity.

$$J = mr^2$$

ANGULAR ACCELERATION is the rate of change of angular velocity and is expressed in radians per second per second. If angular velocity changes from ω_O at time O to ω_t at time t in time (t), the average angular acceleration is:

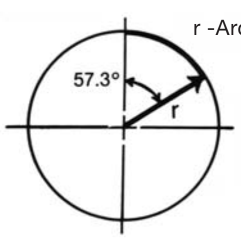
$$\alpha = \frac{\omega_t - \omega_O}{t}$$

ANGULAR VELOCITY is the rate of angular rotation about an axis and is expressed in radians per second. If a body moves through a rotation of θ radians in a time of t seconds, the average angular velocity is:

$$\omega = \frac{\theta}{t}$$

ANGULAR ROTATION is the arc traveled in rotary motion and can be expressed in degrees, revolutions or radians. One radian is the angle defined from the center of a circle by an arc that is equal in length to the radius.

r -Arc length equal to radius



1 revolution = 360° = 2π radians

1 radian = 57.3°

KINETIC ENERGY is the energy of a mass in motion. It is a function of the moment of inertia (J) and the square of the angular velocity (ω) expressed as:

$$E_k = 1/2\,J\,\omega^2$$

EQUATIONS FOR ANGULAR MOTION are analogous to those for linear motion:

$v = at$	$s = 1/2at^2$	$v^2 = 2as$
$\omega = \alpha t$	$\theta = 1/2\alpha t^2$	$\omega^2 = 2\alpha\theta$

If v_o and ω_o denote the initial linear and angular velocity then

$v = v_o + at$	$s = v_ot + 1/2at^2$	$v^2 = v_o^2 + 2as$
$\omega = \omega_o + \alpha t$	$\theta = \omega_ot + 1/2\alpha t^2$	$\omega^2 = \omega_o^2 + 2\alpha\theta$

ANALOGOUS LINEAR & ANGULAR QUANTITIES

Linear Displacements	s	$s = \theta r$	Angular Displacement	θ
Linear Velocity	v	$v = \omega r$	Angular Velocity	ω
Linear Acceleration	a	$a = \alpha r$	Angular Acceleration	α
Mass (Inertia)	m	$J = mr^2$	Moment of Inertia	J
Force	F	$T = Fr$	Torque	T
Linear: $F = ma$	$E_k = 1/2mv^2$		Work = Fs	Power = Fv
Angular: $T = J\alpha$	$E_k = 1/2J\omega^2$		Work = $T\theta$	Power = $T\omega$

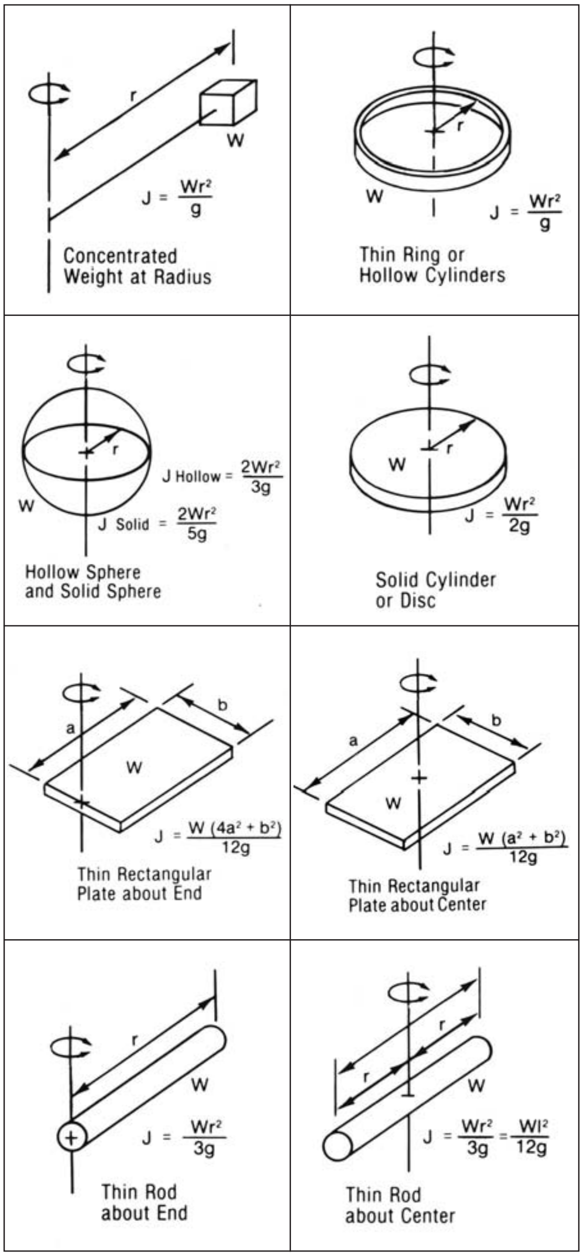
DEFINITIONS

Symbol		Units of Measure
a	= Linear Acceleration	in/sec^2
C_f	= Friction Coefficient	dimensionless
C_T	= Torque Coefficient	lb-in/psi
E_c	= Cushion Energy	lb-in
E_f	= Friction Energy	lb-in
E_g	= Gravitational Energy	lb-in
E_k	= Kinetic Energy	lb-in
E_p	= Propelling Energy	lb-in
E_T	= Total Energy	lb-in
F	= Force	lb
g	= Acceleration due to Gravity	386 in/sec^2
J	= Moment of Inertia	lb-in-sec^2
m	= Mass = W/g	lb-sec^2/in
P	= Pressure	psi
r	= Radius	in
r_a	= Radius Arm Length	in
r_b	= Radius of Bearing	in
s	= Linear Displacement	in
T	= Torque	lb-in
T_a	= Torque of Acceleration	lb-in
T_d	= Torque of Deceleration	lb-in
T_f	= Torque of Friction	lb-in
T_p	= Torque of Propulsion	lb-in
t	= Time	sec
v	= Linear Velocity	in/sec
W	= Weight	lb
α	= Angular Acceleration	rad/sec^2
θ	= Angular Displacement	rad
θ_a	= Angle of Acceleration	rad
θ_d	= Angle of Deceleration	rad
Ø	= Angle of Arm to Vertical	deg
$\bar{Ø}$	= Average Angle from Vertical	deg
ω	= Angular Velocity	rad/sec

CAUTION: Formulas given on pages 30-33 must be applied to all applications to assure proper selection of the actuator and system accessories.

MOMENT OF INERTIA AND CUSHION DATA

MOMENTS OF INERTIA TYPICAL EXAMPLES



CUSHION DATA PNEUMATIC ACTUATORS

MODEL NUMBER	ACTUATOR TORQUE FACTOR C_T (lb-in/psi)	CUSHION DECEL ARC θ_d (rad)	CUSHION CAPACITY Ec (in-lb)
A100	1.00	.84	210
A500	5.00	.39	430
A1000	10.00	.35	665
A4000	40.00	.30	1,920
A10000	100.00	.26	3,380

CUSHION DATA HYDRAULIC ACTUATORS

MODEL NUMBER	ACTUATOR TORQUE FACTOR C_T (lb-in/psi)	CUSHION DECEL ARC θ_d (rad)	CUSHION CAPACITY Ec (in-lb)
900	.30	.25	335
1800	.60	.25	335*
3700	1.23	.33	1,670
7500	2.50	.33	1,670*
15000	5.00	.34	6,290
30000	10.00	.34	6,290*
75000	25.00	.24	19,800
150000	50.00	.24	19,800*
300000	100.00	.27	81,000
600000	200.00	.27	81,000*

*per cushion

CUSHION NEEDLE ADJUSTMENT

CAUTION: Cushion needles should be set between one-half and one full turn from seated position. Setting should result in continuous speed reduction throughout the cushion length. Needle adjustment is set too far closed when there is an abrupt change in speed as the actuator enters the cushion. Never operate with needle in seated position or unscrewed beyond the point where seal relief in the thread is visible.

CAUTION: Cushion needle adjustment is a crucial factor in achieving optimum cushion performance. If the needle valve setting is too far open, cushion capacity will be reduced or rendered ineffective; if set too far closed, cushion action will generate shock and pressure spikes in excess of actuator rating.

CAUTION: See caution note on page 31.

High rotational velocity and/or large mass in rotary motion can cause damaging impact at the end of stroke. Deceleration and absorption of rotating system energy can be achieved with cushions, external shock absorbers or fluid circuit devices which reduce speed as the actuator approaches the end of travel.

Cushions are the simplest design alternative, but consideration must be given to the cushion energy absorption capacity. Exceeding rated cushion capacity can reduce actuator life or result in severe actuator damage. To determine if a cushion is suitable for the application, calculate the total energy that must be absorbed and compare with the cushion capacity rating.

Energy of Application

E_k = Energy of mass in motion (kinetic energy)
$E_k = 1/2\ J\ \omega^2$
E_p = Propelling energy of actuator
$E_p = P_p C_t \theta_d$
E_g = Gravitational energy of lifting or lowering weight
$E_g = W r_a \theta_d \sin\overline{\varnothing}$

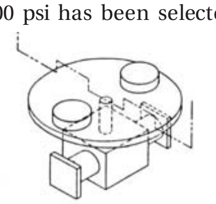
Total Energy, where: $E_t = E_k + E_p \pm E_g$

E_g is added if weight is falling or E_g is subtracted if weight is rising

Note: If weight is rotating in horizontal plane, the gravitational energy is zero.

Horizontal Rotational Deceleration

Two 50 lb parts are positioned diametrically opposed on a 150 lb rotary transfer table which swings through 180º in a horizontal plane. The table radius is 50 in and the radius to the parts is 40 in. Rotational velocity of the table as it enters the cushion deceleration is 80º/sec or (80÷57.3) 1.40 rad/sec. A model 3700 actuator operating at 1,500 psi has been selected to propel the load.



Kinetic Energy $E_k = 1/2\ J\ \omega^2$

Moment of Inertia $J = J_{table} + J_{load}$

$$J_{table} = \frac{W_t r_t^2}{2g} + \frac{(150\ lb)\ (50\ in)^2}{2(386\ in/sec^2)} = 486\ lb\text{-}in\text{-}sec^2$$

$$J_{load} = \frac{W_l r_l^2}{g} + \frac{(50 + 50\ lb)\ (40\ in)^2}{386\ in/sec^2} = 415\ lb\text{-}in\text{-}sec^2$$

$J = J_{table} + J_{load} = 486 + 415 = 901$ lb-in-sec^2
$Ek = 1/2\ J\ \omega^2 = 1/2\ (901\ lb\text{-}in\text{-}sec^2)\ (1.40\ rad/sec)^2$
$= 883$ lb-in

Propelling Energy $E_p = P_p\ C_t\ \theta_d$

Torque Factor (C_t) for Model 3700 (1.23 lb-in/psi)
Deceleration Arc (θ_d) for Model 3700 (0.33 radians)
$E_p = P_p\ C_t\ \theta_d$ = (1,500 psi) (1.23 lb-in/psi) (0.33 rad)
= 609 lb-in

Gravitational Energy $E_g = 0$ for horizontal rotation

Total Energy $E_t = E_k + E_p \pm E_g$

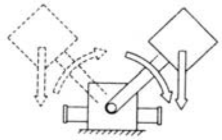
$E_t = 883 + 609 + 0$ lb-in = 1,492 lb-in

Total energy to be absorbed in the example is 1,492 lb-in. The cushion capacity of Model 3700 when properly adjusted is 1,670 lb-in. This is adequate to absorb the deceleration requirement.

Caution: See caution note on page 31.

Vertical Rotational Deceleration

A material handling rollover mechanism transfers a 100 lb machine part through 180º in a vertical plane from a 9 o'clock to a 3 o'clock position. The radius arm to the part grippers is 40 in and the effective weight and radius of the arms and grippers can be approximated by two 40 in long rods weighing 70 lb apiece. Rotational velocity of the mechanism as it enters the cushion deceleration arc is 40º/sec or (40÷57.3) 0.70 rad/sec. A Model 15,000 actuator operating at 2,000 psi has been selected to propel the load.



Kinetic Energy $E_k = 1/2\ J\ \omega^2$

Moment of Inertia $J = J_{arm} + J_{load}$

$$J_{arm} = 2\frac{W_a r_a^2}{3g} = \frac{2\ (70\ lb)\ (40\ in)^2}{3(386\ in/sec^2)} = 193\ lb\text{-}in\text{-}sec^2$$

$$J_{load} = \frac{W_l r_l^2}{g} = \frac{(100\ lb)\ (40\ in)^2}{s} = 415\ lb\text{-}in\text{-}sec^2$$

$J = J_{arm} + J_{load} = 193 + 415 = 608$ lb-in-sec^2
$E_k = 1/2\ J\ \omega^2 = 1/2\ (608\ lb\text{-}in\text{-}sec^2)\ (0.70\ rad/sec)^2$
$= 149$ lb.in.

Propelling Energy $E_p = P_p\ C_t\ \theta_d$

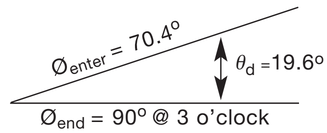
Torque Factor (C_t) for Model 15000 (5.0 lb-in/psi)
Deceleration Arc (θ_d) for Model 15000 (0.34 rad)

$E_p = P_p\ C_t\ \theta_d$ = (2,000 psi) (5.0 lb-in/psi) (0.34 rad)
= 3,400 lb-in

Gravitational Energy $E_g = W r_a \theta_d \sin\overline{\varnothing}$

Wr_a = (100 lb) (40 in) + 2(70 lb) 1/2(40 in) = 6,800 lb-in
Deceleration Arc ($\varnothing_d$) for Model 15000 (0.34 rad or 19.6º)

$\overline{\varnothing} = 1/2\ (\varnothing_{enter} + \varnothing_{end})$
$\varnothing_{enter} = \varnothing_{end} - \theta_d$
$= 90^o - 19.6^o = 70.4^o$
$\overline{\varnothing} = 1/2\ (70.4^o + 90^o) = 80.2^o$
$\sin\overline{\varnothing} = .99$



$E_g = W r_a \theta_d \sin\overline{\varnothing}$ = (6,800 lb-in) (.34 rad) (.99)
= 2,289 lb-in

Total Energy $E_t = E_k + E_p \pm E_g$

$E_t = 149 + 3{,}400 + 2{,}289$ lb-in = 5,838 lb-in

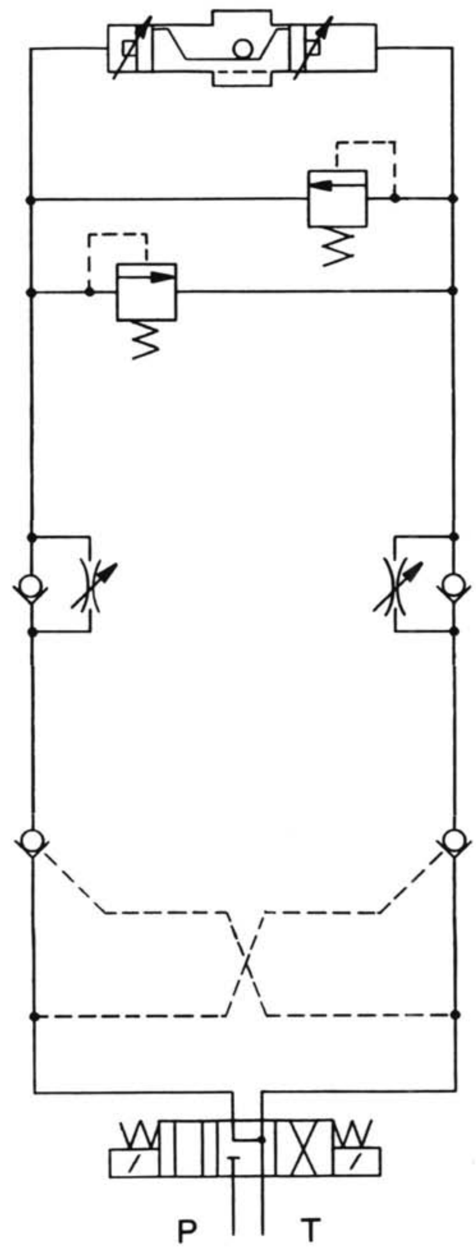
Total energy to be absorbed in the example is 5,838 lb-in. The cushion capacity of Model 15000, is 6,290 lb-in. This is adequate to absorb the deceleration requirement.

When the energy developed exceeds the capacity of the cushion, consider the following:

- Reduce weight of object in motion
- Reduce rotational velocity
- Employ external shock absorbers
- Add proportional hydraulics to the circuit to reduce propelling energy during deceleration.

Caution: Cushion needle adjustment is a crucial factor in achieving optimum cushion performance. If the needle valve setting is too far open, cushion capacity will be reduced or rendered ineffective; if set too tight, cushion action will generate shock and pressure spikes in excess of actuator rating.

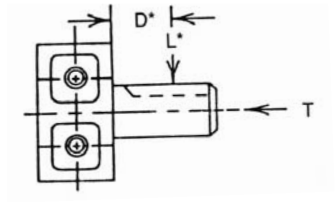
CIRCUIT CONSIDERATIONS



CAUTION: For high speed applications and applications involving external lever arm reactions, considerations must be given to a typical hydraulic system that includes the use of cross-over relief valves to eliminate excess pressure build-up in the FLO-TORK actuator should the operator try to stop the load by closing the discharge valve completely. An alternate method would be to install accumulators or other devices to absorb the hydraulic shock. See additional caution note on page 31.

BEARING LOAD CAPACITIES

BEARING LOAD CAPACITIES - FLO-TORK hydraulic rotary actuator bearings are sized to accept external loads. This feature often allows the shaft to be mounted directly to the rotary actuator without flexible couplings and outboard bearings, utilizing the FLO-TORK actuator as the bearing.



MAXIMUM EXTERNAL RADIAL LOAD L*																					
MODEL NOS.		900		1800		3700		7500		15000		30000		75000		150000		300000		600000	
Dim "D" in/mm		.812	20.62	.812	20.62	1.125	28.58	1.125	28.58	2.195	55.75	2.195	55.75	2.812	71.42	2.812	71.42	4.50	114.3	4.50	114.3
PSI	BAR	LB.	Kg.	LB.	Kg.	LB.	Kg.	LB.	Kg.	LB.	Kg.	LB.	Kg.	LB.	Kg.	LB.	Kg.	LB.	Kg.	LB.	Kg.
0	0	1,349	612	1,349	612	1,856	842	1,856	842	3,959	1,796	3,959	1,796	22,349	10,138	22,349	10,138	41,038	18,615	41,038	18,615
1,000	69	1,188	539	1,349	612	1,479	671	1,856	842	2,890	1,311	3,959	1,796	19,895	9,024	22,349	10,138	31,216	14,160	41,038	18,615
2,000	138	1,027	466	1,349	612	1,102	500	1,856	842	1,821	826	3,959	1,796	17,441	7,911	22,349	10,138	21,394	9,704	41,038	18,615
3,000	207	865	392	1,349	612	725	329	1,856	842	752	341	3,959	1,796	14,987	6,798	22,349	10,138	11,571	5,249	41,038	18,615
		MAXIMUM EXTERNAL THRUST LOAD T*																			
0	0	2,595	1,177	2,595	1,177	4,140	1,878	4,140	1,878	7,605	3,450	7,605	3,450	36,825	16,704	36,825	16,704	39,612	17,968	39,612	17,968
1,000	69	2,421	1,098	2,595	1,177	3,669	1,664	4,140	1,878	6,455	2,928	7,605	3,450	33,396	15,148	36,825	16,704	31,338	14,215	39,612	17,968
2,000	138	2,247	1,019	2,595	1,177	3,198	1,451	4,140	1,878	5,305	2,406	7,605	3,450	29,870	13,549	36,825	16,704	23,098	10,477	39,612	17,968
3,000	207	2,073	940	2,595	1,177	2,727	1,237	4,140	1,878	4,155	1,885	7,605	3,450	26,344	11,950	36,825	16,704	14,860	6,740	39,612	17,968

***CAUTION:** L is the maximum allowable external radial load at the maximum distance D (distance from housing to middle of keyway as shown on the chart as dimension D). To find L match the model and maximum operating pressure to find the maximum external radial load L on the rotary actuator. T is the maximum allowable external thrust load. To find T, match the model and maximum operating pressure to find the maximum thrust load on the rotary actuator. For combined radial and thrust loads consult factory.

SPECIAL CONSIDERATIONS

1. SPECIAL SYSTEM DESIGN consideration must be given to applications that involve high speed rotation, high cycle life, eccentric external loading conditions, or when the actuator maximum allowable pressure is exceeded. These design considerations may include internal or external shock absorbers, external controlled stops, special material or hardness treatment for actuator internal parts and special hydraulic system controls. See additional caution note on page 31.

2. CUSHIONS are available on FLO-TORK air and hydraulic rotary actuators. FLO-TORK's adjustable cushions will help absorb deceleration forces smoothly through the last 15º of rotation.

3. POSITION HOLDING OR BRAKING is possible by using "holding" valves or pilot operated checks. The FLO-TORK rotary actuator provides positive holding when used with good quality holding or locking valves.

4. SPEED CONTROL can be accomplished by controlling the fluid being exhausted from the rotary actuator (meter-out). Meter-out speed control is preferred to meter-in control, as it prevents runaway or cavitation. Consult factory for rotational speeds exceeding 90º in one (1) second.

5. CROSS-OVER RELIEF VALVES may be required to limit shock pressures and protect components in the system.

6. SYSTEM CLEANLINESS-The life and reliability of rotary actuators as well as other fluid power components are largely dependent upon system cleanliness. The best service life can be obtained by:

A) Complete flushing of each segment of the hydraulic circuit before connecting to the rotary actuator.

B) Providing suction line filters of 100 mesh screen or finer and pressure line filters of 25 micron nominal or finer.

7. SLOW ROTATION - The enclosed gear cases of FLO-TORK hydraulic rotary actuators are filled sufficiently with gear oil to lubricate the moving parts by immersion and splashing. In applications with slow rotation caution must be taken to insure that lubricant reaches upper gear components.

8. HOLLOW SHAFT - A high strength steel shaft with full length key engagement is recommended to mate with FLO-TORK's high strength hollow shaft pinion.

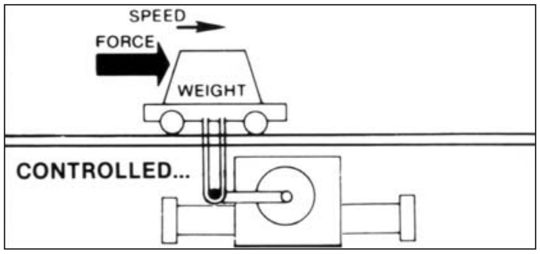
SPECIAL DESIGNS

The following are examples of FLO-TORK designs to satisfy special customer applications:

A) THREE POSITION ACTUATORS
B) AIR-OIL ACTUATORS FOR AIR OPERATIONS WITH OIL SPEED CONTROL
C) NON TIE-ROD DESIGN
D) SPRING RETURN
E) MANIFOLD PIPING
F) BUILT-IN CONTROL VALVES

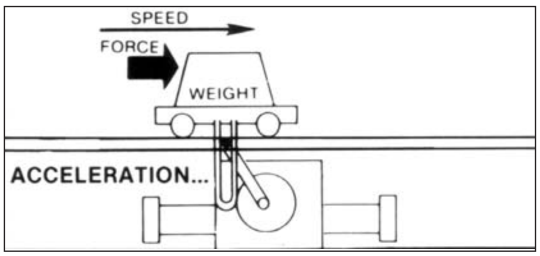
For special designs please forward a completed Application Specification Guide to Flo-Tork, Inc.

NOTE: The foregoing engineering information was developed from theoretical considerations to illustrate how to select a FLO-TORK rotary actuator for a specific application. FLO-TORK does not intend, nor do we imply, that these same performance characteristics will prevail in your applications, and the information is to be used as a guide only.



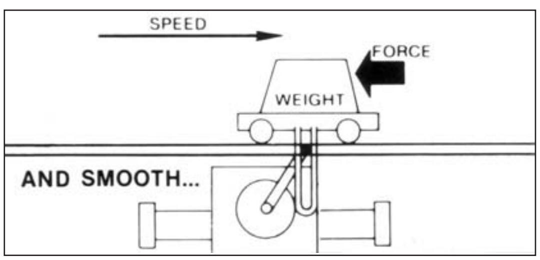
High Speed -Smooth Speed Control

Controlled acceleration and deceleration . . . with the FLO-TORK rotary actuator rotating at a constant speed. You can go faster and smoother using rotary actuators than with any other method.



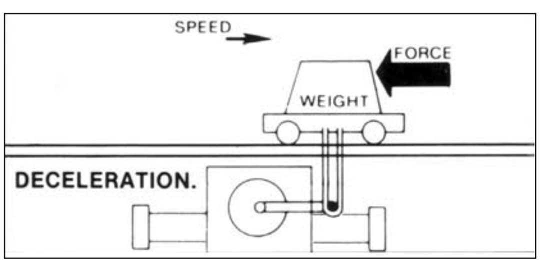
Gentle Acceleration

You have the maximum mechanical advantage where you need it . . . at the beginning of the travel. Force arrow shows maximum force in the direction of start-up to get you started faster.



Speed

Maximum velocity is when the load is halfway to its destination. Smooth acceleration to that point . . . then smooth deceleration.



Gentle Deceleration

You have the maximum mechanical advantage where you need it . . . at the end of the travel. Deceleration is a "mirror" reflection of acceleration and the load will be slowed down by the rotary actuator automatically.

Linear Drive with Flo-Tork Rotary Actuators Using Harmonic Motion

The advantages of using rotary actuators, combined with harmonic-motion-producing linkages, compared to the straight line cylinders, are derived from the principle of converting a constant speed rotating motion to a sinusoidal (sine-wave) motion which produces maximum linear force where needed for acceleration . . . and just the opposite force for deceleration and stopping the load. Meanwhile, you develop maximum linear speed during the middle of the 180º rotation cycle.

Acceleration control is easy to achieve and usually is limited only by the available hydraulic or pneumatic power.

Deceleration is usually the big problem and the speed of any reciprocating or oscillating motion is normally limited by the ability to control deceleration. Deceleration valves are expensive, difficult to field-adjust and susceptible to tampering and to malfunction from contaminated oil or air.

A simple flow control valve to maintain constant speed of the rotary actuator can, when combined with harmonic linkage, decelerate the load smoothly to rest.

How to Size Flo-Tork Rotary Actuators for Moving Loads in a Linear Direction Assuming the Harmonic Motion Principle

Two factors are required before you can size any drive which is moving a load horizontally:

1. Force required to accelerate and decelerate the load.
2. Force required to overcome friction losses in the system.

Two curves have been developed for you to use as guide lines for your particular design needs.

The low friction curve can be used to select the maximum torque required to transfer a given load, a given distance, in a given time for low to moderate friction arrangements such as ball bearings, rollers, etc. (assuming a coefficient of friction of 0.05).

The high friction curve is derived in the same way for moderate to high friction arrangements such as journal bearings, slides, etc. (assuming a coefficient of friction of 0.25).

Since it is not convenient to reverse the pressure system at mid-travel to provide deceleration torque, it is simpler to use a torque value of double the acceleration torque and apply the flow-control to the discharge. . . in other words, a metering-out system. This assures a positive pressure system at all points and gives a simple and positive control system. Our curves include that safety factor.

Caution: See caution note on page 31.

Using the representative range of sliding friction losses, these curves include double the torque required for acceleration (to compensate for leaving the inlet pressure system on and continuing to power the rotary actuator during deceleration with a throttle discharge) plus the coefficient of friction values indicated. The maximum torque required from the rotary actuator, for moving a weight, is given approximately by the following equation:

$$(T/W) = 0.3\left(\frac{R}{t}\right)^2 + R\,C_{f_L}\left(1 + C_{f_A}^2\right)^{1/2} \quad \frac{\text{lb-ft torque}}{\text{lb weight}}$$

Where R is the torque arm length (feet), t is the time for a rotation of 180º (seconds) C_{fL} and C_{fA} are the coefficients of friction of the moving weight (horizontally) and the torque arm slide (vertically). Although T = lb - ft, we have converted the values shown graphically on these curves to lb in of torque per lb of weight moved for the two fictional conditions.

To select the torques required to transfer a 100 lb load a distance of 6 ft in 3 seconds, assuming a coefficient of friction of 0.05, refer to the **Harmonic Motion Torque Curve** for low friction. Reading up from 3 sec to the R = 3 ft (6 ft diameter = 3 ft radius) curve, you then read to the left column to 5.7 lb-in of torque per pound to be moved. Multiply 5.7 x 100 lb = 570 lb-in torque for acceleration, deceleration, and friction. That's very little torque for that much work!

Likewise, moving the same load in one second would require 35 lb-in per lb of load, or 3,500 lb-in of torque.

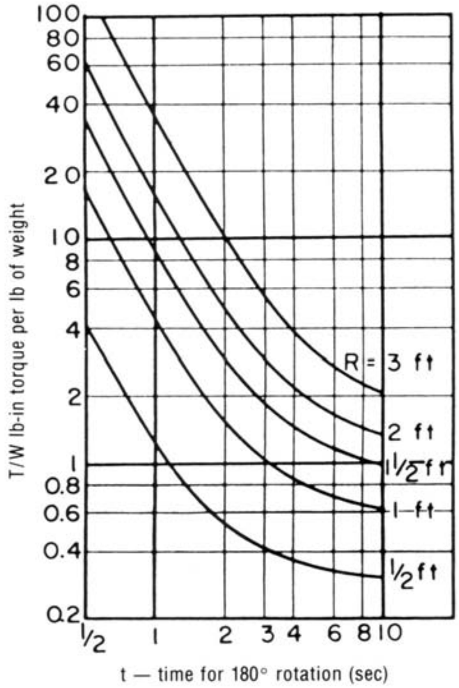
Now let us examine the same load, but assuming a coefficient of friction of 0.25 using the **Harmonic Motion Torque Curve** for high friction. Following the same procedure, a speed of 3 seconds requires 13 lb-in per lb of load, or a total of 1,300 lb-in of torque, and 1 second requires 40 lb-in per lb of load, or a total of 4,000 lb-in of torque.

Note: The foregoing curves were developed from theoretical considerations to illustrate the selection of rotary actuators for a specific application. Flo-Tork does not intend, nor do we imply, that these same performance characteristics will pre vail in your application, and the curves are to be used as guides only.

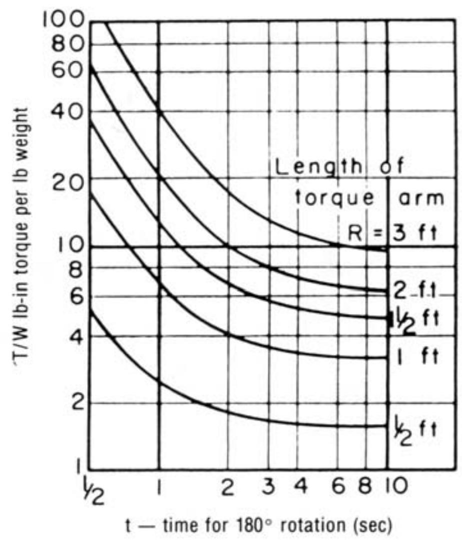
Caution: See page 34 for hydraulic circuit considerations. A typical hydraulic system for a harmonic motion application suggests the use of cross-over relief valves to eliminate excess pressure build-up in the Flo-Tork actuator should the operator try to stop the load at the mid point by closing the discharge valve completely. An alternate method would be to install accu mulators on each side of the rotary actuator to absorb the hydraulic shock. See pages 30 & 31 for applicable formulas, and page 35 for technical data.

HARMONIC MOTION TORQUE

LOW FRICTION APPLICATIONS



HIGH FRICTION APPLICATIONS



ENGINEERING

APPLICATION SPECIFICATION GUIDE

FLO-TORK, INC.

COMPANY

NAME:

ADDRESS: CUST. REF.

CITY: STATE: ZIP: DISTRIBUTOR

PHONE NUMBER: FAX NUMBER: LOCATION

APPLICATION DESCRIPTION

HYDRAULIC ( ) PNEUMATIC ( )

CAPACITY(LB.IN.)

OPERATING TORQUE: OPERATING PRESSURE: PSI

HOLDING TORQUE: HOLDING PRESSURE (MAX.): PSI

ACCELERATING TORQUE: DECELERATING TORQUE:

MAXIMUM ROTATION:

FLUID

TYPE: OPERATING TEMPERATURE RANGE: ºF

DUTY

MAXIMUM ROTATION SPEED: DEGREES PER SECOND:

CYCLE TIME (OVER AND BACK): SECONDS CYCLE RATE: PER HOUR

CYCLE DESCRIPTION IF SPECIAL:

CYCLE LIFE REQUIRED: ENVIRONMENT:

ROTATION LIMITED BY EXTERNAL STOPS: YES ( ) NO ( ) CUSHIONS (15º STD.) YES ( ) NO ( )

PHYSICAL

MAXIMUM HEIGHT: INCHES MAXIMUM WIDTH: INCHES

MAXIMUM LENGTH: INCHES MAXIMUM WEIGHT: POUNDS

MOUNTING (TAPPED FACE (STD.), LUG, FLANGE, OTHER):

SHAFT (HOLLOW (STD.), SINGLE END, DOUBLE END, OTHER):

SHAFT END (SINGLE KEY (STD.), SPLINE, OTHER):

PORTS (NPT (STD.), SAE STRAIGHT THREAD, FLANGE, OTHER):

LOADS

MAXIMUM SHAFT OVERHUNG LOAD (LBS.):

DISTANCE FROM ACTUATOR FACE OVERHUNG LOAD IS APPLIED (IN.):

SHAFT THRUST LOAD (LBS.):

ADDITIONAL LOADING: DESCRIBE:

RESPONSE INFORMATION

DATE QUOTATION REQUIRED: PROPOSAL DRAWING REQUIRED:

DATE PROTOTYPE REQUESTED: INITIAL QUANTITY REQUIRED:

INITIAL SHIPMENT REQUIRED: ANNUAL QUANTITY PURCHASE:

SUBMITTED BY: DATE:

E-MAIL:

The seller warrants its products to be free from defects in material and workmanship for a period of ONE year from the date of shipment from the factory. The Seller shall not be responsible for any damage resulting to or caused by its products by reason of improper storage or installation, unauthorized service, alteration of products, neglect or abuse, or attempt to operate, intentionally or otherwise, products at other than design specification or rated capacity. This warranty does not extend to any component parts not manufactured by Seller, however Seller's warranty herein shall not limit any warranties made by manufacturers of component parts which may extend to Purchaser.

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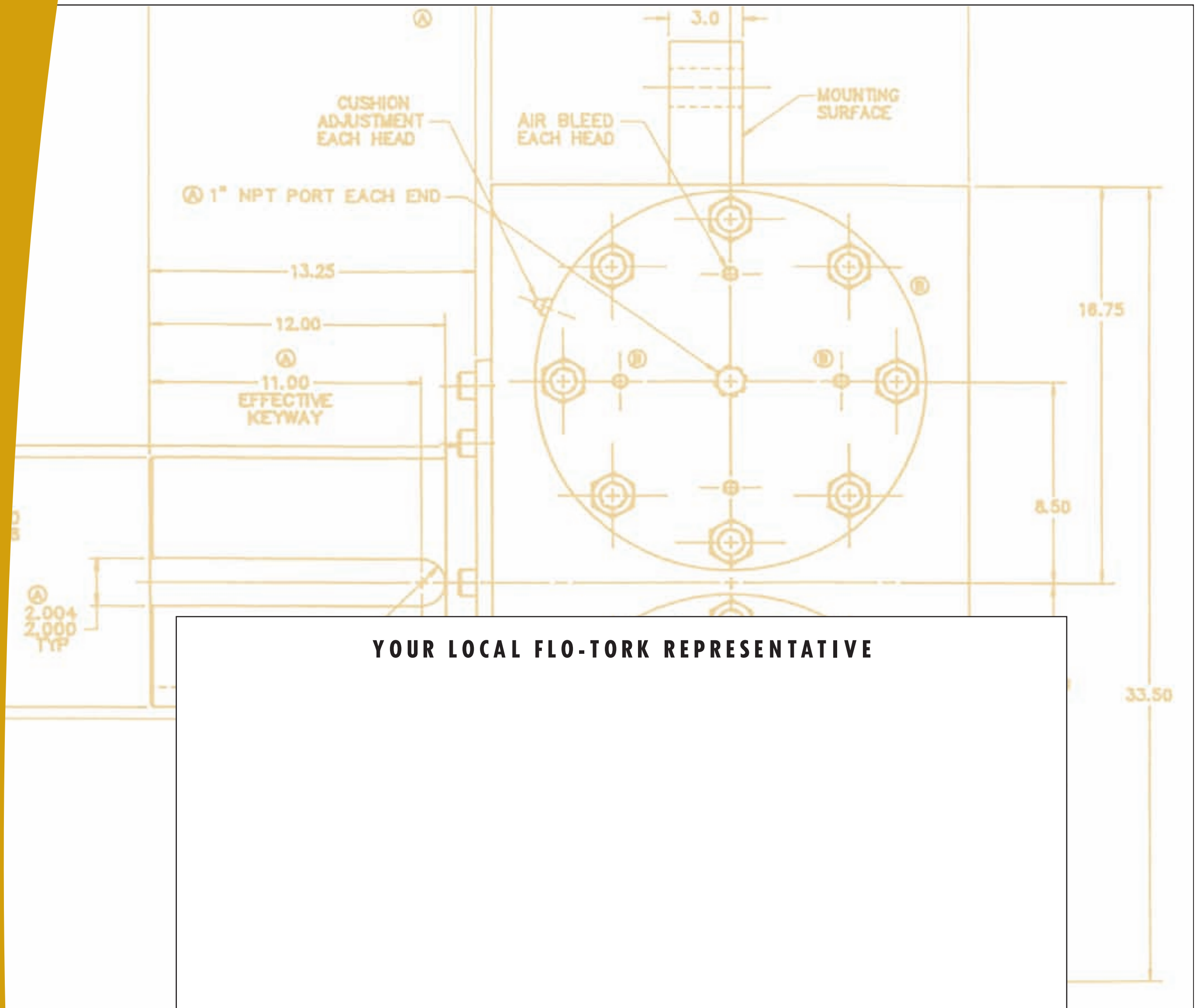

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