SOLUTIONS FOR INDUSTRIAL AUTOMATION

MULTI-MOTION ACTUATORS

SERIES MC

Multi-Motion Actuators provide both rotary and linear motions in one compact unit.

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4A

TO ORDER SPECIFY:
Product, Series, Type, Design No., Size, Angle of Rotation, Stroke, and Options.

SIZE	ROTARY BORE (mm)	LINEAR BORE (mm)
2016	20	16
2520	25	20
3225	32	25
4032	40	32
5040	50	40

LINEAR SECTION
IMPERIAL STROKE (MCS1) METRIC STROKE (MCS5)
STANDARD STROKE LENGTH
1/8" = Minimum stroke in 1/8" increments
5 mm = Minimum stroke in 5 mm increments

BORE (mm)	MAXIMUM STROKE (inches)	MAXIMUM STROKE (mm)
16	2-3/4	70
20	3-3/8	85
25	3-3/8	85
32	3-5/8	90
40	3-7/8	95

PRODUCT
M - Multi-Motion

SERIES
C - Standard Duty

DESIGN NO.
1 - Imperial
5 - Metric

M	C	S	1	2016	x	180	x	1/2	–	DB	–	WM	–	M

TYPE
S - 150 psi [10 bar] Air max.

ANGLE OF ROTATION
45°, 90°, 135°, 180°, 225°, 270°

ROTARY OPTIONS
PORT CONTROL
PB - Port Control both directions
PC - Port Control counterclockwise
PW - Port Control clockwise
CUSHION CONTROL
DB - Cushion both directions
DC - Cushion counterclockwise
DW - Cushion clockwise
SHOCK ABSORBER
NB - Shock installed both directions
NC - Shock installed counterclockwise
NW - Shock installed clockwise
GS - Shock ready both directions
GT - Shock ready counterclockwise
GU - Shock ready clockwise
(Shock absorbers must be ordered separately for -GS, -GT, and -GU options. 225° and 270° units are standard shock ready.)

LINEAR OPTIONS
F11 - Extended length wrench flats
K_ - Extra Tool Plate Extension in 1/8" or 5 mm increments up to 1" or 25 mm maximum Length code example: K1 = 1/8", K3 = 3/8", or K5 = 5 mm, K15 = 15 mm, etc.
WM - Blank Tool Plate (shipped with tool plate unassembled)

SWITCH READY OPTIONS
I - Magnets for PHD Magnetoresistive Switches
M - Reed Magnets for PHD Reed Switches
(Switches must be ordered separately. Rotary and linear sections receive same switch ready options.)

Options may affect unit length. See unit dimension and options pages for adders.

SERIES 5360 MAGNETORESISTIVE SWITCHES

PART NO.	DESCRIPTION
53605-1-02	NPN 6-24 VDC, 2 m cable
53606-1-02	PNP 6-24 VDC, 2 m cable
53625-1	NPN 6-24 VDC, Quick Connect
53626-1	PNP 6-24 VDC, Quick Connect

SERIES 5360 REED SWITCHES

PART NO.	DESCRIPTION
53602-2-02	NPN or PNP 4.5-24 VDC, 2 m cable
53609-2-02	AC Type 110-120 VAC with Current Limit, 2 m cable
53622-2	NPN or PNP 4.5-24 VDC, Quick Connect
53629-2	AC Type 110-120 VAC, Quick Connect with Current Limit

SHOCK ABSORBERS

SIZE	PHD NO.
2016	56722-01
2520	56722-02
3225	56722-03
4032	56722-04
5040	56722-05

CAUTION: These units are not intended for side load, offset load, rotational inertial load, or high velocity applications. Contact PHD for more information.

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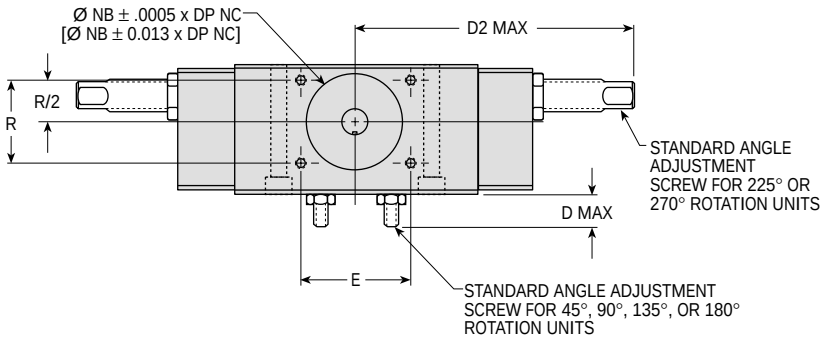
BENEFITS

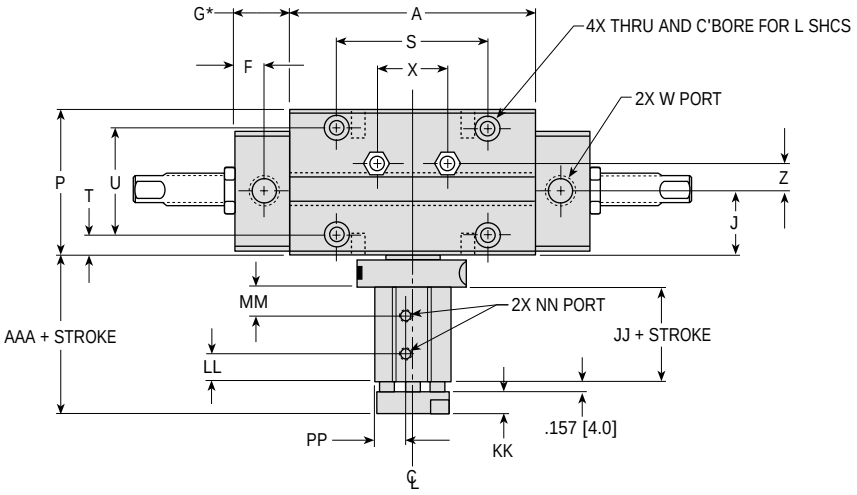
- Series MC Multi-Motion Actuators provide both rotary and linear motions in one compact unit. Available in both imperial and metric versions, these actuators are available in five sizes with six standard rotations and linear stroke lengths up to 3-7/8" [95 mm].
- Built-in standard angle adjustments of +10°, -45° from nominal, make it easy to adjust to specific rotation requirements. This provides a total range of actuator rotation from 0° to 280°.
- Units with rotations of 180° or less have all rotary control adjustments and ports on the same side of the actuator, saving space and providing easy accessibility.
- Mounting patterns on three surfaces provide versatility in design and unit mounting.
- Standard shock pads on the linear section extend cylinder life and minimize piston noise when the piston contacts the head and cap. The shock pads add no additional length to the linear section.
- Optional built-in flow controls save space and provide constant and accurate control of the rotation speed.
- Optional built-in hydraulic shock absorbers provide smooth rotary deceleration of external loads and allow for greater rotational load stopping capacity.
- The hub design provides capability to quickly change the orientation of the linear section in 22.5° increments.
- Standard tool plate on the linear section allows direct mounting of PHD Series 190 & 191 Grippers.
- Modular design allows independent replacement of the linear and rotary sections should the application requirements change.
- Optional built-in adjustable cushions reduce shock at end of rotation and increase the unit's rotational load stopping capacity.
- Optional PHD Reed or Magnetoresistive Switches are available on both the linear and rotary sections.

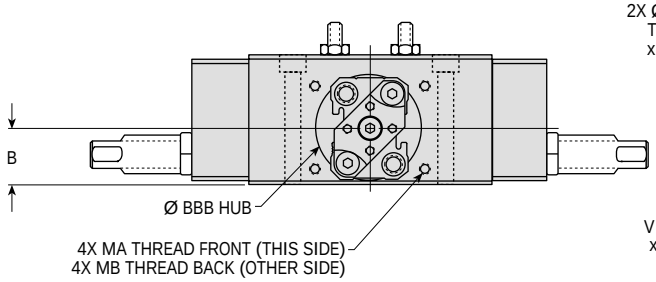
CAUTION: These units are not intended for side load, offset load, rotational inertial load, or high velocity applications. Contact PHD for more information.

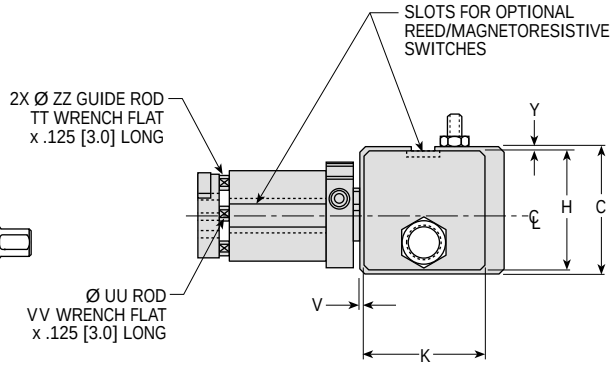
SPECIFICATIONS	SERIES MC
PORTS	NPT [BSP]
LUBRICATION	Permanent for Non-Lube Air
WORKING PRESSURE	150 psi [10 bar] Air Max.
ROTARY SECTION	
PISTON SEALS	One Block Vee per Piston
PISTONS	Free Floating, Acetal Material
PINION SHAFTS	One Piece Alloy Steel
RACKS	Alloy Steel
END CAPS	Clear Anodized Aluminum
BODY	Hardcoated Aluminum
BEARINGS	Two Steel Ball Bearings
STANDARD ROTATIONS	45°, 90°, 135°, 180°, 225°, 270°
OPTIONS	Port Controls®, Cushions, Shock Absorbers, Magnets for Proximity Switches
LINEAR SECTION	
PISTON ROD/GUIDE RODS	Hard Chrome-plated Steel
BODY/BORE	Hardcoated Aluminum
PISTON SEAL	Long Life Nitrile
ROD SEAL	Long Life Nitrile U-cup
PISTON ROD BUSHING	Bronze
TOOL PLATE	Anodized Aluminum
GUIDE ROD BUSHINGS	Oil-impregnated Bronze
OPTIONS	Extended Length Wrench Flats, Extra Tool Plate Extension, Blank Tool Plate

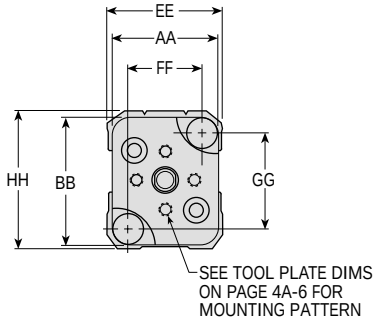


NOTES:
1) NUMBERS IN [ ] ARE IN MILLIMETERS.
2) *G DIMENSION INCREASES WITH CUSHION OPTION. SEE PAGE 4A-10.

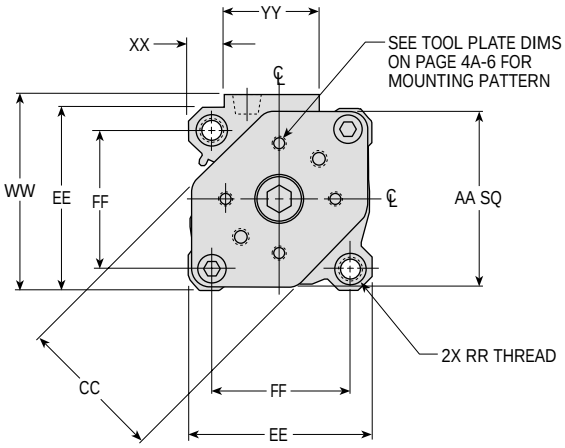








MCSx2016 ONLY
End view of cylinder. See page 4A-6 for tool plate dimensions



MCSx2520, MCS3225, MCS4032, & MCS5040

All dimensions are reference only unless specifically toleranced.

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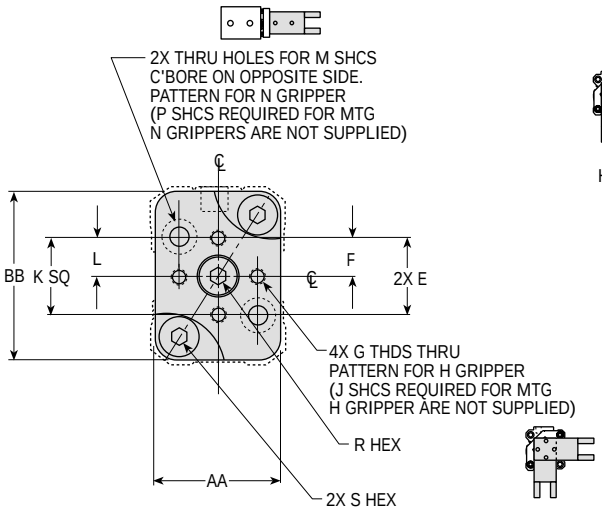
DIMENSIONS: SERIES MC MULTI-MOTION ACTUATORS

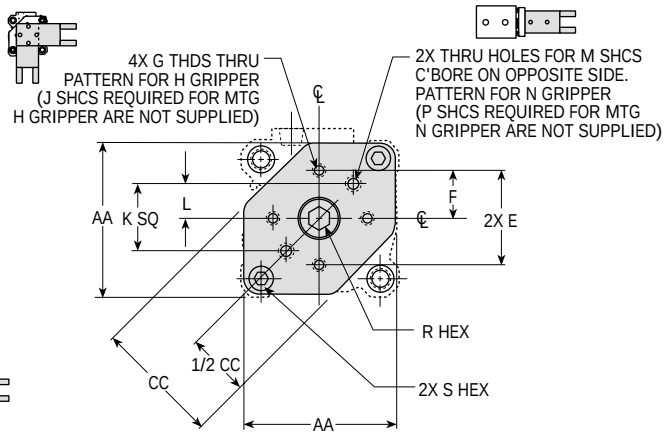
	SIZE									
	2016		2520		3225		4032		5040	
DIMENSION	in	mm	in	mm	in	mm	in	mm	in	mm
A (45°-90°)	3.524	89.5	3.819	97.0	4.606	117.0	5.256	133.5	6.300	160.0
A (135°-180°)	3.760	95.0	4.508	114.5	5.650	143.5	6.476	164.5	7.343	186.5
A (225°-270°)	4.390	111.5	5.295	134.5	6.693	170.0	7.736	196.5	8.917	226.5
B	.807	20.5	.983	25.0	1.161	29.5	1.516	38.5	1.674	42.5
C	1.831	46.5	2.224	56.5	2.697	68.5	3.366	85.5	3.918	99.5
D	.604	15.34	.724	18.39	.920	23.37	.977	24.82	1.191	30.25
D2	4.39	111.5	5.06	128.5	5.87	149.1	6.66	169.1	7.32	186.0
E	1.574	40.0	1.772	45.0	2.166	55.0	2.558	65.0	2.952	75.0
F	.394	10.0	.394	10.0	.394	10.0	.472	12.0	.472	12.0
G*	.768	19.5	.768	19.5	.768	19.5	.945	24.0	.945	24.0
H	1.712	43.5	2.087	53.0	2.559	65.0	3.228	82.0	3.720	94.5
J	.91	23.0	1.01	25.5	1.18	30.0	1.57	39.75	1.74	44.25
K	1.732	44.0	1.929	49.0	2.264	57.5	3.071	78.0	3.346	85.0
L	#10	M5	#10	M5	1/4	M6	5/16	M8	3/8	M10
MA	10-24 x .281	M5 x 0.8 x 7	10-24 x .285	M5 x 0.8 x 7	1/4-20 x .250	M6 x 1.0 x 7.5	5/16-18 x .437	M8 x 1.25 x 12	3/8-16 x .375	M10 x 1.5 x 10
MB	10-24 x .375	M5 x 0.8 x 12.5	10-24 x .500	M5 x 0.8 x 12.5	1/4-20 x .500	M6 x 1.0 x 15	5/16-18 x .750	M8 x 1.25 x 20	3/8-16 x .750	M10 x 1.5 x 20
NB	1.3785	35.014	1.4572	37.013	1.8509	47.013	2.0477	52.012	2.4414	62.012
NC	.085	2.16	.080	2.03	.100	2.54	.115	2.92	.125	3.17
P	2.047	52.0	2.362	60.0	2.835	72.0	3.544	90.0	3.976	101.0
R	1.181	30.0	1.378	35.0	1.772	45.0	2.164	55.0	2.362	60.0
S	2.166	55.0	2.362	60.0	2.952	75.0	3.346	85.0	3.936	100.0
T	.276	7.0	.295	7.5	.335	8.5	.394	10.0	.452	11.5
U	1.496	38.0	1.772	45.0	2.165	55.0	2.756	70.0	3.071	78.0
V	.04	1.0	.04	1.0	.05	1.2	.03	0.8	.07	1.8
W	1/8 NPT	1/8 BSP	1/8 NPT	1/8 BSP	1/8 NPT	1/8 BSP	1/8 NPT	1/8 BSP	1/4 NPT	1/4 BSP
X	1.004	25.5	1.124	28.5	1.458	37.0	1.598	40.6	1.984	50.4
Y	.06	1.5	.08	2.0	.08	2.0	.08	2.0	.10	2.5
Z	.397	10.0	.539	13.7	.667	16.9	.869	22.0	.983	25.0
AA	1.000	25.5	1.375	35.0	1.500	38.0	1.750	44.5	2.000	51.0
BB	1.250	31.75	—	—	—	—	—	—	—	—
CC	—	—	.906	23	1.024	26	1.378	35	1.650	42
EE	1.104	28.0	1.476	37.5	1.576	40.0	1.870	47.5	2.205	56.0
FF	.710	18.0	1.000	25.4	1.100	28.0	1.339	34.0	1.575	40.0
GG	.946	24.0	—	—	—	—	—	—	—	—
HH	1.340	34.0	—	—	—	—	—	—	—	—
JJ	1.380	35.0	1.615	41.0	1.615	41.0	1.790	45.5	1.790	45.5
KK	.295	7.5	.394	10.0	.394	10.0	.394	10.0	.394	10.0
LL	.415	10.5	.670	17.0	.670	17.0	.710	18.0	.710	18.0
MM	.415	10.5	.415	10.5	.415	10.5	.450	11.5	.450	11.5
NN	10-32 x .15	M5 x .8 x 4	10-32 x .15	M5 x .8 x 4	10-32 x .15	M5 x .8 x 4	1/8 NPT	1/8 BSP	1/8 NPT	1/8 BSP
PP	.454	11.5	.531	13.5	.552	14.0	.610	15.5	.738	18.75
RR	10-24 x .550	M5 x .8 x 14.5	1/4-20 x .875	M6 x 1.0 x 22.5	1/4-20 x .875	M6 x 1.0 x 22.5	1/4-20 x .875	M6 x 1.0 x 22.5	1/4-20 x .875	M6 x 1.0 x 22.5
TT	.219	5.5	.250	7.0	.250	7.0	.250	7.0	.250	7.0
UU	.250	6.35	.375	9.5	.375	9.5	.625	15.9	.625	15.9
VV	.219	5.5	.312	8.0	.312	8.0	.500	13.0	.500	13.0
WW	—	—	1.576	40.0	1.746	44.5	2.037	52.0	2.363	60.0
XX	—	—	.344	8.75	.288	7.30	.266	6.75	.392	10.0
YY	—	—	.788	20.0	1.000	25.4	1.340	34.0	1.340	34.0
ZZ	.236	6.0	.315	8.0	.315	8.0	.315	8.0	.315	8.0
AAA	2.287	58.0	2.621	66.5	2.737	69.5	2.912	74.0	3.170	80.5
BBB	1.535	39.0	1.850	47.0	2.165	55.0	2.717	69.0	2.953	75.0

All dimensions are reference only unless specifically toleranced.

LINEAR SECTION TOOL PLATE



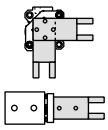
MCSx2016



MCSx2520, 3225, 4032, 5040

LETTER DIM	SIZE									
	2016		2520		3225		4032		5040	
	in	mm	in	mm	in	mm	in	mm	in	mm
AA	1.00	25.5	1.375	35.0	1.500	38.0	1.750	44.5	2.00	51.0
BB	1.250	31.75	—	—	—	—	—	—	—	—
CC	—	—	.906	23.0	1.024	26.0	1.378	35.0	1.650	42.0
E	.550	14.0	.710	18.0	.710	18.0	1.100	28.0	1.100	28.0
F	.275	7.0	.355	9.0	.355	9.0	.55	14.0	.55	14.0
G	4-40	M3 x .5	6-32	M3 x .5	6-32	M3 x .5	8-32	M3 x .7	8-32	M3 x .7
J	4-40 x 1	M3 x .5 x 20	6-32 x 1-1/4	M3 x .5 x 30	6-32 x 1-1/4	M3 x .5 x 30	8-32 x 1-5/8	M4 x .7 x 40	8-32 x 1-5/8	M4 x .7 x 40
K	.550	14.0	.550	14.0	.550	14.0	.710	18.0	.710	18.0
L	.275	7.0	.275	7.0	.275	7.0	.355	9.0	.355	9.0
M	#4	M3	#4	M3	#4	M3	#6	M3	#6	M3
P	4-40 x 3/8	M3 x .5 x 8	4-40 x 3/8	M3 x .5 x 10	4-40 x 3/8	M3 x .5 x 10	6-32 x 3/8	M3 x .5 x 8	6-32 x 3/8	M3 x .5 x 8
R	—	3.0	—	5.0	—	5.0	—	6.0	—	6.0
S	—	3.0	—	4.0	—	4.0	—	4.0	—	4.0

*Imperial grippers mount to MCS1 only. Metric grippers mount to MCS5 only.



LETTER DIM	SIZE									
	2016		2520		3225		4032		5040	
	ANGULAR	PARALLEL	ANGULAR	PARALLEL	ANGULAR	PARALLEL	ANGULAR	PARALLEL	ANGULAR	PARALLEL
H (PHD SERIES 190)*	— [19002]	1906x [1906x]	— [19012]	1907x [1907x]	— [19012]	1907x [1907x]	— [19022]	1908x [1908x]	— [19022]	1908x [1908x]
N (PHD SERIES 19x)*	— [19x02]	19x6x [19x6x]	— [19x02]	19x6x [19x6x]	— [19x02]	19x6x [19x6x]	— [19x12]	19x7x [19x7x]	— [19x12]	19x7x [19x7x]

NUMBERS IN [ ] ARE IN mm OR FOR METRIC UNITS.

PRESSURE RATINGS

All Series MC Multi-Motion Actuators have a maximum pressure rating of 150 psi [10 bar] and are for pneumatic use only.

BREAKAWAY

The breakaway pressure of the Series MC Multi-Motion Actuators is 20 psi [1.5 bar].

OPERATING TEMPERATURES

Series MC Multi-Motion Actuators are recommended for use in ambient temperatures from -20° to +180°F [-28° to +82°C]. Consult PHD for temperatures beyond this range.

TOLERANCES

Tolerance on the nominal stroke length is ±1/32 inch [0.8 mm]. The total rotational tolerance is +10°, -0° on the nominal specified rotation.

ROTATIONAL RATES

The average speed of rotation for units with zero load is 180° in .06 second for 2016, 2520, 3225, and 4032 units, and 180° in .075 second for 5040 units. Average minimum velocity of the linear section is 20 in/sec [.5 m/sec] with zero load.

BACKLASH

The rotary motion of the tool plate is controlled and transmitted by a rack and pinion in the rotary section and guide rods on the linear section. Tolerances in the guide rods and bushings allow a maximum theoretical backlash of 1° from the tool plate.

ANGLE OF ROTATION

Standard angles of rotation are 45°, 90°, 135°, 180°, 225°, and 270°. Consult PHD for other rotation requirements. All units have built-in angle adjustments providing +10°, -45° of adjustment as standard.

LUBRICATION

All units are permanently lubricated at assembly for service using non-lubricated air. Life can be extended by periodic lubrication of the rack and pinion using high grade bearing grease and by using lubricated air. Seals are compatible with standard petroleum-based oil used for lubrication of air cylinders.

CONTROLS

To attain maximum unit life, control of both rotational and linear speed is extremely important. The rotational inertia force is a function of rotational speed and distance from the load to the axis of rotation. PHD's built-in flow controls, cushions, and shock absorbers should be considered when rotational inertial loads are applied. In addition, external flow controls are recommended to control the speed of the linear section of the unit. See pages 4A-10 to 4A-12 for information on Series MC Rotary Section Controls. See pages 4A-16 to 4A-21 for maximum loads and kinetic energy performance data.

APPLICATION

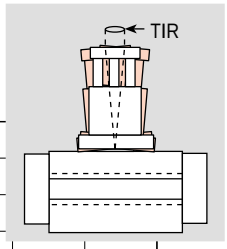
The PHD Series MC Multi-Motion Actuators provide both rotary and linear motions in one unit. They are intended for use where side load and rotational inertial load on the linear section are limited. For maximum unit life, the center of gravity of attached loads should be in line with the centerline of the linear section. For applications which subject the linear section to significant torques, other PHD Multi-Motion Actuators (see section 4B) or automation alternatives should be considered.

CAUTION: PHD does not recommend the use of external stops against the tool plate of the linear section to stop rotation on Series MC Multi-Motion Actuators.

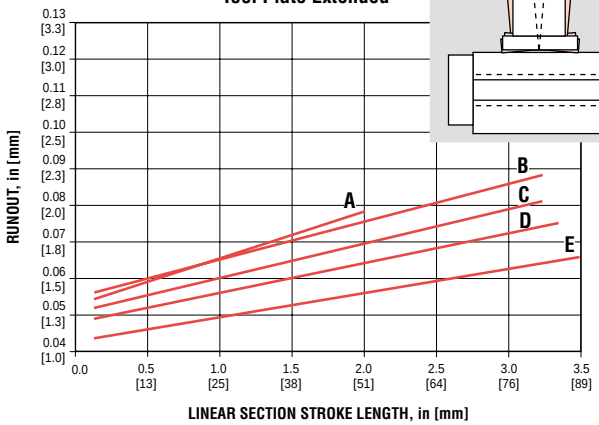
ROTATIONAL ACCURACY

Series MC Multi-Motion Actuators are intended for use in medium precision applications. The tables below present the typical and maximum theoretical values of total indicator reading (TIR) for the center of the tool plate during rotation with the tool plate extended. For applications where higher precision is required, other PHD automation solutions should be considered.

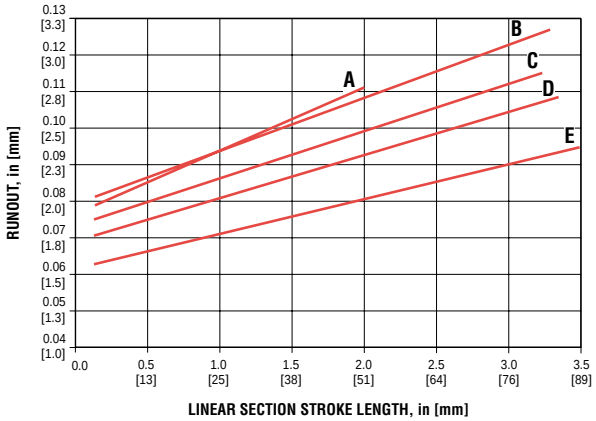
A = MCSx2016 B = MCSx2520 C = MCSx3225
D = MCSx4032 E = MCSx5040



TYPICAL TIR
Tool Plate Extended



MAX. THEORETICAL TIR
Tool Plate Extended



SERIES MC ACTUATOR WEIGHT TABLE

SIZE	ROTATION	BASE WEIGHT lb	BASE WEIGHT kg	ADDERS PER 1" STROKE lb	ADDERS PER 1" STROKE kg	ADDERS CUSHION-DB lb	ADDERS CUSHION-DB kg	ADDERS SHOCK-NB lb	ADDERS SHOCK-NB kg
2016	45°/90°	2.1	0.95	0.12	0.05	0.3	0.14	0.2	0.09
	135°/180°	2.1	0.95	0.12	0.05	0.3	0.14	0.3	0.14
	225°/270°	2.6	1.18	0.12	0.05	0.3	0.14	0.1	0.05
2520	45°/90°	2.8	1.27	0.16	0.07	0.4	0.18	0.5	0.23
	135°/180°	3.2	1.45	0.16	0.07	0.4	0.18	0.5	0.23
	225°/270°	3.9	1.75	0.16	0.07	0.4	0.18	0.3	0.14
3225	45°/90°	5.0	2.27	0.21	0.10	0.6	0.27	0.9	0.41
	135°/180°	5.6	2.54	0.21	0.10	0.6	0.27	0.9	0.41
	225°/270°	7.2	3.27	0.21	0.10	0.6	0.27	0.6	0.27
4032	45°/90°	8.6	3.90	0.31	0.14	0.8	0.36	1.8	0.82
	135°/180°	9.7	4.40	0.31	0.14	0.8	0.36	1.9	0.86
	225°/270°	12.6	5.72	0.31	0.14	0.8	0.36	1.2	0.54
5040	45°/90°	13.1	5.94	0.34	0.15	1.1	0.50	2.7	1.22
	135°/180°	14.3	6.49	0.34	0.15	1.1	0.50	2.9	1.32
	225°/270°	19.2	8.71	0.34	0.15	1.1	0.50	1.3	0.59

ROTARY SECTION SPECIFICATIONS

SIZE	BORE mm	GEAR RACKS 45°-180°	GEAR RACKS 225°-270°	PISTON DIAMETER in	PISTON DIAMETER mm	PISTON AREA in²	PISTON AREA mm²	DISPLACEMENT in³/DEG. ROT.	DISPLACEMENT mm³/DEG. ROT.
2016	20	1	2	.79	20	.49	314.16	.002	32.77
2520	25	1	2	.98	25	.76	490.87	.004	65.55
3225	32	1	2	1.26	32	1.25	804.25	.007	114.71
4032	40	1	2	1.57	40	1.95	1256.64	.014	229.42
5040	50	1	2	1.97	50	3.04	1963.50	.027	442.45

LINEAR SECTION SPECIFICATIONS

SIZE	BORE in	BORE mm	ROD DIAMETER in	ROD DIAMETER mm	ROD DIRECTION	EFFECTIVE AREA in²	EFFECTIVE AREA mm²
2016	.630	16	.250	6.35	PUSH	.312	201
					PULL	.263	169
2520	.787	20	.375	9.53	PUSH	.487	314
					PULL	.377	243
3225	.984	25	.375	9.53	PUSH	.761	491
					PULL	.650	420
4032	1.260	32	.625	15.88	PUSH	1.247	804
					PULL	.940	606
5040	1.575	40	.625	15.88	PUSH	1.948	1257
					PULL	1.641	1059

THEORETICAL TORQUE AND THRUST OUTPUT

OPERATING PRESSURE	IMPERIAL UNITS														
	2016			2520			3225			4032			5040		
	TORQUE	THRUST-lb		TORQUE	THRUST-lb		TORQUE	THRUST-lb		TORQUE	THRUST-lb		TORQUE	THRUST-lb	
psi	in-lb	PUSH	PULL	in-lb	PUSH	PULL	in-lb	PUSH	PULL	in-lb	PUSH	PULL	in-lb	PUSH	PULL
20	2	6	5	4	10	8	8	15	13	15.5	25	19	30	39	33
40	4	12	11	8	19.5	15	16	30	26	31	50	38	60	78	66
50	5	16	13	10	24	19	20	38	33	38	62	47	76	97	82
60	6	19	16	11	29	23	24	46	39	46	75	56	91	117	98
70	7	22	18	13	34	26	29	53	46	54	87	66	106	136	115
80	8	25	21	15	39	30	33	61	52	62	100	75	121	156	131
90	9	28	24	17	44	34	37	68	59	70	112	85	136	175	148
100	10	31	26	19	49	38	41	76	65	77	125	94	152	195	164
120	11	37	32	22	58	45	49	91	78	93	150	113	182	234	197
130	12	41	34	24	63	49	54	99	85	101	162	122	197	253	213
140	13	44	37	26	68	53	58	107	91	109	175	132	213	273	230
150	14	47	39	28	73	56	62	114	98	116	187	141	228	292	246

OPERATING PRESSURE	METRIC UNITS														
	2016			2520			3225			4032			5040		
	TORQUE	THRUST-N		TORQUE	THRUST-N		TORQUE	THRUST-N		TORQUE	THRUST-N		TORQUE	THRUST-N	
bar	Nm	PUSH	PULL	Nm	PUSH	PULL	Nm	PUSH	PULL	Nm	PUSH	PULL	Nm	PUSH	PULL
1.4	0.2	28	24	0.4	44	34	0.9	69	59	1.8	113	85	3.4	176	148
2.7	0.4	54	46	0.9	85	65	1.8	132	113	3.5	217	164	6.8	339	286
3.4	0.6	68	57	1.0	106	82	2.3	165	141	4.4	271	205	8.6	424	357
4.1	0.7	81	68	1.2	127	98	2.8	198	170	5.2	326	245	10.0	509	428
4.8	0.8	96	81	1.5	151	116	3.2	235	201	6.1	386	291	12.0	603	508
5.5	0.9	111	93	1.7	173	133	3.7	270	230	7.0	442	333	13.0	691	582
6.2	1.0	125	105	1.9	195	150	4.2	304	260	7.9	498	376	15.0	779	656
6.8	1.1	136	114	2.1	212	163	4.6	331	283	8.8	543	409	17.0	848	714
8.2	1.3	165	139	2.5	257	198	5.6	402	344	10.0	659	497	20.0	1030	868
8.9	1.4	179	150	2.7	279	215	6.1	436	373	11.0	716	539	22.0	1118	942
9.6	1.5	193	162	3.0	301	232	6.5	470	402	12.0	772	582	24.0	1206	1016
10	1.6	204	171	3.2	318	245	7.0	496	424	13.0	814	614	25.0	1272	1071

STANDARD ANGLE ADJUSTMENT

All PHD Series MC Multi-Motion Actuators are supplied as standard with built-in adjustable angle stops. Together these mechanical positive stops provide an adjustment range of +10°, -45° on each nominal angle of rotation (See Table 1.) (-5° to 22-1/2° from each end).

Units with rotations of 180° or less utilize adjusting screws in the top of the actuator which stop against a stop cam attached to the pinion shaft (see Illustration A). Units with rotations of 225° and 270° use angle adjustment screws located in the end caps which stop against the auxiliary lower rack (see Illustration B). When 225° or 270° units are ordered with optional shock absorbers, the shock absorbers double as the angle adjustment screws.

The ability to adjust over such a wide range eliminates the need to order special units for specific angles of rotation. The range of nominal rotations and the +10°, -45° adjustments provide a total rotation range of 0° to 280° across the Series MC Multi-Motion Actuator line.

NOTE: Cushions are effective for approximately the last 40° of rotation each direction. The cushion angle will decrease by the same amount that the nominal rotation is reduced by the angle adjustment. Consult PHD for non-standard angles of rotation if cushions are required.

TABLE 1

ROTATION ORDERED	STANDARD ADJUSTMENT RANGE
45°	0° through 55°
90°	45° through 100°
135°	90° through 145°
180°	135° through 190°
225° or 270°	180° through 280°

ILLUSTRATION A

0-180° ROTATIONS

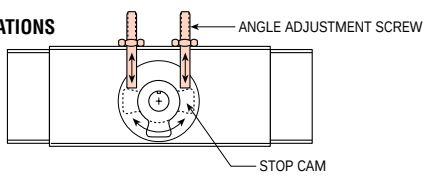
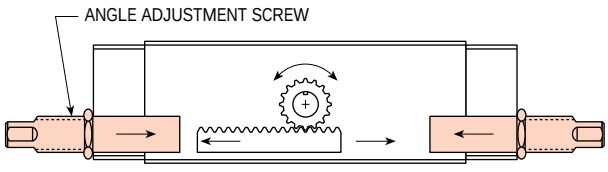


ILLUSTRATION B

181°-270° ROTATIONS



UPPER RACK OMITTED FOR CLARITY

4A

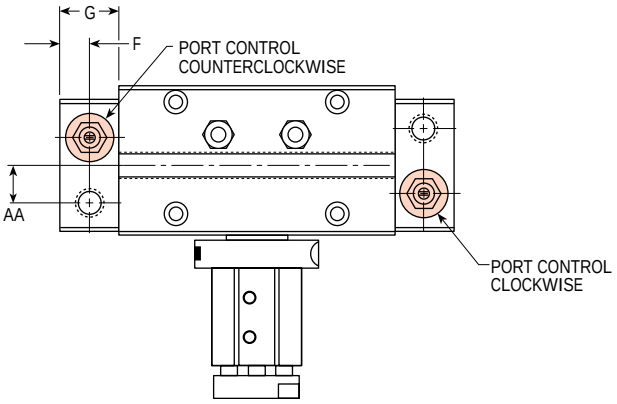
PB PORT CONTROL® BOTH DIRECTIONS

PC PORT CONTROL® COUNTERCLOCKWISE DIRECTION

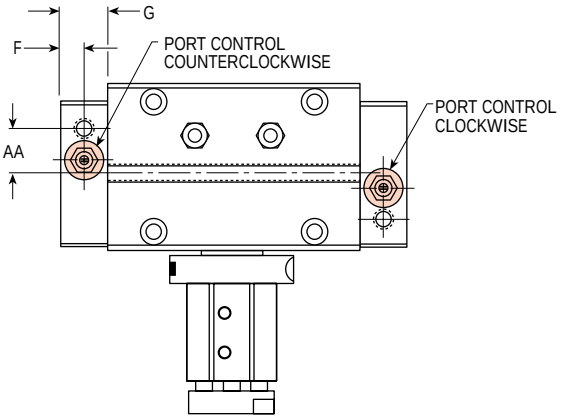
PW PORT CONTROL® CLOCKWISE DIRECTION

PHD Port Control® is a built-in flow control valve for controlling the speed throughout rotation. The Port Control® is based on the "meter-out" principle and features an adjustable needle in a cartridge. The self-locking needle has micrometer threads and is adjustable under pressure. The PHD Port Control® saves space and eliminates the cost of fittings and installation for external flow control valves.

SIZE	F		G		AA	
	in	mm	in	mm	in	mm
2016	.394	10.0	.768	19.5	.374	9.5
2520	.394	10.0	.768	19.5	.374	9.5
3225	.394	10.0	.768	19.5	.374	9.5
4032	.472	12.0	.945	24.0	.965	24.5
5040	.472	12.0	.945	24.0	1.083	27.5



MCSx2016, 2520, 3225



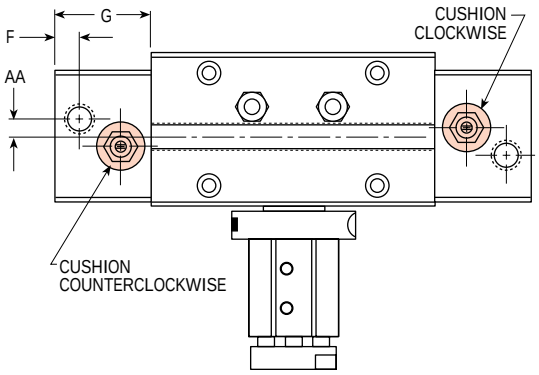
MCSx4032, 5040

DB CUSHION BOTH DIRECTIONS

DC CUSHION COUNTERCLOCKWISE DIRECTION

DW CUSHION CLOCKWISE DIRECTION

PHD Cushions allow for smooth deceleration at the end of rotation. When the cushion operates, the remaining volume of air in the actuator must exhaust past an adjustable needle, which controls the deceleration of the pinion shaft. The effective length of the cushion is approximately 40° of rotation at the end of full nominal rotation. The use of angle adjustment screws to reduce the angle of rotation has a direct effect on the length of cushion engagement. Example: 5° of angle reduction on one end will reduce cushion engagement by 5° on that end of rotation. See pages 4A-16 to 4A-21 for information on unit stopping capacity with adjustable cushions.



SIZE	F		G		AA	
	in	mm	in	mm	in	mm
2016	.315	8.0	1.280	32.5	.118	3.0
2520	.315	8.0	1.280	32.5	.118	3.0
3225	.315	8.0	1.280	32.5	.118	3.0
4032	.394	10.0	1.378	35.0	—	—
5040	.394	10.0	1.378	35.0	—	—

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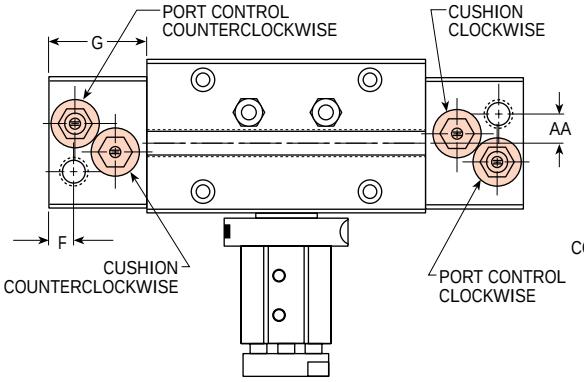
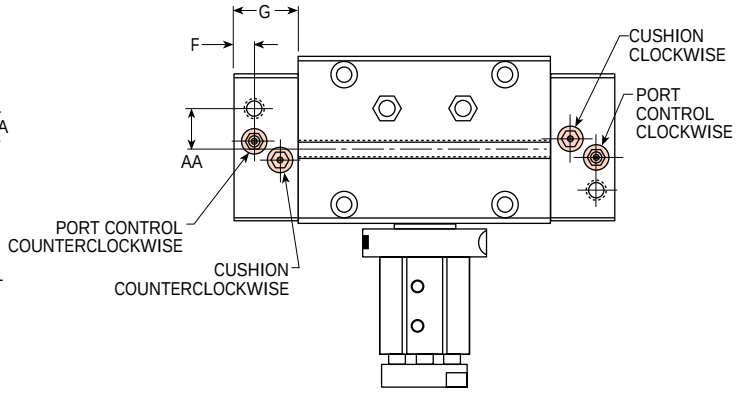
All dimensions are reference only unless specifically toleranced.

PORT CONTROL® AND CUSHION LOCATIONS



MCSx2016, 2520, 3225, 4032



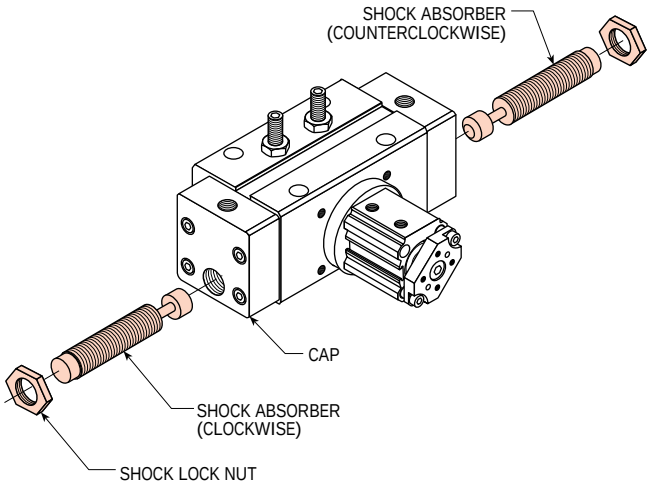
MCSx5040

	F		G		AA	
SIZE	in	mm	in	mm	in	mm
2016	.335	8.5	1.280	32.5	.374	9.5
2520	.335	8.5	1.280	32.5	.374	9.5
3225	.335	8.5	1.280	32.5	.374	9.5
4032	.394	10.0	1.378	35.0	.453	11.5
5040	.453	11.5	1.378	35.0	1.083	27.5

NB SHOCK ABSORBER INSTALLED BOTH DIRECTIONS

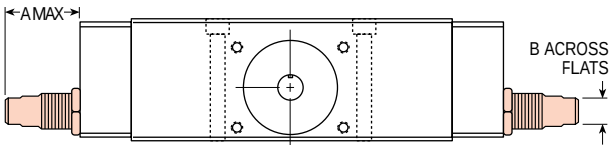
NC SHOCK ABSORBER INSTALLED COUNTERCLOCKWISE DIRECTION

NW SHOCK ABSORBER INSTALLED CLOCKWISE DIRECTION



Hydraulic shock absorbers provide optimum control of deceleration and maximum load stopping capacity. The -NB, -NC, and -NW options equip the rotary actuator with a hydraulic shock absorber installed in the cap(s). See pages 4A-16 to 4A-21 for details on unit stopping capacity with built-in shock absorbers. Shock absorbers are nominally effective for 45° of rotation each direction.

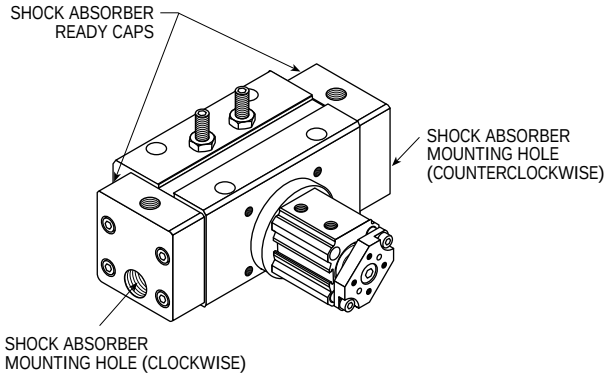
NOTE: The shock absorber also provides the rotation adjustment on units with rotations greater than 180°.



GS SHOCK ABSORBER READY BOTH DIRECTIONS

GT SHOCK ABSORBER READY COUNTERCLOCKWISE DIRECTION

GU SHOCK ABSORBER READY CLOCKWISE DIRECTION



The -GS, -GT, and -GU options should only be ordered if the shock absorber(s) is to be supplied separately from the multi-motion actuator. These options make provisions for the installation of hydraulic shock absorbers but do not include the shock absorber units. They include the shock sealing kit for each direction ordered. See pages 4A-16 to 4A-21 for details on unit stopping capacity with built-in shock absorbers.

NOTE: The shock absorber also provides the rotation adjustment on units with rotations greater than 180°. Shock absorbers **must** be installed in the rotary section prior to operating the unit. Operation of units with shock absorber ready options without shock absorbers installed can damage the units and void any and all warranties. Only the shock absorbers listed should be used in Series MC Multi-Motion Actuators. The use of any other shock absorbers will affect actuator performance and life expectancy.

SHOCK ABSORBER SPECIFICATIONS

SIZE	PHD SHOCK ABSORBER NUMBER	THREAD TYPE	STROKE		SHOCK ABSORBER WEIGHT		STROKE		A MAX.		B ACROSS FLATS	
			in	mm	lb	kg	in	mm	in	mm	in	mm
2016	56722-01	M12 x 1	.13	3.30	.09	.04	.13	3.30	1.24	31.5	—	—
2520	56722-02*	M14 x 1.5	.19	4.83	.12	.054	.19	4.83	1.97	50.0	.47	12
3225	56722-03	M20 x 1.5	.25	6.35	.34	.15	.25	6.35	2.41	61.2	.71	18
4032	56722-04*	M25 x 1.5	.31	7.87	.57	.26	.31	7.87	3.38	85.7	.91	23
5040	56722-05*	M25 x 1.5	.31	7.87	.57	.26	.31	7.87	3.44	87.4	.91	23

*The shock absorbers have an adjustment feature. (See startup procedure.)

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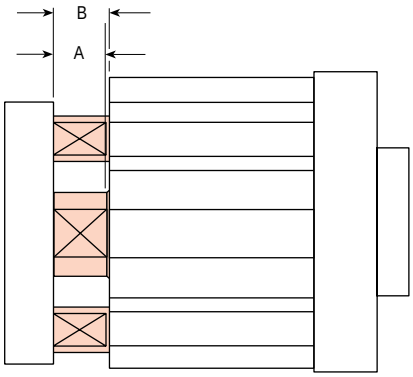
F11 EXTENDED LENGTH WRENCH FLATS

The standard wrench flat length is .125" [3 mm]. The option -F11 provides wrench flats which allow standard wrench access.

SIZE	A EXTENDED ROD & GUIDE ROD WRENCH FLATS in	A EXTENDED ROD & GUIDE ROD WRENCH FLATS mm	B ROD EXTENSION in	B ROD EXTENSION mm
2016	.200	5.25	.250	6.5
2520, 3225	.200	5.25	.250	6.5
4032, 5040	.290	8.00	.344	9.0



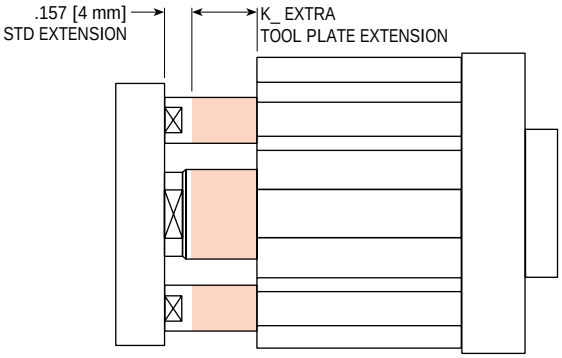
K_ EXTRA TOOL PLATE EXTENSION

Extra tool plate extension can be specified by calling out the -K option followed by the length code.

Length code example (for imperial MCS1 units)
K1 = 1/8" of extra tool plate extension
K3 = 3/8", etc.

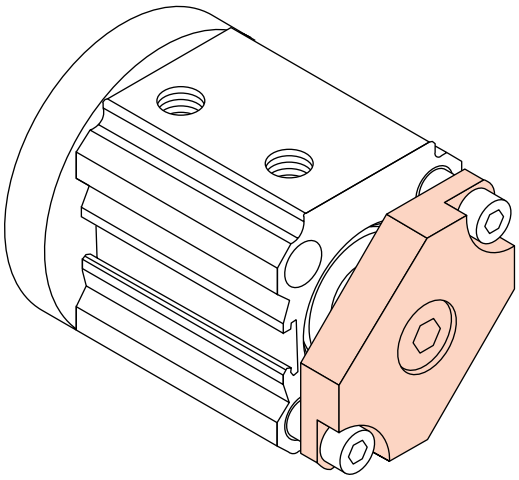
Length code example (for metric MCS5 units)
K5 = 5 mm of extra tool plate extension
K15 = 15 mm, etc.

.157" [4 mm] of tool plate extension is standard. Available in 1/8" [5 mm] increments only. Maximum extension is 1" [25 mm].



WM BLANK TOOL PLATE

With this option PHD provides a tool plate without mounting threads and counterbores. The tool plate is supplied unassembled for easy modification. Assembly and torque specifications are furnished with each unit. When assembling the unit, a threadlocking adhesive is required.

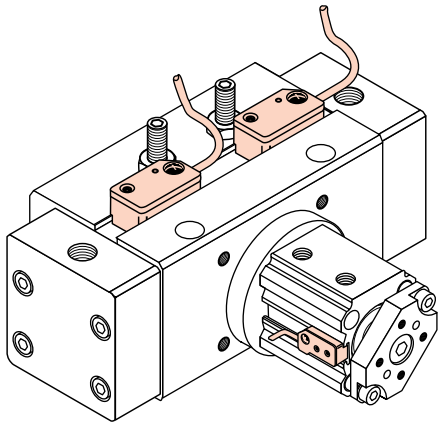


NOTE: Blank tool plate is shipped unassembled.

I MAGNETS FOR PHD MAGNETORESISTIVE SWITCHES

This option equips the multi-motion actuator with magnets on both the rotary and linear sections for use with PHD Magneto-resistive Switches. These switches mount easily to the bodies of the linear and the rotary sections using "T" slots. See Switches and Sensors section for complete specifications. Switches must be ordered separately.

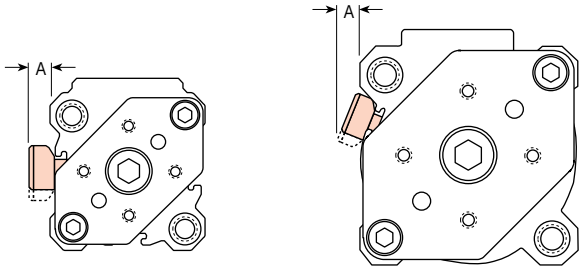
PART NO.	COLOR	DESCRIPTION
53605-1-02	Black	NPN 6-24 VDC, 2 m cable
53606-1-02	Orange	PNP 6-24 VDC, 2 m cable
53625-1	Black	NPN 6-24 VDC, Quick Connect
53626-1	Orange	PNP 6-24 VDC, Quick Connect



M MAGNETS FOR PHD MINIATURE REED SWITCHES

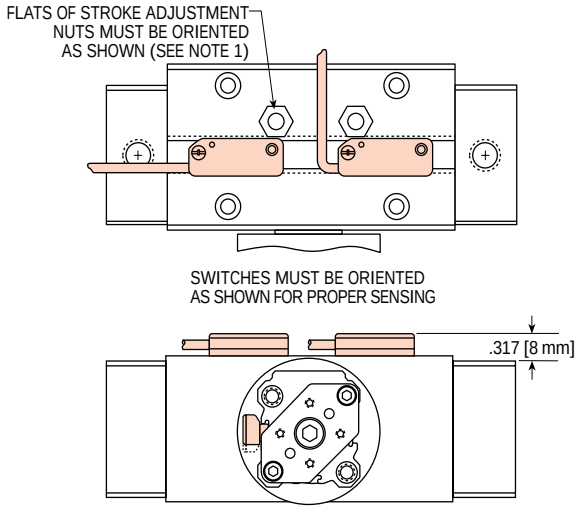
This option equips the multi-motion actuator with magnets on both the rotary and linear sections for use with PHD Series 5360 Miniature Reed Switches. These switches mount easily to the bodies of the linear and the rotary sections using the "T" slots. See Switches and Sensors section for complete specifications. Switches must be ordered separately.

PART NO.	COLOR	DESCRIPTION
53602-2-02	White	NPN or PNP 4.5-24 VDC, 2 m cable
53609-2-02	Green	AC Type 110-120 VAC with Current Limit, 2 m cable
53622-2	White	NPN or PNP 4.5-24 VDC, Quick Connect
53629-2	Green	AC Type 110-120 VAC, Quick Connect with Current Limit



SIZE	A in	A mm
2016	.300	8.0
2520	.200	5.5
3225	.250	6.5
4032	.250	6.5
5040	.250	6.5

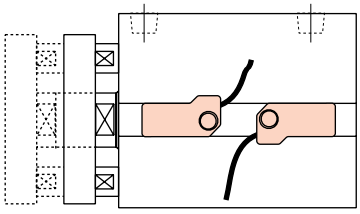
NOTE: Caution must be taken when mounting switches on the linear section to ensure enough "loop" in the switch cable to allow for flexing as the linear section rotates.



NOTES:
1) When mounting miniature switches on the MCSx2016 and MCSx2520 units with rotations up to 180°, see drawing above.
2) Minimum rotation on a MCSx2016 with two switches is 45°.

LINEAR SECTION SWITCH MOUNTING TABLE

SIZE	MINIMUM STROKE FOR TWO SWITCHES ON ONE SIDE: AC REED in	AC REED mm	DC REED in	DC REED mm	MAGNETO-RESISTIVE in	MAGNETO-RESISTIVE mm
2016, 2520	1.750	45	1.625	40	1.125	30
3225, 4032, 5040	1.500	40	1.500	40	1.125	30



All dimensions are reference only unless specifically toleranced.

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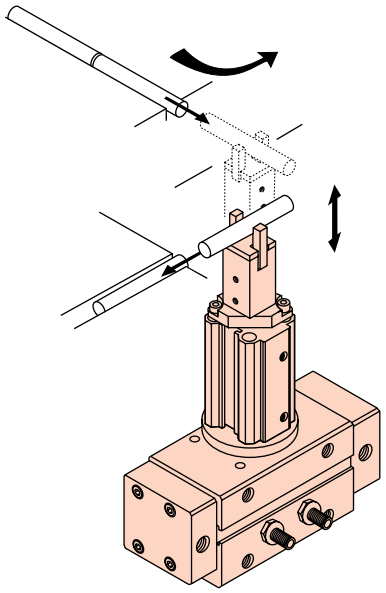
APPLICATION EXAMPLES

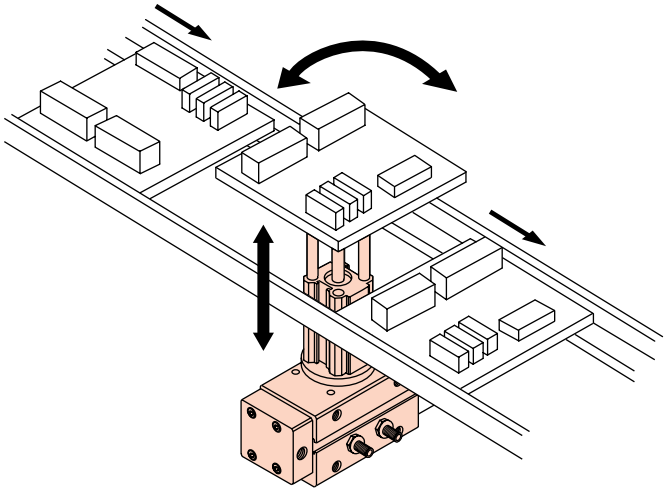
PHD Series MC Multi-Motion Actuators are designed to provide reach and turn motion for light to medium duty applications. Please refer to pages 4A-16 to 4A-21 for proper sizing and performance data.

CAUTION: PHD does not recommend the use of external stops against the tool plate of the linear section to stop rotation on Series MC Multi-Motion Actuators.

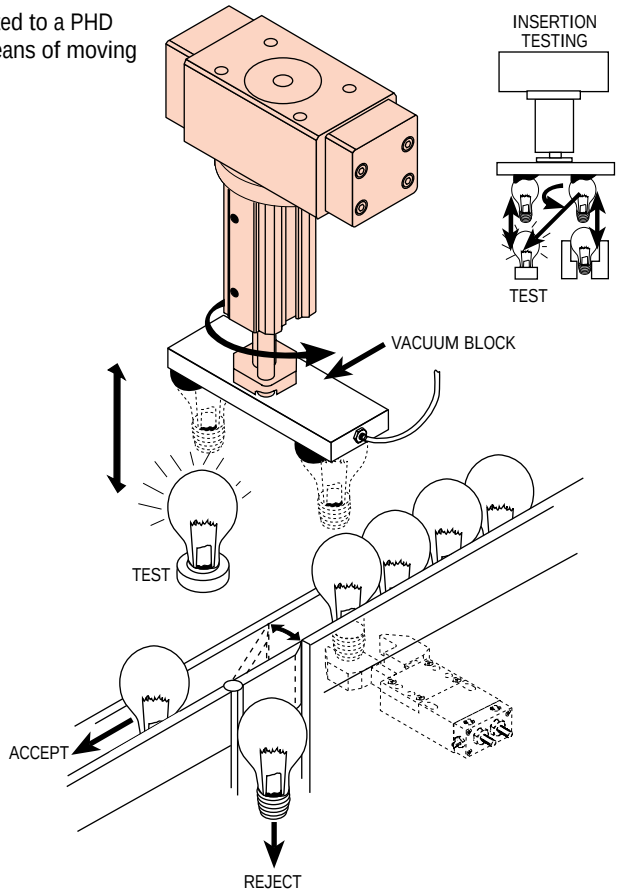
This illustration demonstrates how a PHD Multi-Motion Actuator with a PHD Series 190 Gripper mounted directly to the tool plate, can grasp, reorient, and lower a part for transfer. PHD Series 190 and 191 Grippers mount easily to standard tool plates.



PHD Series MC Multi-Motion Actuators are well suited for lifting and reorienting lightweight assemblies for easy access to all sides. The multi-motion actuator lifts the assembly from its track, rotates it 90° and returns it to the track. The multi-motion actuator then resets itself by rotating back 90° and awaits the next assembly. The ability to orient the assembly can save money in fixturing and tooling the assembly machine.



A vacuum block with suction cups mounted to a PHD Multi-Motion Actuator provides an efficient means of moving delicate, lightweight parts.



ACTUATOR SIZING: LINEAR SECTION

A number of factors must be considered when selecting a Series MC Multi-Motion Actuator. These include actuator orientation, total load attached to the linear section, linear travel, linear speed, and rotational speed.

The process of selecting the proper Series MC Multi-Motion Actuator consists of two main steps:

1) Size the actuator based on the linear section.
2) Size the actuator based on the rotary section.

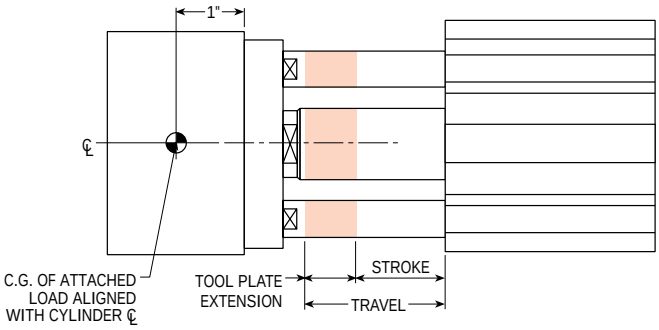
Choose the actuator which meets the minimum requirements of your application for both the linear and rotary sections.

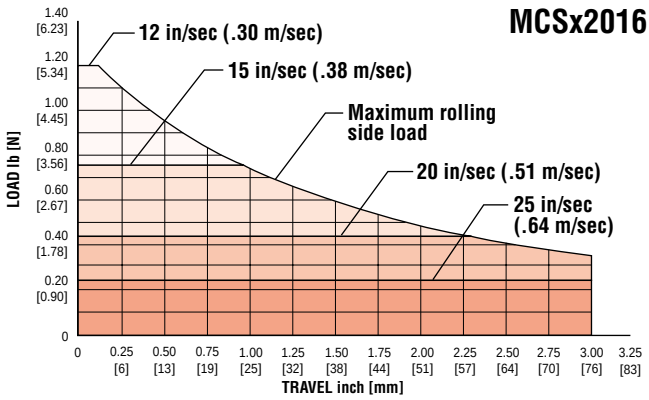
STEP 1: ACTUATOR SIZING BASED ON THE LINEAR SECTION

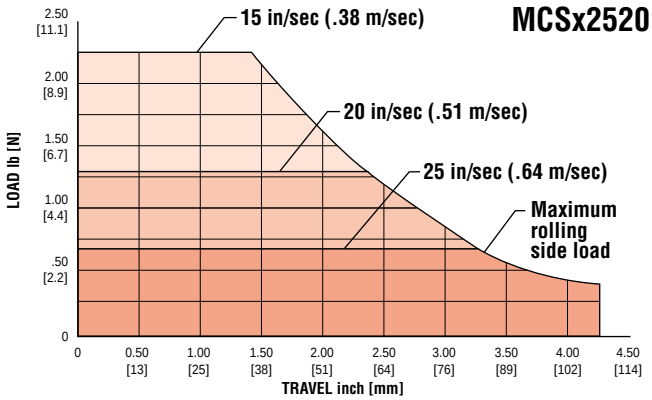
The following charts are divided into horizontal and vertical applications. Use the charts to determine the allowable attached load and maximum speed at end of stroke. Refer to the proper charts based on your intended actuator orientation.

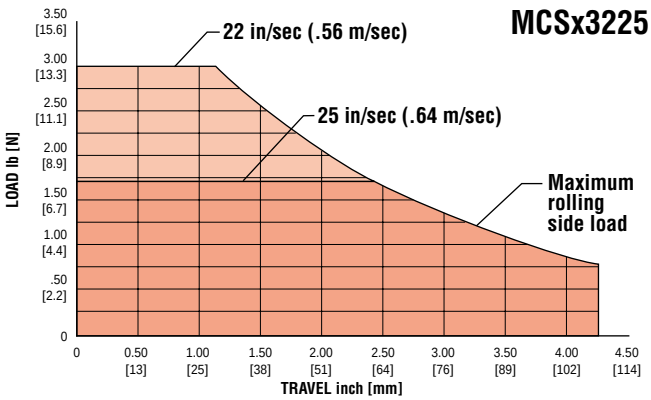
HORIZONTAL APPLICATIONS: MAXIMUM ATTACHED LOADS AND LINEAR SPEEDS

NOTE: Horizontal side load performance data is based upon the center of gravity (C.G.) of the attached load located as shown. Locating the C.G. beyond the stated distance may decrease the life of the unit.









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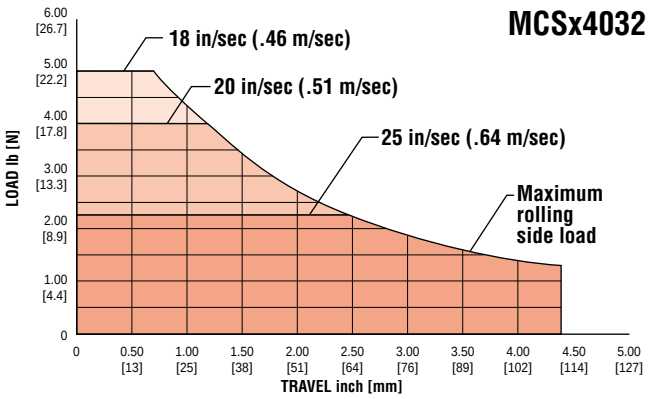
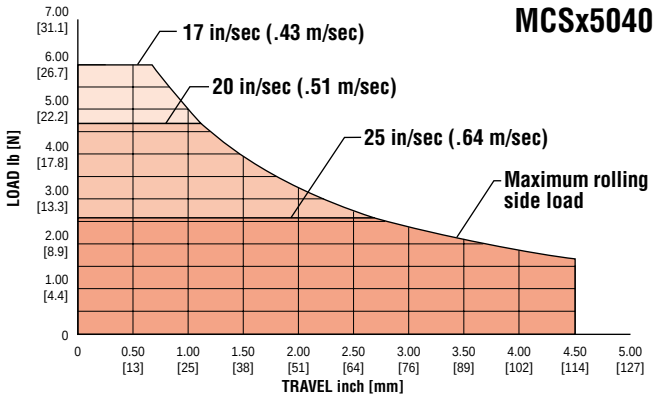
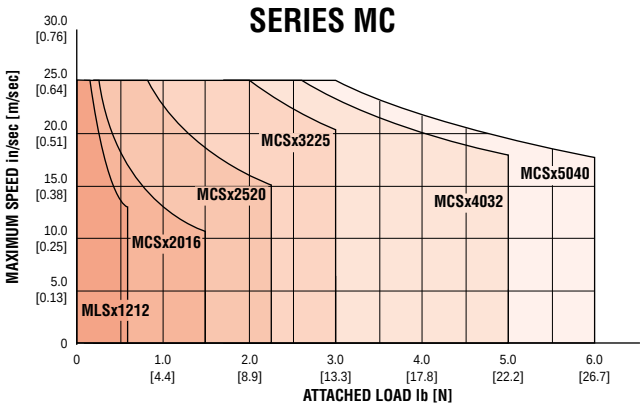
HORIZONTAL APPLICATIONS: MAXIMUM ATTACHED LOADS AND LINEAR SPEEDS





VERTICAL APPLICATIONS: MAXIMUM ATTACHED LOADS AND LINEAR SPEEDS



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STEP 2: ACTUATOR SIZING BASED ON THE ROTARY SECTION

Calculating the stopping capacity of the Series MC Multi-Motion Actuator can be done in either of two methods. The first uses the Kinetic Energy (KE) Ratings Graphs (see page 4A-20). Where the application approaches or exceeds the extreme range of the relevant graph, the second method should be employed. This requires calculation of the kinetic energy for the application and comparing the required KE to the KE performance ratings for each actuator.

METHOD 1

To calculate stopping capacity using the KE Ratings Graphs:

1) Determine Total Mass Moment of Inertia:

   a) Refer to the Linear Section Inertia (Jm) Table on page 4A-19 and determine the Jm value for your selected linear section. Be sure to sum the base value plus the appropriate stroke adder.

   b) Select the illustration from the application types on the next page that most resembles your specific application. Using the appropriate application equation, calculate the mass moment of inertia (Jm) for the load to be attached to the linear section.

   c) Sum the two Jm values

      Total Jm = Jm (linear section) + Jm (attached load)

2) Determine Rotational Velocity (ω):

   Review your application and determine the required velocity in degrees per second (required cycle time).
   NOTE: Velocity must be based on peak rotation rate at the end of rotation. If the peak velocity is not determinable due to acceleration, use twice the rotation rate to account for acceleration.

3) With Total Jm and rotational velocity, use the Kinetic Energy Ratings Graphs on page 4A-20 to determine if the actuator selected in Step 1 is acceptable and whether shock pads, cushions, or shock absorbers are required. The actuator's KE rating must be equal to or greater than the KE of the application. If the actuator is unacceptable, either decrease the kinetic energy of the application (lower ω) or repeat the rotary sizing process with the next larger actuator (Note: The Jm of the linear section will change with a change in actuators).

METHOD 2

To calculate stopping capacity by determining the kinetic energy of the application:

1) Determine Total Mass Moment of Inertia:

   a) Refer to the Linear Section Inertia (Jm) Table on page 4A-20 and determine the Jm value for your selected linear section. Be sure to sum the base value plus the appropriate stroke adder.

   b) Select the illustration from the application types on the next page that most resembles your specific application. Using the appropriate application equation, calculate the mass moment of inertia (Jm) for the load to be attached to the linear section.

   c) Sum the two Jm values

      Total Jm = Jm (linear section) + Jm (attached load)

2) Determine Rotational Velocity (ω):

   Use one of the two Rotational Velocity Equations on page 4A-20 to determine the peak velocity in rad/sec (ω). Use Equation A if the rotation rate is known at the end of rotation. If the load is accelerating through rotation and the end of rotation rate cannot be determined, use Equation B.

3) Use the Kinetic Energy Basic Equation on page 4A-20 to determine KE. (Use the Total Jm value in this calculation.) Compare the KE of the application to the allowable KE in the Kinetic Energy Table on page 4A-20 for the actuator selected in Step 1. The actuator's KE rating must be equal to or greater than the KE of the application. If the actuator is unacceptable, either decrease the kinetic energy of the application (lower ω) or repeat the rotary sizing process with the next larger actuator (Note: The Jm of the linear section will change with a change in actuators.)

LINEAR SECTION INERTIA TABLE

SIZE	BASE Jm		ADDER PER 1" STROKE	
	in-lb-sec²	kg-m²	in-lb-sec²	kg-m²
2016	2.18×10^{-4}	2.40×10^{-5}	7.80×10^{-5}	8.10×10^{-6}
2520	5.25×10^{-4}	6.01×10^{-5}	1.61×10^{-4}	1.75×10^{-5}
3225	9.12×10^{-4}	1.03×10^{-4}	2.51×10^{-4}	2.68×10^{-5}
4032	1.99×10^{-3}	2.24×10^{-4}	5.11×10^{-4}	5.76×10^{-5}
5040	4.07×10^{-3}	4.60×10^{-4}	7.66×10^{-4}	8.99×10^{-5}

Rotational mass moment of inertia is based on hub, hub screw, and linear section of multi-motion actuator.

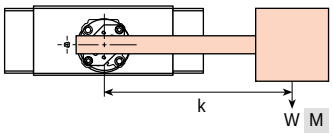
IMPERIAL UNITS:

Jm = Rotational Mass Moment of Inertia (in-lb-sec²)
(Dependent on physical size of object and weight)
W = Weight of Load (lb)
g = Gravitational Constant = 386.4 in/sec²
k = Radius of Gyration (in)

METRIC UNITS:

Jm = Rotational Mass Moment of Inertia [kg-m²]
(Dependent on physical size of object and weight)
M = Mass of Load [kg]
g = Gravitational Constant = 980 cm/sec²
k = Radius of Gyration [m]

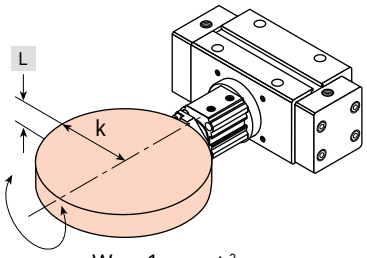
Point Load



$$Jm = \frac{W}{g} \times k^2$$

$$Jm = M \times k^2$$

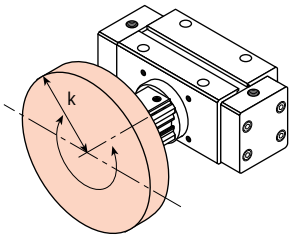
Thin Disk
End mounted on center



$$Jm = \frac{W}{g} \times \frac{1}{4} \times \left(\frac{L^2}{3} + k^2\right)$$

$$Jm = \frac{M}{4}\left(\frac{L^2}{3} + k^2\right)$$

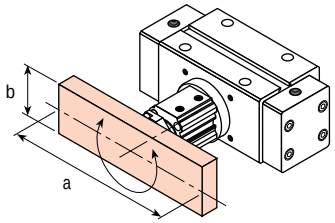
Thin Disk
Mounted on center



$$Jm = \frac{W}{g} \times \frac{k^2}{2}$$

$$Jm = M \times \frac{k^2}{2}$$

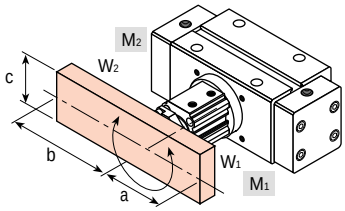
Rectangular Thin Plate
Mounted on center



$$Jm = \frac{W}{g} \times \frac{a^2 + b^2}{12}$$

$$Jm = M \times \frac{a^2 + b^2}{12}$$

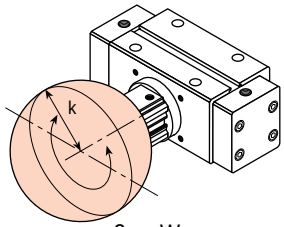
Rectangular Thin Plate
Mounted off center



$$Jm = \frac{W_1}{g} \times \frac{4a^2 + c^2}{12} + \frac{W_2}{g} \times \frac{4b^2 + c^2}{12}$$

$$Jm = M_1 \times \frac{4a^2 + c^2}{12} + M_2 \times \frac{4b^2 + c^2}{12}$$

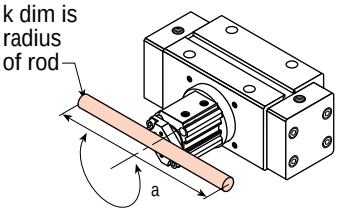
Solid Sphere
Mounted on center



$$Jm = \frac{2}{5} \times \frac{W}{g} \times k^2$$

$$Jm = \frac{2}{5} \times M \times k^2$$

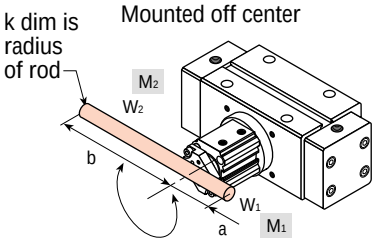
Slender Rod
Mounted on center



$$Jm = \frac{W}{g} \times \frac{a^2 + 3k^2}{12}$$

$$Jm = M \times \frac{a^2 + 3k^2}{12}$$

Slender Rod
Mounted off center



$$Jm = \left(\frac{W_1}{g} \times \frac{(4a^2 + 3k^2)}{12}\right) + \left(\frac{W_2}{g} \times \frac{(4b^2 + 3k^2)}{12}\right)$$

$$Jm = \left(M_1 \times \frac{(4a^2 + 3k^2)}{12}\right) + \left(M_2 \times \frac{(4b^2 + 3k^2)}{12}\right)$$

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ACTUATOR SIZING: ROTARY SECTION

ROTATIONAL VELOCITY EQUATIONS

EQUATION A

ω = Peak Velocity (rad/sec)
At end of rotation

$$\omega = \frac{\text{rad}}{\text{sec}} = \frac{\text{deg}}{\frac{57.296}{\text{rot. time}}}$$

EQUATION B

ω = Peak Velocity (rad/sec)
Uniformly accelerated from rest

$$\omega = \frac{\text{rad}}{\text{sec}} = .035 \times \frac{\text{angle traveled (deg)}}{\text{rotating time (sec)}}$$

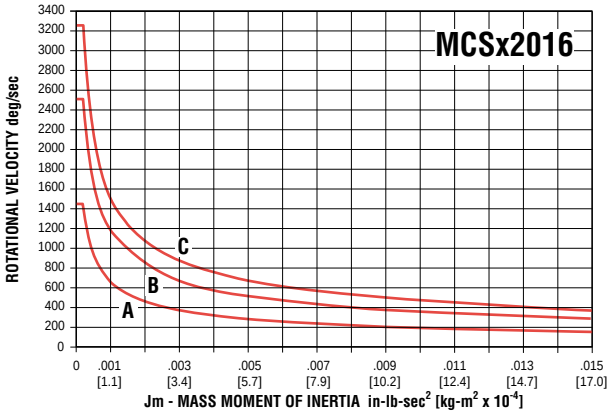
(Assuming twice average velocity)

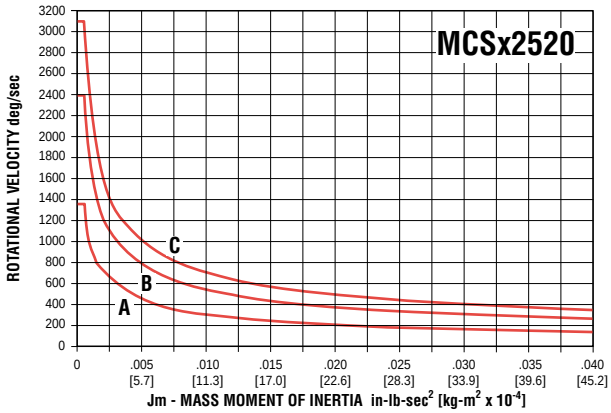
KINETIC ENERGY BASIC EQUATION

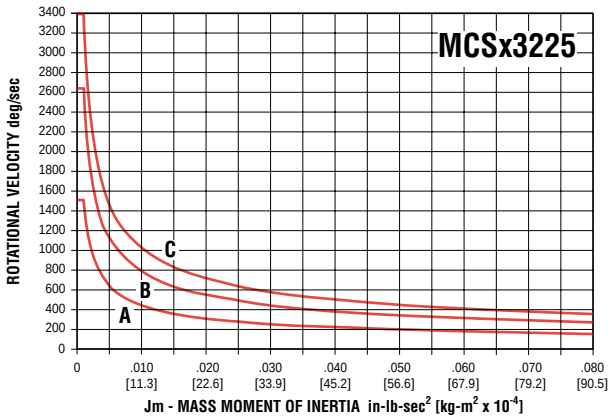
$KE = 1/2\ Jm\ \omega^2$

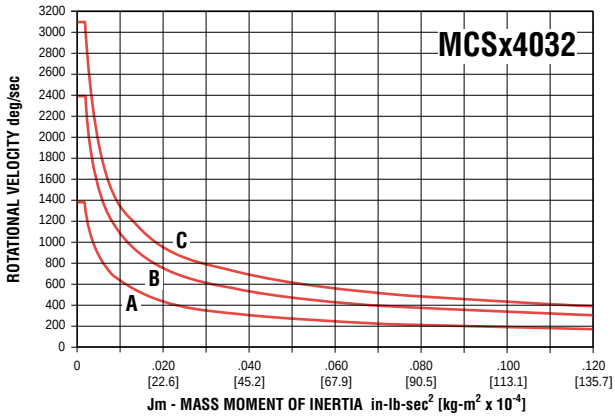
KINETIC ENERGY RATINGS GRAPHS
FOR METHOD 1

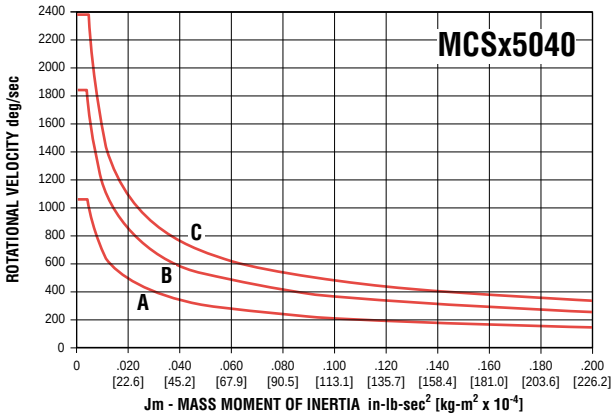
A = plain rotary section
B = rotary section with PHD Cushion
C = rotary section with shock absorber











SERIES MC KINETIC ENERGY TABLE
FOR METHOD 2

	KE MAX. PLAIN UNIT		KE MAX. WITH CUSHION		KE MAX. WITH SHOCK ABSORBER	
SIZE	in-lb	Nm	in-lb	Nm	in-lb	Nm
2016	.07	.0079	.21	.0237	.35	.0396
2520	.15	.0173	.46	.0520	.77	.0866
3225	.32	.0362	.96	.1085	1.60	.1808
4032	.58	.0655	1.74	.1966	2.90	.3277
5040	.71	.0802	2.13	.2407	3.55	.4012

SIZING EXAMPLE

APPLICATION DATA - IMPERIAL MODEL

Linear Stroke = 1.5 inch
Extend/Retract Speed = 20 in/sec
Rotation Time = 180°/.20 sec
Load = Aluminum Disk Weight of .236 lb
Application Orientation = Horizontal

1) Determine actuator based on linear section
   Travel = Stroke + Tool Plate Extension = 1.5 inch
   Extend/retract speed = 20 in/sec
   Load = .236 lb (horizontal application)
   Per linear section sizing charts, an MCS12016 is acceptable.

2) Determine actuator based on rotary section
   a) Calculate **Total** Jm
      From Linear Section Inertia Table (page 4A-19)
      Linear Section Jm = .000218 + 1.5(.000078) =
      = .000335 in-lb-sec^2

      $$\text{Load Jm (for disk)} = \frac{W}{g} \times \frac{k^2}{2} = \frac{.236\ \text{lb}}{386.4} \times \frac{.875^2}{2} =$$

      = .000234 in-lb-sec^2

      Total Jm = .000335 + .000234 = .000569 in-lb-sec^2

3) Determine Rotational Velocity (ω):

   If peak velocity known: (Equation A, page 4A-20)
   (rad/sec = ω)

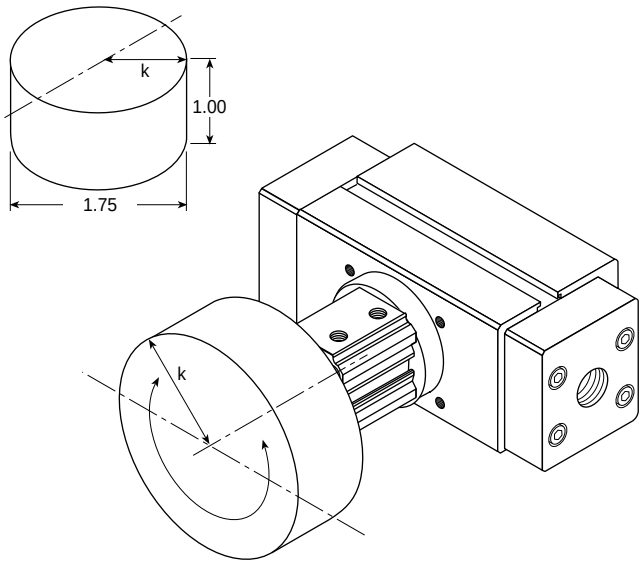
   $$\omega = \frac{\text{deg.}}{\frac{57.296}{\text{rot. time}}} = \frac{180°}{\frac{57.296}{.20\ \text{sec}}} = 15.7\ \text{rad/sec}$$

4) Determine KE:

   KE = 1/2 Jm ω^2 = (1/2) (.000569) (15.7^2) = .070 in-lb

   A plain MCS12016 with shock pads is acceptable.

Rotational Kinetic Energy = 1/2 Jm ω^2
Jm = Total Mass Moment of Inertia
ω = Rotational Velocity (avg./peak)
KE = Kinetic Energy



3) Determine Rotational Velocity (ω):

   If peak velocity not known for constant acceleration:
   (Equation B, page 4A-20)
   (rad/sec = ω)

   $$\omega = \frac{\text{rad}}{\text{sec}} = \frac{.035 \times \text{deg}}{\text{rot. time}} = \frac{.035 \times 180°}{.2\ \text{sec}} = 31.5\ \text{rad/sec}$$

4) Determine KE:

   KE = 1/2 Jm ω^2 = (1/2) (.000569) (31.5^2) = .282 in-lb

   An MCS12016 with shock absorbers is acceptable.

   If the KE is too high, either resize for the next larger Series MC, or reduce the rotational speed (ω).

NOTE: When the Rotational Kinetic Energy falls out of range for a specific actuator, one of two actions can be taken:
a) Reduce the rotational speed (ω) until the Kinetic Energy falls in the range of the actuator.
b) Revise the calculations for a larger actuator (the linear section Jm value will change) and determine which actuator is acceptable.

NOTES

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