EL SERIES

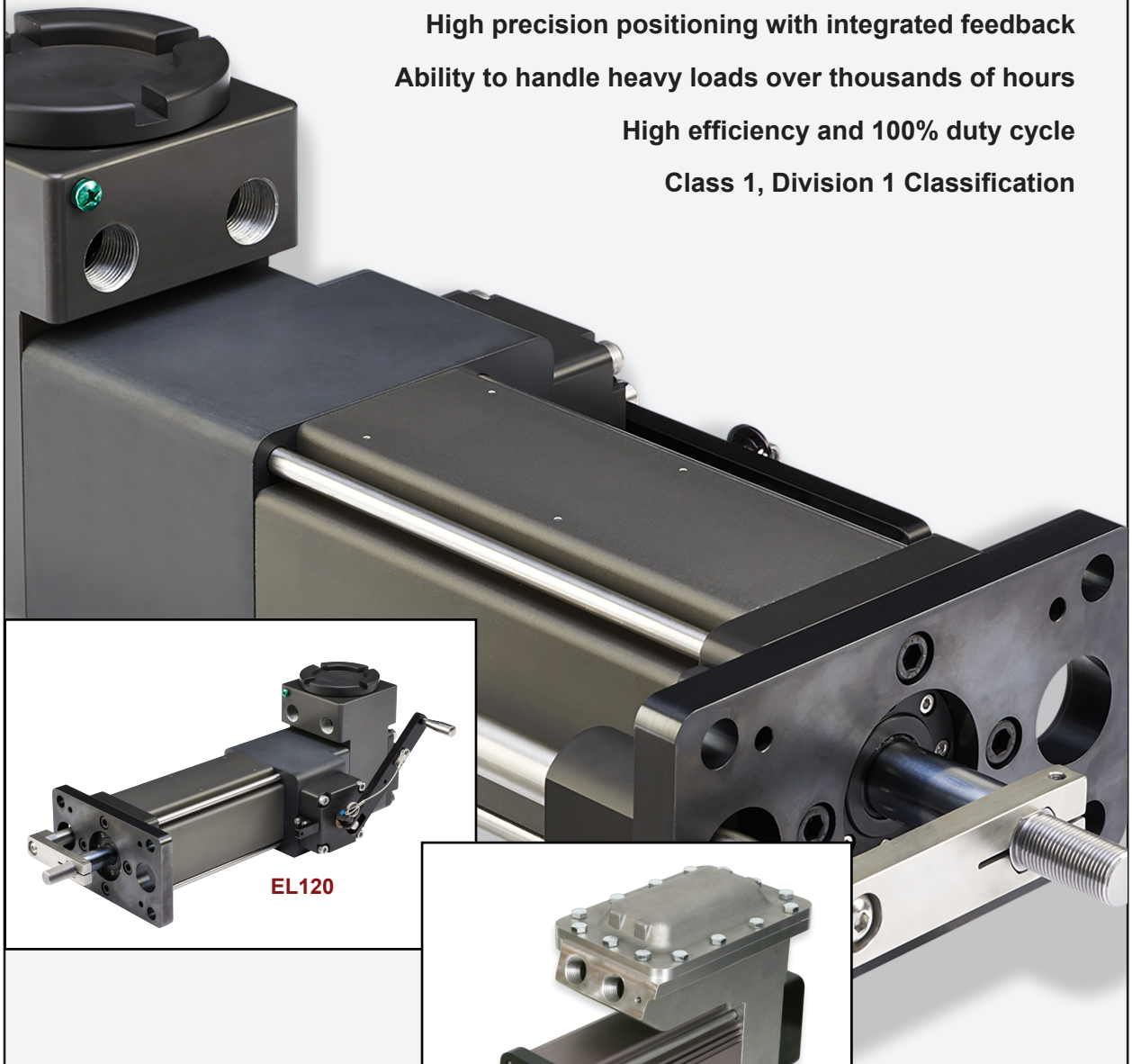
HAZARDOUS LOCATION ACTUATORS AND MOTORS

High precision positioning with integrated feedback

Ability to handle heavy loads over thousands of hours

High efficiency and 100% duty cycle

Class 1, Division 1 Classification



EL120

EL100

ER120

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EL120

ATEX Rated Explosion-Proof Linear Actuators

Perfect for valve control or other hazardous environment applications, the EL120 is a high performance electric actuator offered as a direct replacement for hydraulics. EL120 actuators feature longer life, linear speeds up to 37 inches per second, closed loop feedback, 90% efficiency and 100% duty cycle.

For gas turbines with variable guide vanes, EL120 actuators provide precise positioning and feedback for fine tuning injector airflow to effectively manage CO and NOx emissions. In Oil & Gas applications, the EL120 is well suited for position-based drilling choke valves.

CE 0518

Ex II 2G
Ex d IIB+H2 T4 Gb
SIRA 15ATEX1010X

C SA US 163694
Class I Division 1
Groups B, C, D, T4

EL120 explosion-proof actuators meet ATEX requirements for use in potentially explosive atmospheres and are in conformity with the EU ATEX Directive 94/9/EC. Additionally, these actuators are rated for Class 1, Division 1, Groups B, C, D, and T4 hazardous environments.

The EL Series integrates a highly efficient planetary roller screw mechanism with a high torque servomotor in a single self-contained package. This highly robust design is engineered to provide reliable and precise operation over thousands of hours, handling heavy loads—even under very arduous conditions.

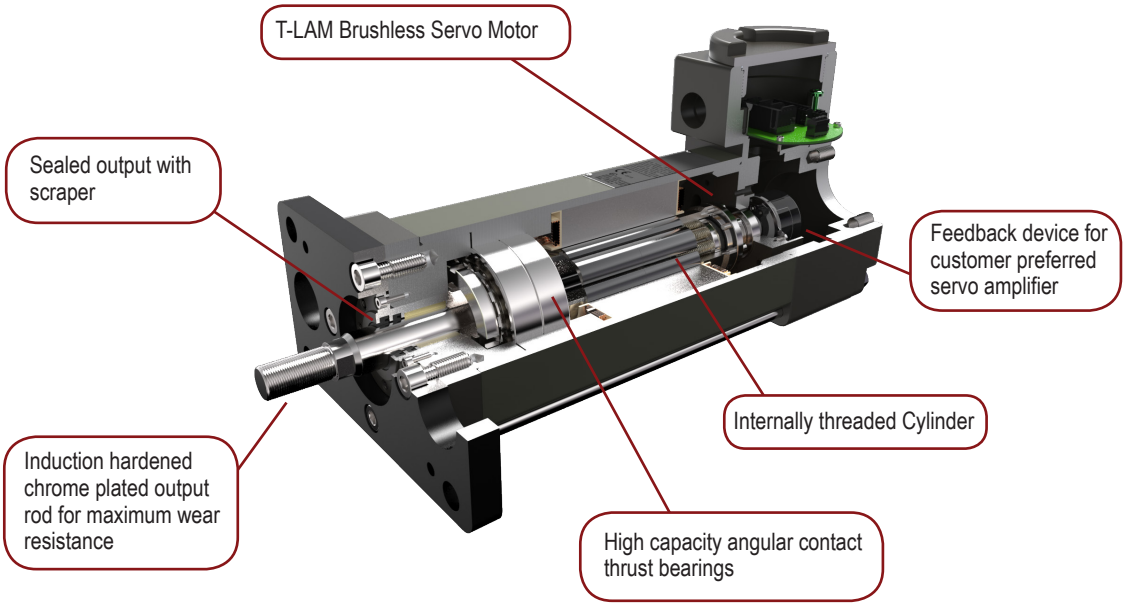
The EL120 Actuator is compatible with nearly any manufacturer's servo amplifier.

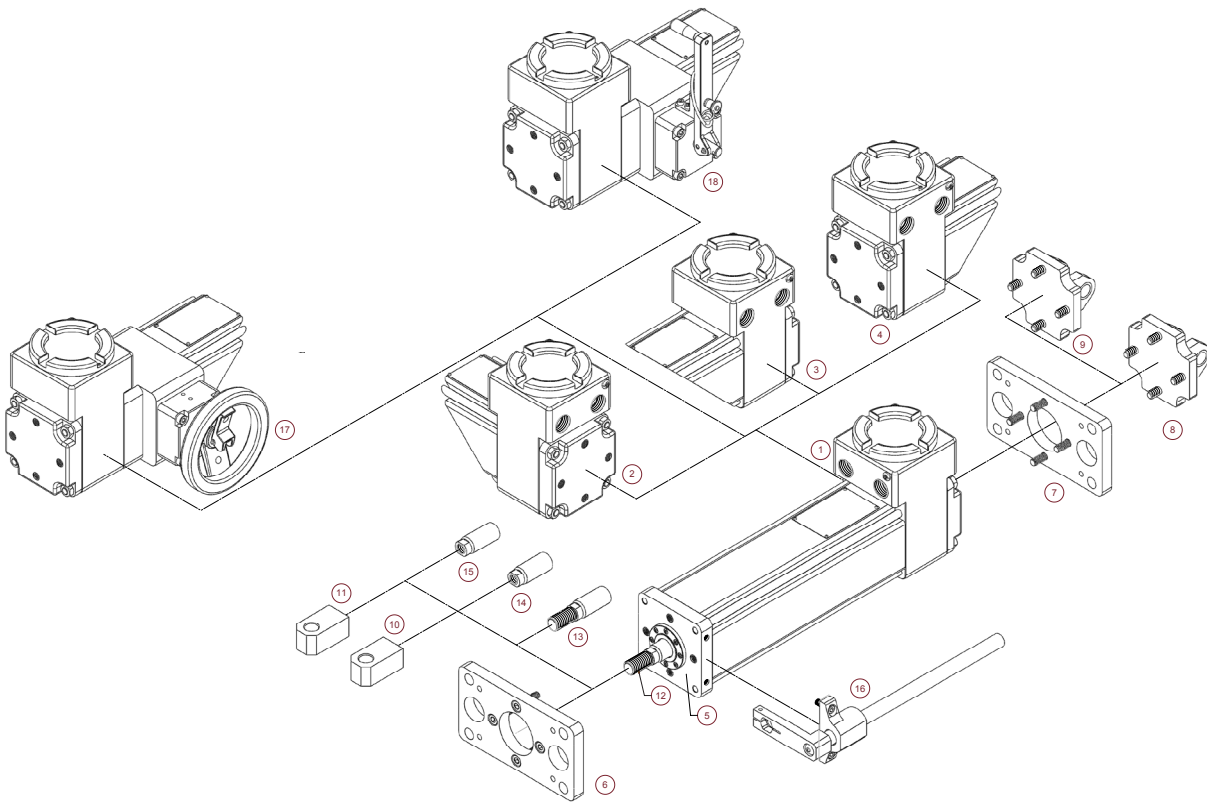
Features
Forces up to 4000 lbs
Speeds up to 37.5 ips
Strokes up to 18 inches
8 pole brushless motors
Feedback configurations for nearly any servo amplifier
Several mounting configurations
Windings available from 24 VDC to 460 Vrms
CSA Class I, Div 1 Group B, C, D, and T4 hazardous environment rating
ATEX, Ex d II B +H2 T4 Gb IP66S, Type 4
IECEx CSA 14.0014
Completely sealed motor assures trouble-free operation

Technical Characteristics	
Frame Sizes in (mm)	4.7 (120)
Screw Leads in (mm)	0.1 (2.54), 0.2 (5.08), 0.5 (12.7), 0.8 (20.3)
Standard Stroke Lengths in (mm)	4 (100), 6 (150), 8 (200), 10 (250), 12 (300), 18 (450)
Force Range	up to 4081 lbf-in (18 kN)
Maximum Speed	up to 37.5 in/sec (953 mm/s)

Operating Conditions and Usage		
Accuracy:		
Screw Lead Error	in/ft (µm / 300 mm)	0.001 (25)
Screw Travel Variations	in/ft (µm / 300 mm)	0.0012 (30)
Screw Lead Backlash	in (mm)	0.004 maximum
Ambient Conditions:		
Ambient Temperature	°C	-29 to 93
Storage Temperature	°C	-54 to 93
IP Rating		IP66S
Rel. Humidity	%	5 to 100 at 60° C
Vibration		3.5 grms, 5 to 520 hz

Product Features





1- Two 0.75 in NPT Ports, Front Facing (as viewed from rod end) 2 - Two 0.75 in NPT Ports, Back Facing (as viewed from rod end)
3 - Two 0.75 in NPT Ports, Right Facing (as viewed from rod end) 4 - Two 0.75 in NPT Ports, Left Facing (as viewed from rod end)
5 - Threaded Front & Rear Face, Metric and Threaded Front & Rear Face, English 6 - Standard Front Flange 7 - Standard Rear Flange 8 - Metric Rear Clevis
9 - English Rear Clevis 10 - Metric Rear Eye 11 - English Rear Eye 12 - Male, US Standard Thread 13 - Male, Metric Thread 14 - Female, US Standard Thread
15 - Female, Metric Thread 16 - External anti-rotate assembly 17 - Handwheel Drive - Standard 18 - Crank Drive

Industries and Applications

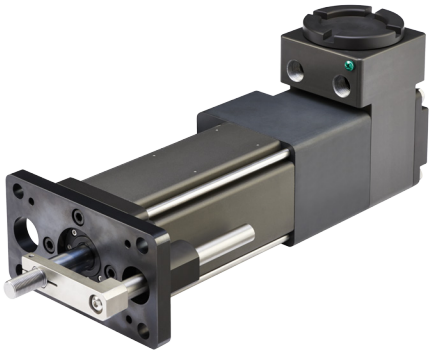
Process Control
- Valve control
- Damper control
- Turbine control
- Choke valves
- Fuel control
- Plunger pumps

Automotive
- Paint booths
- Fuel control
- Engine test stands

Defense
- Weapons room

Material Handling
- Printing presses

The EL Series of explosion proof actuators is ideal for valve control, as well as many other applications in hazardous environments. These all-electric actuators easily outperform hydraulics and other competing technologies offering long life, high speeds, closed loop feedback, 90% efficiency and 100% duty cycle.



Notes

Mechanical Specifications

Motor Stacks		1 Stack				2 Stack				3 Stack		
Screw Lead Designator		**01**	**02**	**05**	**08**	**01**	**02**	**05**	**08**	**02**	**05**	**08**
Screw Lead	in	0.1	0.2	0.5	0.75	0.1	0.2	0.5	0.75	0.1	0.2	0.5
	mm	2.54	5.08	12.7	19.05	2.54	5.08	12.7	19.05	2.54	5.08	12.7
Continuous Force** *(Motor Limited)*	lbf	2,984	1,748	839	559	NA	2,865	1,375	917	4,081	1,959	1,306
	N	13,272	7,776	3,733	2,488	NA	12,744	6,117	4,078	18,152	8,713	5,809
Max Velocity	in/sec	5	10	25	37.5	5	10	25	37.5	5	10	25
	mm/sec	127	254	635	953	127	254	635	953	127	254	635
Friction Torque	in-lbf	2.7				3.0				3.5		
	N-m	0.31				0.34				0.40		
Friction Torque *(preloaded screw)*	in-lbf	7.2				7.5				8.0		
	N-m	0.82				0.85				0.91		
Back Drive Force [1]	lbf	380	150	60	50	380	150	60	50	150	60	50
	N	1700	670	270	220	1700	670	270	220	670	270	220
Min Stroke	in	4				NA	6			8		
	mm	100				NA	150			200		
Max Stroke	in	18			12	NA	18		12	18		12
	mm	450			300	NA	450		300	450		300
C_a (Dynamic Load Rating)	lbf	7900	8300	7030	6335	7900	8300	7030	6335	7900	8300	7030
	N	35,141	36,920	31,271	28,179	35,141	36,920	31,271	28,179	35,141	36,920	31,271
Inertia *(zero stroke)*	lb-in-s^2	0.01132				0.01232				0.01332		
	Kg-m^2	0.000012790				0.00001392				0.00001505		
Inertia *(per inch of stroke)*	lb-in-s^2/in	0.0005640										
	Kg-m^2/in	0.0000006372										
Weight *(zero stroke)*	lb	8.0				11.3				14.6		
	Kg	3.63				5.13				6.62		
Weight Adder *(per inch of stroke)*	lb/in	2.0										
	Kg/mm	0.91										

* Please note that stroke mm are Nominal dimensions.
** Force ratings at 25°C.
*** Inertia +/-5%
[1] Back drive force is a nominal value only. Operating conditions can cause wide variations in back drive force. Exlar cannot assure that an actuator will or will not back drive.

DEFINITIONS:

Continuous Force: The linear force produced by the actuator at continuous motor torque.

Max Velocity: The linear velocity that the actuator will achieve at rated motor rpm.

Friction Torque (standard screw): Amount of torque required to move the actuator when not coupled to a load.

Friction Torque (preloaded screw): Amount of torque required to move the actuator when not coupled to a load.

Back Drive Force: Amount of axial force applied to the rod end of the actuator that will produce motion with no power applied to the actuator.

Min Stroke: Shortest available stroke length.

Max Stroke: Longest available stroke length.

C_a (Dynamic Load Rating): A design constant used when calculating the estimated travel life of the roller screw.

Inertia (zero stroke): Base inertia of an actuator with zero available stroke length.

Inertia Adder (per inch of stroke): Inertia per inch of stroke that must be added to the base (zero stroke) inertia to determine the total actuator inertia.

Weight (zero stroke): Base weight of an actuator with zero available stroke length.

Weight Adder (per inch of stroke): Weight adder per inch of stroke that must be added to the base (zero stroke) weight to determine the total actuator weight.

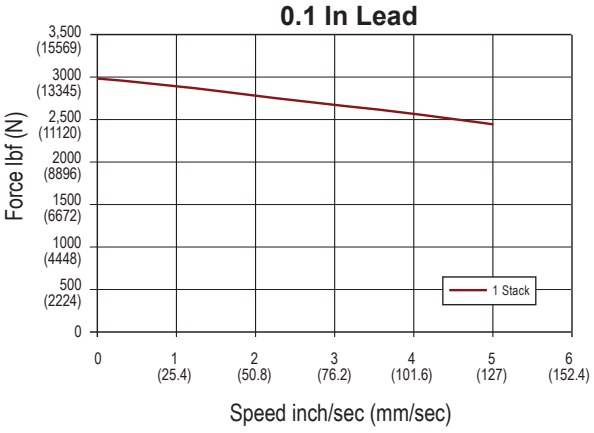
Electrical Specifications

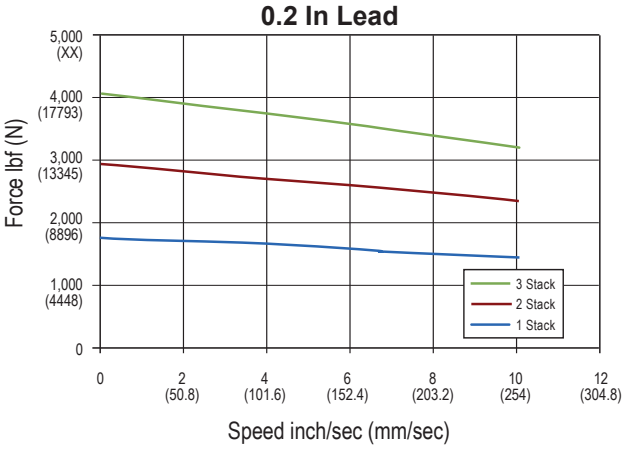
Motor Stator		118	138	158	168	238	258	268	338	358	368
RMS SINUSOIDAL COMMUTATION DATA											
Continuous Motor Torque	lbf-in	74.1	74.1	74.3	74.1	123.6	121.4	123.6	172.3	168.9	176.9
	N-m	8.37	8.37	8.39	8.37	13.96	13.72	13.96	19.46	19.09	19.98
Peak Motor Torque	lbf-in	148.20	148.20	148.60	148.10	247.20	242.80	247.20	344.50	337.80	353.70
	N-m	16.74	16.74	16.79	16.74	27.93	27.43	27.93	38.93	38.17	39.96
Torque Constant (Kt)	lbf-in	4.30	8.70	15.70	17.30	8.70	15.80	17.30	8.50	15.80	17.50
	N-m/A	0.49	1.00	1.80	2.00	1.00	1.80	2.00	1.00	1.80	2.00
Continuous Current Rating	A	19.10	9.50	5.30	4.80	15.90	8.60	8.00	22.70	11.90	11.30
Peak Current Rating	A	38.20	19.10	10.60	9.50	31.80	17.10	15.90	45.40	23.80	22.50
O-PEAK SINUSOIDAL COMMUTATION											
Continuous Motor Torque	lbf-in	74.1	74.1	74.3	74.1	123.6	121.4	123.6	172.3	168.9	176.9
	N-m	8.37	8.37	8.39	8.37	13.96	13.72	13.96	19.46	19.09	19.98
Peak Motor Torque	lbf-in	148.20	148.20	148.60	148.10	247.20	242.80	247.20	344.50	337.80	353.70
	N-m	16.74	16.74	16.79	16.74	27.93	27.43	27.93	38.93	38.17	39.96
Torque Constant (Kt)	lbf-in/A	3.10	6.10	11.10	12.30	6.10	11.20	12.30	6.00	11.20	12.40
	N-m/A	0.35	0.70	1.30	1.40	0.70	1.30	1.40	0.70	1.30	1.40
Continuous Current Rating	A	27.00	13.50	7.50	6.70	22.50	12.10	11.30	32.10	16.90	15.90
Peak Current Rating	A	54.00	27.00	15.00	13.50	45.00	24.20	22.50	64.20	33.70	31.90
MOTOR DATA											
Voltage Constant @ 25˚C (Ke)	Vrms	29.6	59.2	106.9	118.5	59.2	108.2	118.5	58.0	108.2	119.8
	Krpm	41.9	83.8	151.2	167.6	83.8	153.0	167.6	82.0	153.0	169.4
Pole Configuration		8	8	8	8	8	8	8	8	8	8
Resistance (L-L)	Ohms	0.20	0.80	2.60	3.21	0.34	1.17	1.35	0.20	0.72	0.81
Inductance (L-L)	mH	3.30	11.90	42.40	48.30	5.90	21.10	25.30	3.70	11.60	17.10
Brake Inertia	lbf-in-sec^2	0.00146									
	kg-cm^2	1.66									
Brake Current @24 VDC +/- 10%	A	1.0									
Brake Holding Torque - Dry	lbf-in	177									
	Nm/A	20									
Brake Engage/Disengage Time	ms	13/50									
Mechanical Time Constant (tm)	ms	0.79	0.79	0.79	0.79	0.60	0.63	0.60	0.54	0.56	0.51
Electrical Time Constant (te)	ms	16.26	14.88	16.34	15.06	17.60	18.06	18.72	18.51	16.06	21.16
Friction Torque	lbf-in	1.43	1.43	1.43	1.43	1.81	1.81	1.81	2.32	2.32	2.32
	N-m	0.16	0.16	0.16	0.16	0.20	0.20	0.20	0.26	0.26	0.26
Bus Voltage	Vrms	115	230	400	460	230	400	460	230	400	460
Speed @ Bus Voltage	rpm	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Insulation Class		180(H)									
Ambient Temperature Rating		-29°C to 93°C									
Insulation System Voltage Rating		T4, 135°C Maximum Allowable Surface Temperature									

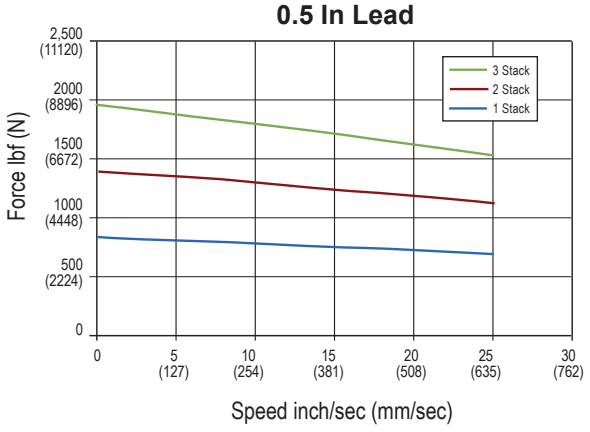
Test data derived using NEMA recommended aluminum heatsink 12" x 12" x 1/2" at 25°C ambient.

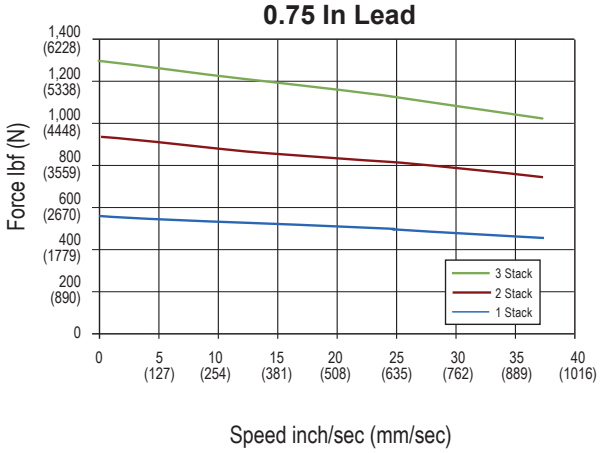
Speed vs. Force Curves

The speed vs. force curves (below) represent approximate continuous thrust ratings at the indicated linear speed. Different types of servo amplifiers offer varying motor torque and, thus, varying actuator thrust. These values are at constant velocity and do not account for motor torque required for acceleration.









Estimated Service Life

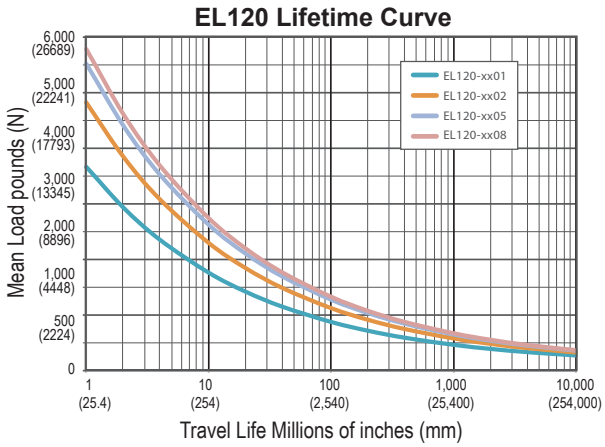
The L_{10} expected life of a roller screw linear actuator is expressed as the linear travel distance that 90% of properly maintained roller screws are expected to meet or exceed. For higher than 90% reliability, multiply the result by the following factors: 95% x 0.62; 96% x 0.53; 97% x 0.44; 98% x 0.33; 99% x 0.21. This is not a guarantee; these charts should be used for estimation purposes only.

The underlying formula that defines this value is:
Travel life in millions of inches, where:

C_a = Dynamic load rating (lbf)
F_{cml} = Cubic mean applied load (lbf)
ℓ = Roller screws lead (inches)

$$L_{10} = \left(\frac{C_a}{F_{cml}} \right)^3 \times \ell$$

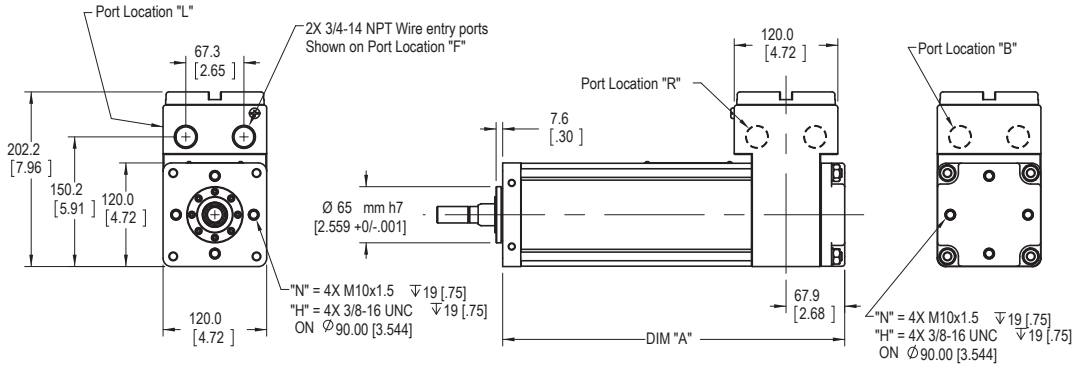
All curves represent properly lubricated and maintained actuators. Ratings may vary, depending on the application.



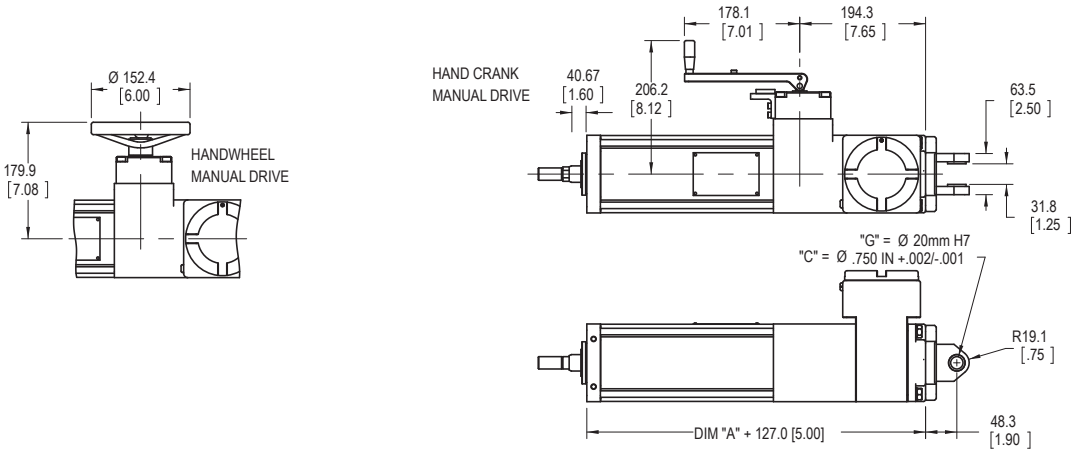
Dimensions

Base Actuator

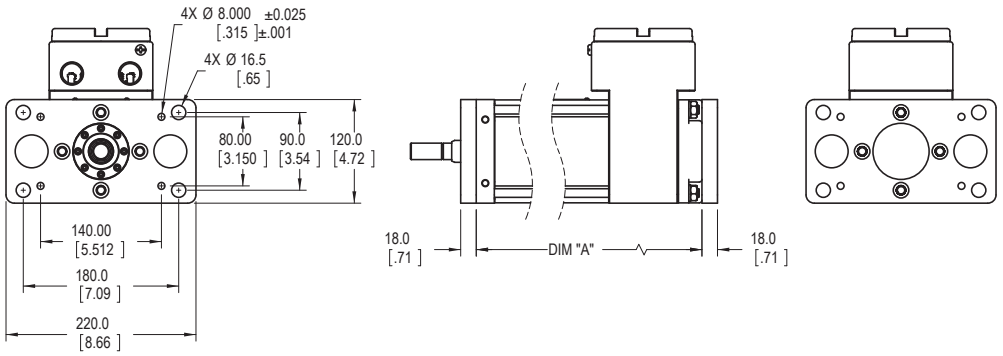
All dimensions shown in mm (inches)



Clevis Mount and Manual Drive Options



Front and Rear Flange Mount

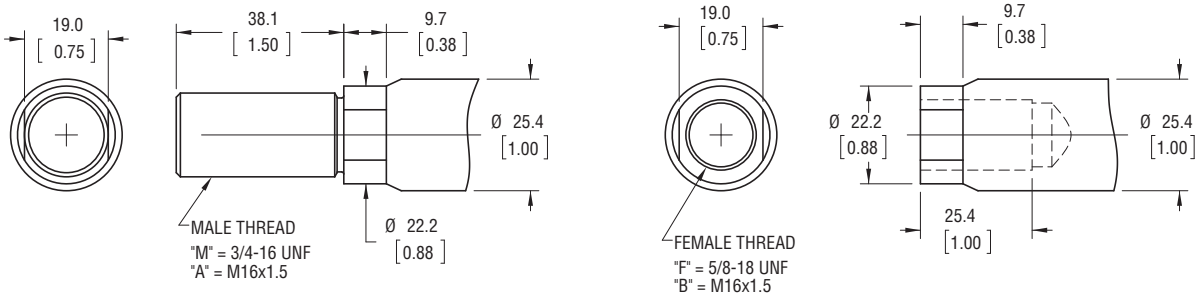


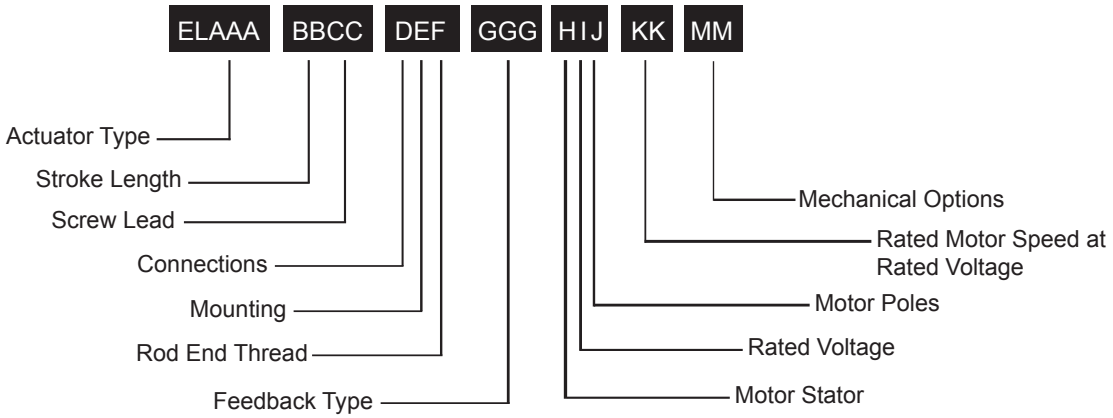
Dim	4" (102 mm) Stroke in (mm)	6" (152 mm) Stroke in (mm)	8" (203 mm) Stroke in (mm)	10" (254 mm) Stroke in (mm)	12" (305 mm) Stroke in (mm)	18" (457 mm) Stroke in (mm)
A	345 (13.6)	396 (15.6)	447 (17.6)	498 (19.6)	549 (21.6)	701 (27.6)

Note: Add 1.63 Inches (41.4 mm) to Dims "A" if ordering a brake without a manual drive.

Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.

Rod End Options





EL = Model Series
EL = Explosion proof linear actuator

AAA = Frame Size
120 = 120 mm

BB = Stroke Length
04 = 4 in
06 = 6 in
08 = 8 in
10 = 10 in
12 = 12 in
18 = 18 in

CC = Screw Lead (linear travel per screw revolution)
01 = 0.1 in/rev (2.54 mm/rev)
02 = 0.2 in/rev (5.08 mm/rev)
05 = 0.5 in/rev (12.7 mm/rev)
08 = 0.8 in/rev (20.3 mm/rev)

D = Connections
F = Two 0.75 in NPT Ports, Front Facing (as viewed from rod end)
B = Two 0.75 in NPT Ports, Back Facing (as viewed from rod end)
R = Two 0.75 in NPT Ports, Right Facing (as viewed from rod end)
L= Two 0.75 in NPT Ports, Left Facing (as viewed from rod end)

E = Mounting
F = Standard Front Flange
R = Standard Rear Flange
G = Metric Rear Clevis
C = English Rear Clevis
J = Metric Rear Eye
K = English Rear Eye

F = Rod End Thread
M = Male, US Standard Thread
A = Male, Metric Thread
F = Female, US Standard Thread
B = Female, Metric Thread

GGG = Feedback Type
See page 207 for detailed information

H = Motor Stator
1 = 1 stack motor
2 = 2 stack motor
3 = 3 stack motor

I = Rated Voltage
1 = 115 Volt RMS
3 = 230 Volt RMS
5 = 400 Volt RMS
6 = 460 Volt RMS

J = Motor Poles
8 = 8 pole motor

KK = Rated Motor Speed at Rated Voltage
01 - 45 Two digit number x 100 = rated RPM

MM = Mechanical Option [3]
PF = Preloaded follower[1]
AR = External anti-rotate assembly
RB = Rear brake
HW = Manual drive, handwheel with interlock switch
CD = Crank drive with interlock switch

NOTES:
1. The dynamic load rating of zero backlash, preloaded screws is 63% of the dynamic load rating of the standard non-preloaded screws. The calculated travel life of a preloaded screw will be 25% of the same size and lead of a non-preloaded screw.
2. Not compatible with Kinetix 300 Drives.
3. For extended temperature operation consult factory for model number.

For options or specials not listed above or for extended temperature operation, please contact Exlar

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EL100

Explosion-Proof Linear Actuators

This electromechanical system provides process engineers with a clean, fast, simple, and cost effective replacement for hydraulic actuation and a longer life alternative to pneumatic actuation. The roller screw technology manufactured by Exlar offer 15 times the travel life of rival ball screws and can carry higher loads. The compact design allows users to effectively replace hydraulic or air cylinders with an electromechanical actuator, while meeting all required capabilities of the application. Servo electric actuation reduces emissions, lowers energy consumption (80% system energy efficiency), and increases position control and accuracy—all leading to reduced cost.

The EL100 explosion-proof linear actuator offers a Class 1, Division 1, Groups B, C, D, and T3 rating. Additionally, it meets ATEX essential requirements and are in conformance with the EU ATEX Directive 94/9/EC.

The EL Series linear actuators are compatible with nearly any manufacturer's resolver-based amplifier.

CE 0518

Ex II 2 G
Ex d IIB+H2 T3 Gb
IECEx SIR 13.0139X

C SA® US 163694
Class I Division 1
Groups B, C, D, T3C

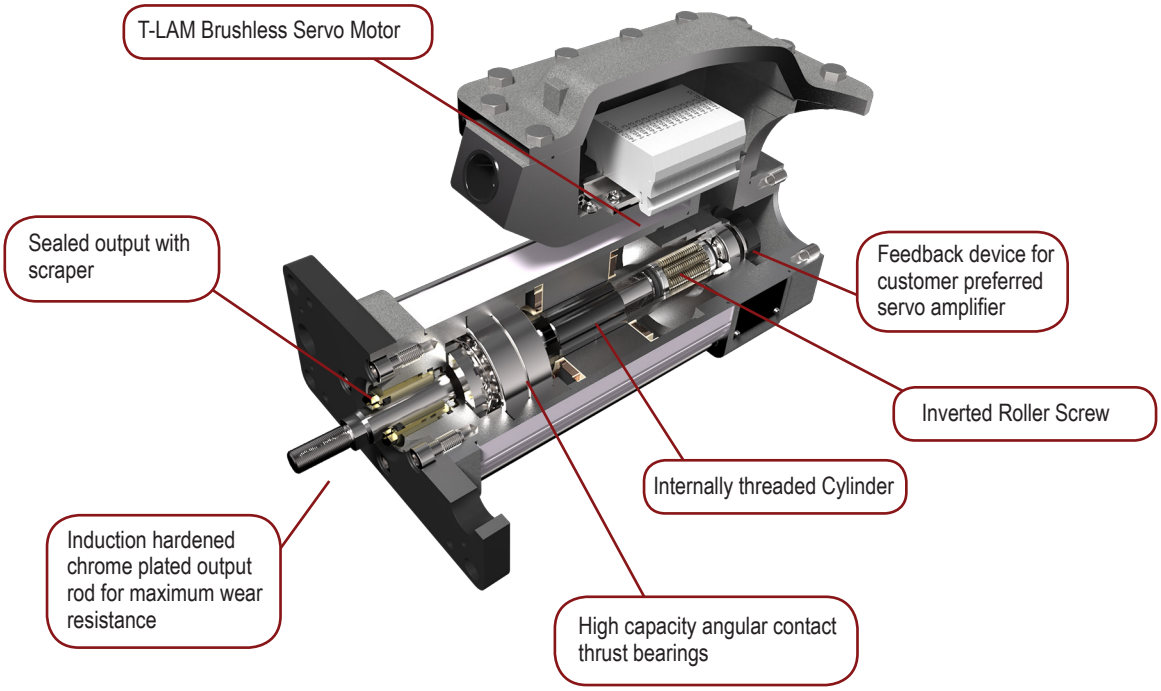
** "Class I" means that flammable gases or vapors may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. "Division 1" means that hazardous concentrations in the air may exist continuously, intermittently, or periodically under normal operating conditions. "Group B" allows for atmospheres containing hydrogen, gases, or vapors of equivalent hazard, such as manufactured gas. "Group C" allows for atmospheres containing ethyl-ether vapors, ethylene or cyclo propane. "Group D" allows for atmospheres containing gasoline, hexane, naphtha, benzene, butane, alcohol, acetone, benzol, lacquer solvent vapors or natural gas. EL Series actuators are not rated for operation in atmospheres containing acetylene. Temperature classification defines the maximum surface temperature the product will reach at full load. T3 = 200° C, T3A =180° C, T4 = 135° C.*

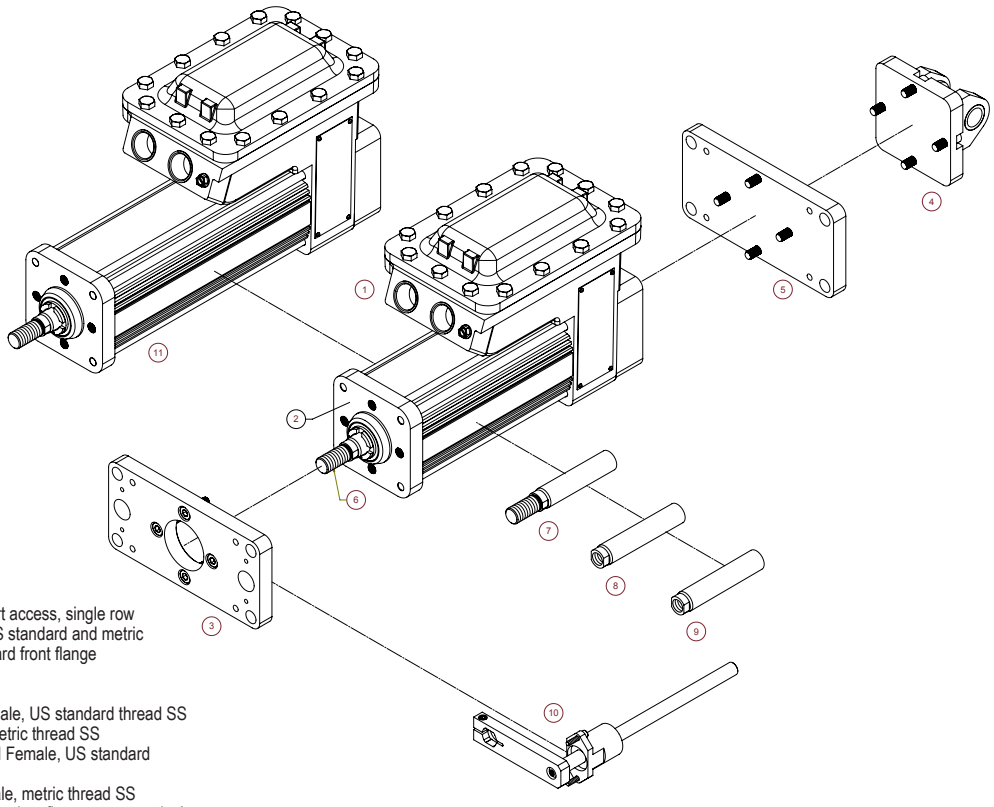
Technical Characteristics	
Frame Sizes in (mm)	4 (100)
Screw Leads in (mm)	0.1 (2.54), 0.2 (5.08), 0.5 (12.7)
Standard Stroke Lengths in (mm)	5.9 (150)
Force Range	up to 4081 lbf-in (18 kN)
Maximum Speed	up to 37.5 in/sec (953 mm/s)

Features
T-LAM technology yielding 35% increase in continuous motor torque over traditional windings
Forces up to 2000 lbs
Speeds up to 25 ips
Resolver feedback
Strokes up to 6 inches
8 pole motors
Rod end options
Several mounting configurations
Potted NPT connectors
Windings available from 24 VDC to 460 VAC rms
Class 180H insulation, IP66S Standard

Operating Conditions and Usage		
Accuracy:		
Screw Lead Error	in/ft (µm / 300 mm)	0.001 (25)
Screw Travel Variation	in/ft (µm / 300 mm)	0.0012 (30)
Screw Lead Backlash	in (mm)	0.004 maximum
Ambient Conditions:		
Ambient Temperature	°C	-29 to 93
Storage Temperature	°C	-54 to 93
IP Rating		IP66S
Shock		10g
Vibration		5 grms, 5 to 2000 hz

Product Features





1 - Terminal strips with 3/4" NPT port access, single row
2 - Threaded front and rear face, US standard and metric
3 - Front and rear flange and standard front flange
4 - Standard rear clevis
5 - Front and rear flange
6 - Male, US standard thread and Male, US standard thread SS
7 - Male, metric thread and Male, metric thread SS
8 - Female, US standard thread and Female, US standard thread SS
9 - Female, metric thread and Female, metric thread SS
10 - External anti-rotate assembly (requires flange mount option)
11 - Rear brake

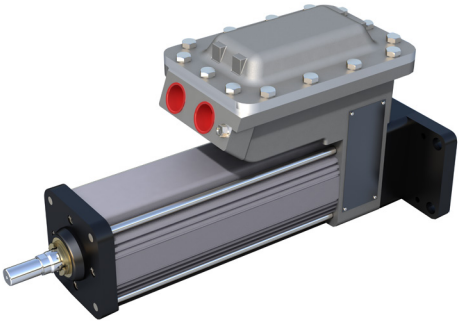
Industries and Applications

Process Control
- Turbine fuel flow
- Chemical process plants
- Fuel distribution systems
- Shipbound fuel management
- Valve control
- Damper control
- Fuel Skids
- Silos

Defense
- Weapons room

Material Handling
- Printing presses

Automotive
- Engine test stands
- Paint booths



The EL100 actuator is another simple, clean, and cost effective replacement for hydraulics meeting Class 1, Division 1, Group B, C, D, and T3 as well as ATEX requirements.

Mechanical Specifications

Motor Stacks		2 Stacks		
Screw Lead Designator		**01**	**02**	**05**
Screw Lead	in	0.1	0.2	0.5
	mm	2.54	5.08	12.7
Continuous Force *(Motor Limited)*	lbf	2011	1005	402
	N	8943	4472	1789
Max Velocity	in/sec	6.66	13.33	33.33
	mm/sec	169.33	338.58	846.58
Friction Torque *(standard screw)*	in-lbf	1.7		
	N-m	0.19		
Friction Torque *(preloaded screw)*	in-lbf	3.5		
	N-m	0.39		
Back Drive Force	lbf	180	80	40
	N	800	360	180
Min Stroke	in	3		
	mm	75		
Max Stroke	in	18		
	mm	450		
C_a (Dynamic Load Rating)	lbf	5516	5800	4900
	N	24,536	25,798	21,795
Inertia	lb-in-s^2	0.002829		
	Kg-m^2	0.000003196		
Weight	lb	7.65		
	Kg	3.47		

*Please note that stroke mm are nominal dimensions. Specifications subject to change without notice.
**Inertia +/– 5%

See definitions on page 190.

Electrical Specifications

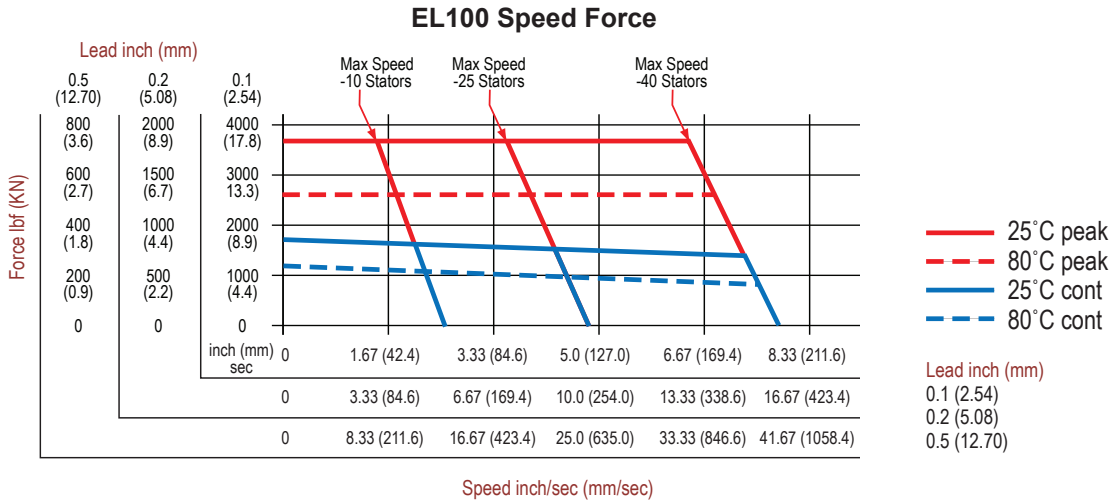
Motor Stator		2A8-10	2B8-25	2C8-40	218-40	238-40	258-40	268-40
RMS SINUSOIDAL COMMUTATION DATA								
Continuous Motor Torque (25°/80°C)	lbf-in	35.2/24.3	35.9/24.8	36.5/25.2	39.6/27.3	40.0/27.6	39.5/27.3	39.9/27.6
	N-m	3.98/2.75	4.06/2.80	4.12/2.85	4.47/3.09	4.52/3.12	4.46/3.08	4.51/3.11
Torque Constant	lbf-in	1.7	1.7	2.6	3.2	6.6	11.6	13.2
	N-m/A	0.19	0.19	0.30	0.37	0.75	1.31	1.50
Continuous Current Rating (25°/80°C)	A	23.1/15.9	23.6/16.3	15.6/10.7	13.6/9.4	6.8/4.7	3.8/2.6	3.4/2.3
Peak Current Rating (25°/80°C)	A	46.2/31.9	47.1/32.5	31.1/21.5	27.3/18.8	13.5/9.3	7.6/5.3	6.7/4.7
O-PEAK SMUSOIDAL COMMUTATION DATA								
Continuous Motor Torque (25°/80°C)	lbf-in	35.2/24.3	35.9/24.8	36.5/25.2	39.6/27.3	40.0/27.6	39.5/27.3	39.9/27.6
	N-m	3.98/2.75	4.06/2.80	4.12/2.85	4.47/3.09	4.52/3.12	(4.46/3.08)	(4.51/3.11)
Torque Constant	lbf-in/A	1.2	1.2	1.9	2.3	4.7	8.2	9.4
	N-m/A	0.14	0.14	0.21	0.26	0.53	0.92	1.06
Continuous Current Rating (25°/80°C)	A	32.7/22.6	33.3/23.0	22.0/15.2	19.3/13.3	9.5/6.6	5.4/3.7	4.8/3.3
Peak Current Rating (25°/80°C)	A	65.4/45.1	66.7/46.0	44.0/30.4	38.6/26.6	19.1/13.2	10.8/7.5	9.5/6.6
MOTOR STATOR DATA								
Voltage Constant @ 25˚C (Ke)	Vrms/Krpm	11.6	11.6	17.9	22.1	45.2	78.9	90.4
	Vpk/Krpm	16.5	16.5	25.3	31.3	64.0	111.6	127.9
Pole Configuration		8	8	8	8	8	8	8
Resistance (L-L)	Ohms	0.10	0.1	0.2	0.30	1.2	3.8	4.86
Inductance (L-L)	mH	0.75	0.8	1.9	2.93	12.2	37.2	48.9
Brake Inertia	lbf-in-sec^2	0.00047						
	kg-cm^2	0.53						
Brake Current @24 VDC +/- 10%	A	0.5						
Brake Holding Torque - Dry	lbf-in	70						
	Nm/A	8						
Brake Engage/Disengage Time	ms	25/50						
Mechanical Time Constant (tm)	ms	1.4	1.3	1.3	1.1	1.1	1.1	1.1
Electrical Time Constant (te)	ms	7.2	7.9	8.2	9.9	10.1	9.9	10.1
Frictional Torque	lbf-in	2.22	2.22	2.22	2.22	2.22	2.22	2.22
	N-m	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Bus Voltage	Vrms	24 VDC	48 VDC	120 VDC	115 VAC	230 VAC	400 VAC	460 VAC
Speed @ Bus Voltage	rpm	1,000	2,500	4,000	4,000	4,000	4,000	4,000
Insulation Class		180 (H)						
Ambient Temperature Rating		-29° C to 93° C						
CSA/ATEX Temperature Class		T3, 200˚ C Maximum Allowable Surface Temperature						

For amplifiers using peak sinusoidal ratings, multiply RMS sinusoidal Kt by 0.707, and peak current by 1.414.
Test data derived using NEMA recommended aluminum heatsink 12" x 12" x 1/2" at 25° / 80°C ambient.

Specifications subject to change without notice.

Performance Curves

The below speed vs. force curves represent approximate continuous thrust ratings at indicated linear speed. Different types of servo amplifiers offer varying motor torque and, thus, varying actuator thrust. These values are at constant velocity and do not account for motor torque required for acceleration.



DEFINITIONS:

Continuous Force: The linear force produced by the actuator at continuous motor torque.

Max Velocity: The linear velocity that the actuator will achieve at rated motor rpm.

Friction Torque (standard screw): Amount of torque required to move the actuator when not coupled to a load.

Friction Torque (preloaded screw): Amount of torque required to move the actuator when not coupled to a load.

Back Drive Force: Amount of axial force applied to the rod end of the actuator that will produce motion with no power applied to the actuator.

Min Stroke: Shortest available stroke length.

Max Stroke: Longest available stroke length.

C_a (Dynamic Load Rating): A design constant used when calculating the estimated travel life of the roller screw.

Inertia (zero stroke): Base inertia of an actuator with zero available stroke length.

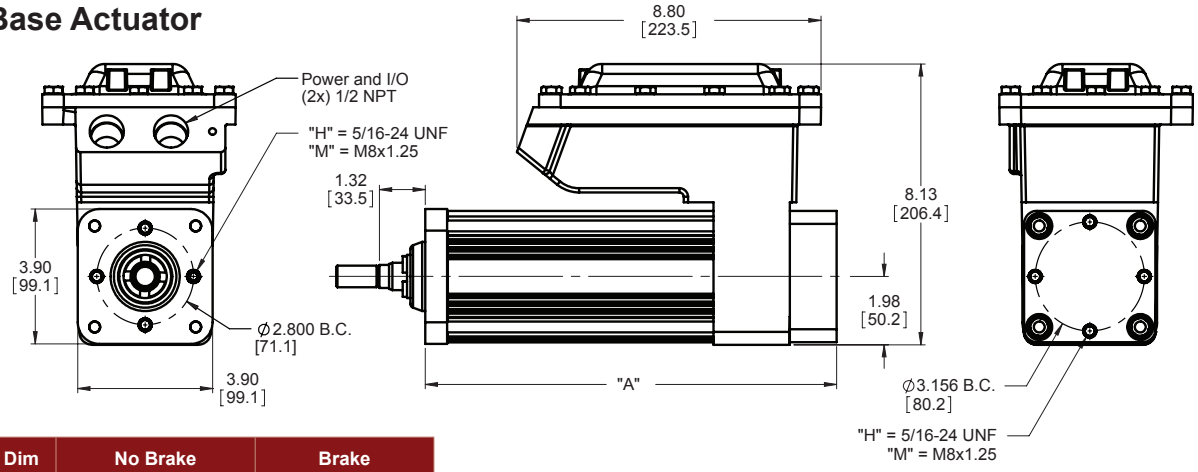
Inertia Adder (per inch of stroke): Inertia per inch of stroke that must be added to the base (zero stroke) inertia to determine the total actuator inertia.

Weight (zero stroke): Base weight of an actuator with zero available stroke length.

Weight Adder (per inch of stroke): Weight adder inch unit of stroke that must be added to the base (zero stroke) weight to determine the total actuator weight.

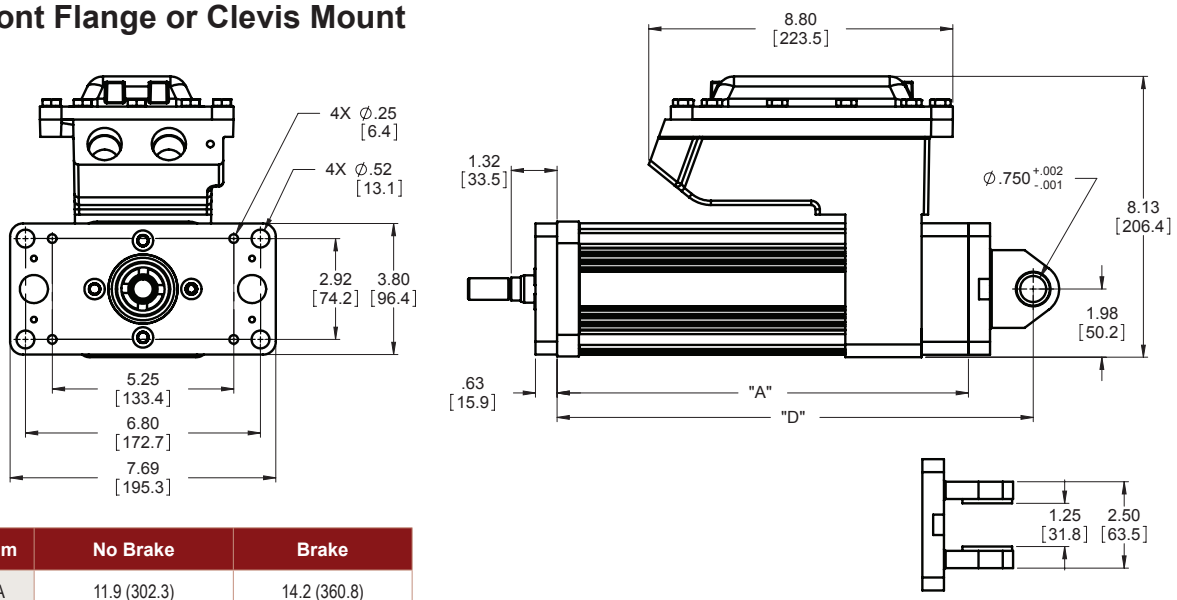
Dimensions

Base Actuator



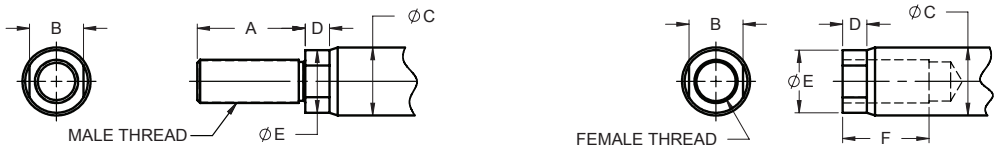
Dim	No Brake	Brake
A	11.9 (302.3)	14.2 (360.8)

Front Flange or Clevis Mount



Dim	No Brake	Brake
A	11.9 (302.3)	14.2 (360.8)
D	13.77 (349.9)	16.7 (408.2)

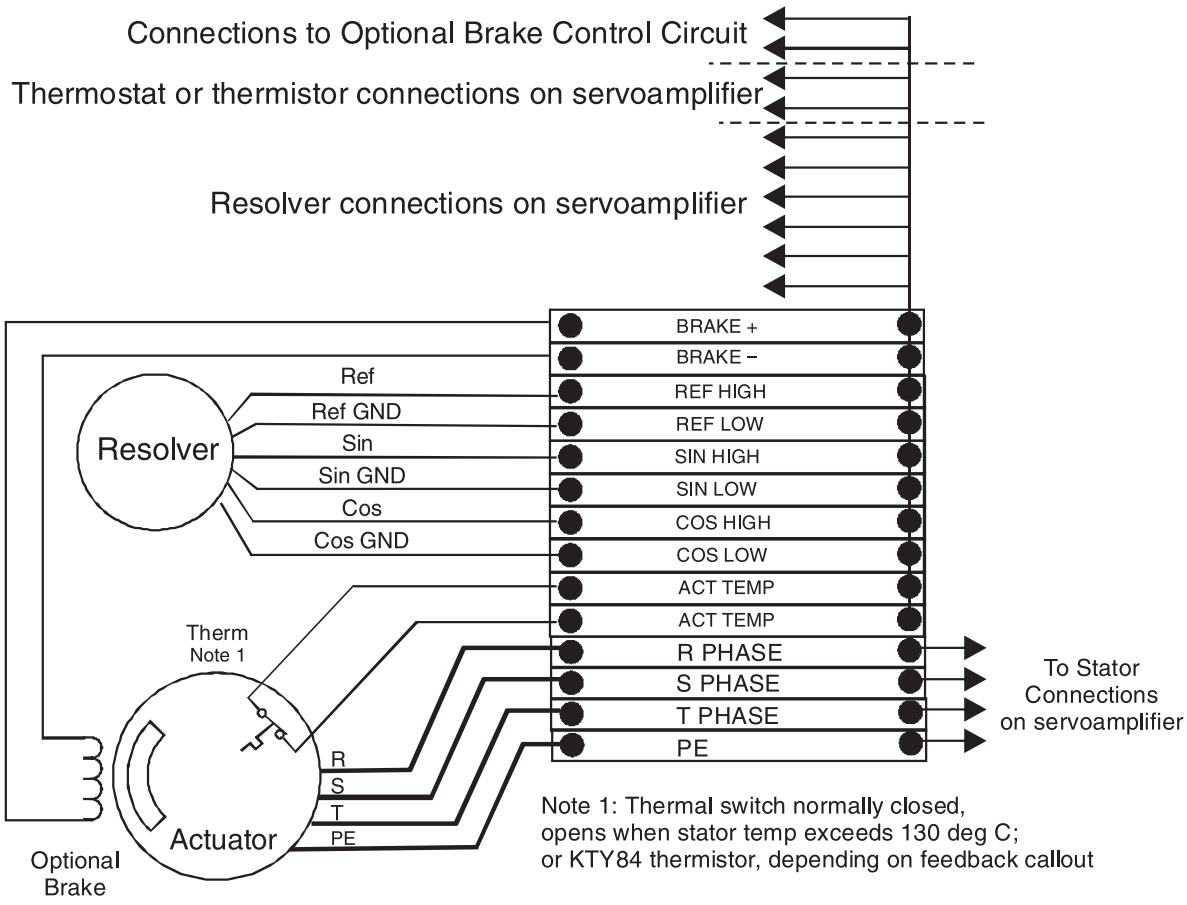
Rod End Options



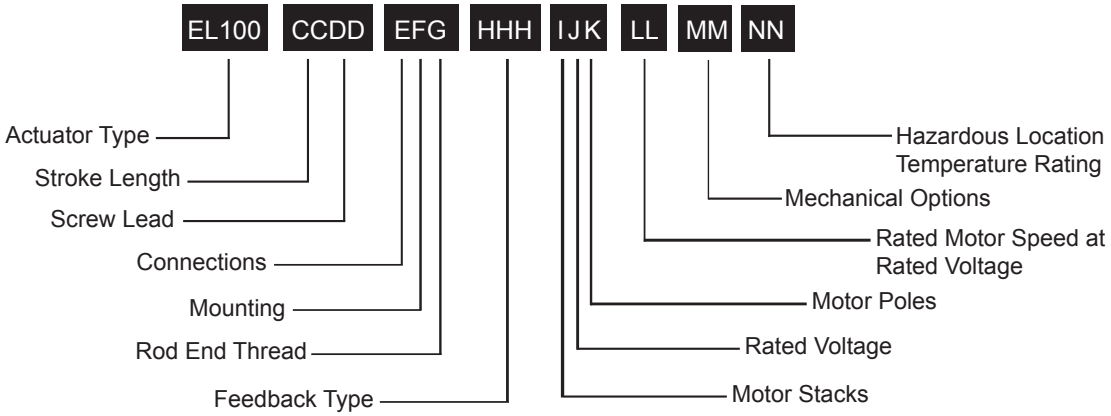
	A	B	ØC	D	ØE	F	Male "M" Inch	Male "A" Metric	Female "F" Inch	Female "B" Metric
EL100 in (mm)	1.250 (31.8)	0.625 (17.0)	0.787 (20.0)	0.281 (7.1)	0.725 (18.4)	1.000 (25.4)	1/2 - 20 UNF – 2A	M16 x 1.5 6g	1/2 - 20 UNF – 2B	M16 x 1.5 6h

Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.

Terminal Box Wiring



Pre-sale drawings and models are representative and are subject to change. Certified drawings and models are available for a fee. Consult your local Exlar representative for details.



EL100 = Model Series

CC = Stroke Length
06 = 5.9 inch (150 mm)

DD = Roller Screw Lead (Linear Travel per Screw Revolution)
01 = 0.1 in/rev (2.54 mm/rev)
02 = 0.2 in/rev (5.08 mm/rev)
05 = 0.5 in/rev (12.7 mm/rev)

E = Connections
S = Terminal strips with 3/4" NPT port access, single row

F = Mounting
H = Threaded front and rear face, US standard thread
N = Threaded front and rear face, metric thread
B = Front and rear flange
F = Standard front flange
C = Standard rear clevis
R = Rear flange

G = Rod End
M = Male, US standard thread
A = Male, metric thread
F = Female, US standard thread
B = Female, metric thread
W = Male, US standard thread SS
R = Male, metric thread SS
V = Female, US standard thread SS
L = Female, metric thread SS

HHH = Controller Feedback Option
XX1 = Custom Feedback. Resolver only. Consult Exlar
AB6 = Allen-Bradley/Rockwell - standard resolver
AM3 = Advanced Motion Control - standard resolver
AP1 = API Controls - standard resolver
BD2 = Baldor - standard resolver
BM2 = Baumueller - standard resolver
BR1 = B&R Automation
CT5 = Control Techniques - standard resolver
CO2 = Copely Controls - standard resolver
DT2 = Delta Tau Data Systems - standard resolver
EL1 = Elmo Motion Control - standard resolver
EX4 = Exlar - standard resolver
IF1 = Infranor - standard resolver
IN6 = Indramat/Bosch-Rexroth - standard resolver
JT1 = Jetter Technologies - standard resolver
KM5 = Kollmorgen/Danaher - standard resolver
LZ5 = Lenze/AC Tech - standard resolver
MD1 = Modicon - standard resolver
MG1 = Moog - standard resolver
MN4 = Momentum – Standard Resolver
MX1 = Metronix - standard resolver
OR1 = Ormec - standard resolver
PC7 = Parker - standard resolver - European only
PC0 = Parker - standard resolver - US only
PS3 = Pacific Scientific - standard resolver
SM2 = Siemens - standard resolver
SW1 = SEW/Eurodrive - standard resolver
WD1 = Whedco/Fanuc - standard resolver

I = Motor Stacks
2 = 2 stack motor

J = Rated Voltage
A = 24 VDC
B = 48 VDC
C = 120 VDC
1 = 115 Volt RMS
3 = 230 Volt RMS
5 = 400 Volt RMS
6 = 460 Volt RMS

K = Motor Poles
8 = 8 Pole Motor

LL = Rated Motor Speed at Rated Voltage
01 - 99 = Two digit number x 100 = rated RPM

MM = Mechanical Options [2]
PF = Pre-loaded roller screw follower[1]
AR = External anti-rotate assembly (requires flange mount option)
RB = Rear brake

NN = Haz Loc Temp Rating
T3 = 200˚ C max allowable surface temperature

For options or specials not listed above or for extended temperature operation, please contact Exlar

NOTES:
1. The dynamic load rating of zero backlash, preloaded screws is 63% of the dynamic load rating of the standard non-preloaded screws. The calculated travel life of a preloaded screw will be 25% of the calculated travel life of the same size and lead of a non-preloaded screw.
2. For extended temperature operation consult factory for model number.

Commonly Ordered Options Shown in BOLD

Elmo Motion Control:
EL1 = Standard Resolver
EL2 = Standard Incremental Encoder
EL3 = EnDat Heidenhain EQN1125 multi-turn absolute encoder

Emerson/Control Techniques:
EM2 = Std Incremental Encoder – NT motor wiring w/MS connectors for 'M' option
EM5 = Encoder 5000 line, with commutation, 5 VDC – NT motor wiring w/MS connectors for 'M' option

Elau:
EU1 = Hiperface Stegmann SRM050 multi-turn absolute encoder – 40-50-60 Frame Size. SH motor wiring w/MS connectors for 'M' option
EU4 = Hiperface Stegmann SKM036 multi-turn absolute encoder – 20-30 Frame Size. SH motor wiring w/MS connectors for 'M' option.

Exlar:
EX4 = Standard Resolver
EX5 = Standard Resolver with KTY84 thermistor
EX6 = EnDat Heidenhain EQN1125 multi-turn absolute encoder
EX7 = Incremental encoder, 5000 line with commutation, 5Vdc
EX8 = Hiperface Stegmann SRM50 multi-turn absolute encoder

Indramat/Bosch-Rexroth:
IN6 = Std Resolver – MKD/MHD motor wiring w/M23 euro connectors for 'M' option
IN7 = Hiperface Stegmann SKM036 multi-turn absolute encoder – MSK motor wiring w/M23 euro connectors for 'M' option – plug & play option
IN8 = Indradrive EnDat Heidenhain EQN1125 multi-turn absolute w/M23 connectors

Kollmorgen/Danaher:
KM4 = EnDat Heidenhain EQN1325 multi-turn absolute encoder (Sine Encoder)– AKM motor wiring w/M23 Intercontec euro connectors for 'M' option
KM5 = Standard Resolver – AKM motor wiring w/M23 Intercontec euro connectors for 'M' option
KM6 = Standard Incremental Encoder – AKM motor wiring w/ M23 Intercontec euro connectors for 'M' option

Lenze/AC Tech:
LZ1 = Hiperface Stegmann SRM050 multi-turn absolute encoder – MCS motor wiring w/M23 euro connectors for 'M' option
LZ5 = Standard Resolver – MCS motor wiring w/ M23 euro connectors for 'M' option
LZ6 = Standard Incremental Encoder – MCS motor wiring w/ M23 euro connectors for 'M' option

Mitsubishi[2]:
MT2 = DSL Stegmann MR-J4 compatible

Parker Compumotor:
PC6 = Std Incremental Encoder – SMH motor wiring w/M23 connectors for 'M' option – European only
PC7 = Std Resolver – SMH motor wiring w/M23 connectors for 'M' option – European only
PC8 = Standard Incremental Encoder – MPP series motor wiring w/PS connectors for 'M' option – US Only
PC9 = Hiperface Stegmann SRM050 multi-turn absolute encoder – MPP motor wiring w/PS connectors for 'M' option – US Only
PC0 = Standard Resolver – MPP motor wiring w/PS connectors for 'M' option – US Only

Schneider Electric:
SC2 = Hiperface Steamann SKM036 multi-turn absolute encoder – BSH motor wiring w/M23 euro connectors for 'M' option

Stober Drives:
SB3 = EnDat Heidenhain EQN1125 multi-turn absolute encoder – ED/EK motor wiring w/M23 euro connectors for 'M' option
SB4 = Standard Resolver ED/EK motor wiring W/23 connector for "M" option

Siemens:
SM2 = Standard Resolver – 1FK7 motor wiring w/M23 connectors for 'M' option
SM3 = EnDat Heidenhain EQN1325 multi-turn absolute encoder – 40-50-60 Frame Size. 1FK7 motor wiring w/M23 euro connectors for 'M' option
SM4 = EnDat Heidenhain EQN1125 multi-turn absolute encoder – 20-30 Frame Size. 1FK7 motor wiring w/M23 euro connectors for 'M' option
SM9 = Siemens Heidenhain EQN1325 4096 (12 bits) multi-turn absolute w/M23 connectors

SEW/Eurodrive:
SW1 = Standard Resolver – CM motor wiring w/ M23 euro connectors for 'M' option
SW2 = Standard Incremental Encoder
SW3 = Hiperface Stegmann SRM050 multi-turn absolute encoder – CM motor wiring w/ M23 euro connectors for 'M' option

Yaskawa:
YS5 = Yaskawa Sigma V absolute encoder

NOTES:
1. Not compatible with Kinetix 300 Drives.
2. N/A with holding brake unless application details are discussed with your local sales representative.
3. All rotary motors to be used with Kinetix or Sercos based systems will require prior approval from Rockwell Automation.

Sizing and Selection of Exlar Linear and Rotary Actuators

Move Profiles

The first step in analyzing a motion control application and selecting an actuator is to determine the required move profile. This move profile is based on the distance to be traveled and the amount of time available in which to make that move. The calculations below can help you determine your move profile.

Each motion device will have a maximum speed that it can achieve for each specific load capacity. This maximum speed will determine which type of motion profile can be used to complete the move. Two common types of move profiles are trapezoidal and triangular. If the average velocity of the profile, is less than half the maximum velocity of the actuator, then triangular profiles can be used. Triangular Profiles result in the lowest possible acceleration and deceleration. Otherwise a trapezoidal profile can be used. The trapezoidal profile below with 3 equal divisions will result in 25% lower maximum speed and 12.5% higher acceleration and deceleration. This is commonly called a 1/3 trapezoidal profile.

The following pages give the required formulas that allow you to select the proper Exlar linear or rotary actuator for your application. The first calculation explanation is for determining the required thrust in a linear application.

The second provides the necessary equations for determining the torque required from a linear or rotary application. For rotary applications this includes the use of reductions through belts or gears, and for linear applications, through screws.

Pages are included to allow you to enter your data and easily perform the required calculations. You can also describe your application graphically and fax it to Exlar for sizing. Reference tables for common unit conversions and motion system constants are included at the end of the section.

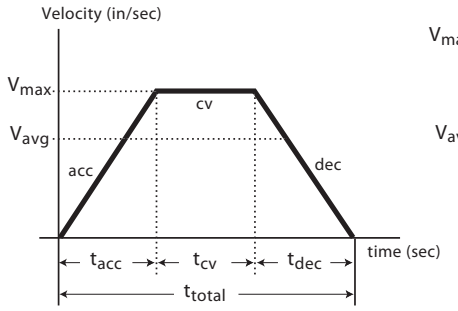
Linear Move Profile Calculations

Vmax = max.velocity-in/sec (m/sec)
Vavg = avg. velocity-in/sec (m/sec)
tacc = acceleration time (sec)
tdec = deceleration time (sec)
tcv = constant velocity (sec)
ttotal = total move time (sec)
acc = accel-in/sec^2 (m/sec^2)
dec = decel-in/sec^2 (m/sec^2)
cv = constant vel.-in/sec (m/sec)
D = total move distance-in (m)
or revolutions (rotary)

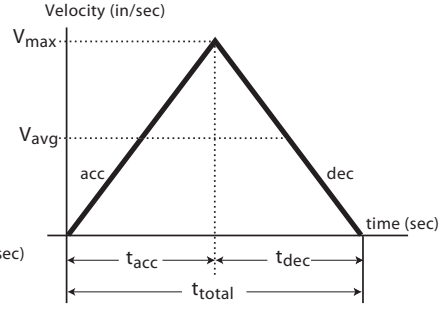
Standard Equations

Vavg = **D** / ttotal
If tacc = **t**dec **Then: V**max =
(**t**total/(**t**total-tacc)(**V**avg)
and
D = Area under profile curve
D = (1/2(**t**acc+**t**dec)+**t**cv)(**V**max)

Trapezoidal Move Profile



Triangular Move Profile



Trapezoidal Equations

If tacc = **t**cv = **t**dec **Then:**
Vmax = 1.5 (**V**avg)
D = (2/3) (**t**total) (**V**max)
acc = dec = $\frac{\mathbf{V}max}{\mathbf{t}acc}$

Triangular Equations

If tacc = **t**total/2 **Then:**
Vmax = 2.0 (**V**avg)
D = (1/2) (**t**total) (**V**max)
acc = dec = $\frac{\mathbf{V}max}{\mathbf{t}acc}$

Terms and (units)

THRUST = Total linear force-lbf (N)
Ø = Angle of inclination (deg)
Ffriction = Force from friction-lbf (N)
tacc = Acceleration time (sec)
Facc = Acceleration force-lbf (N)
v = Change in velocity-in/sec (m/s)
Fgravity = Force due to gravity-lbf (N)
μ = Coefficient of sliding friction
Fapplied = Applied forces-lbf (N)
(refer to table on page 136 for different materials)
WL = Weight of Load-lbf (N)
g = 386.4: Acceleration of gravity - in/sec^2 (9.8 m/sec^2)

Thrust Calculation Equations

THRUST = **F**friction + [**F**acceleration] + **F**gravity + **F**applied

THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied

Sample Calculations: Calculate the thrust required to accelerate a 200 pound mass to 8 inches per second in an acceleration time of 0.2 seconds. Calculate this thrust at inclination angles(ø) of 0˚, 90˚ and 30˚. Assume that there is a 25 pound spring force that is applied against the acceleration.

WL = 200 lbm, v = 8.0 in/sec., **t**a = 0.2 sec., **F**app. = 25 lbf, μ = 0.15

ø = 0˚

THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied
= (200)(0.15)(1) + [(200/386.4)(8.0/0.2)] + (200)(0) + 25

= 30 lbs + 20.73 lbs + 0 lbs + 25 lbs = **75.73 lbs force**

ø = 90˚

THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied
= (200)(0.15)(0) + [(200/386.4)(8.0/0.2)] + (200)(1) + 25

= 0 lbs + 20.73 lbs + 200 lbs + 25 lbs = **245.73 lbs force**

ø = 30˚

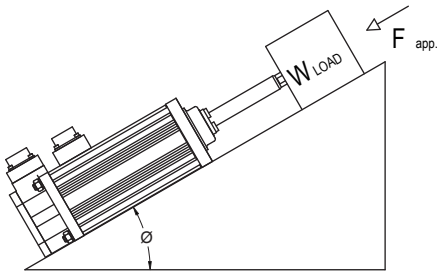
THRUST = **W**Lμcosø + [(**W**L /386.4) (**v**/tacc)] + **W**Lsinø + **F**applied
= (200)(0.15)(0.866) + [(200/386.4)(8.0/0.2)] + (200)(0.5) + 25

= 26 lbs + 20.73 lbs + 100 + 25 = **171.73 lbs force**

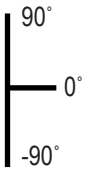
Thrust Calculations

Definition of thrust:

The thrust necessary to perform a specific move profile is equal to the sum of four components of force. These are the force due to acceleration of the mass, gravity, friction and applied forces such as cutting and pressing forces and overcoming spring forces.



Angle of Inclination



Note: at ø = 0˚
cosø = 1; sinø = 0
at ø = 90˚
cosø = 0; sinø = 1

It is necessary to calculate the required thrust for an application during each portion of the move profile, and determine the worst case criteria. The linear actuator should then be selected based on those values. The calculations at the right show calculations during acceleration which is often the most demanding segment of a profile.

Motor Torque Calculations

When selecting an actuator system it is necessary to determine the required motor torque to perform the given application. These calculations can then be compared to the torque ratings of the given amplifier and motor combination that will be used to control the actuator's velocity and position.

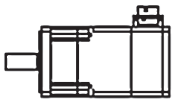
When the system uses a separate motor and screw, like the FT actuator, the ratings for that motor and amplifier are consulted. In the case of the GSX Series actuators with their integral brushless motors, the required torque divided by the torque constant of the motor (Kt) must be less than the current rating of the GSX or SLM motor.

Inertia values and torque ratings can be found in the GSX, FT, and SLM/SLG Series product specifications.

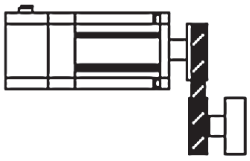
For the GSX Series the screw and motor inertia are combined.

Motor with screw (GSX, GSM, FT, & EL)

Motor & motor with reducer (SLM/SLG & ER)



Motor with belt and pulley



Terms and (units)

λ	=	Required motor torque, lbf-in (N-m)
λa	=	Required motor acceleration torque, lbf-in (N-m)
F	=	Applied force load, non inertial, lbf (kN)
S	=	Screw lead, in (mm)
R	=	Belt or reducer ratio
TL	=	Torque at driven load lbf-in (N-m)
vL	=	Linear velocity of load in/sec (m/sec)
ωL	=	Angular velocity of load rad/sec
ωm	=	Angular velocity of motor rad/sec
η	=	Screw or ratio efficiency
g	=	Gravitational constant, 386.4 in/s^2 (9.75 m/s^2)
α	=	Angular acceleration of motor, rad/s^2
m	=	Mass of the applied load, lb (N)
JL	=	Reflected Inertia due to load, lbf-in-s^2 (N-m-s^2)
Jr	=	Reflected Inertia due to ratio, lbf-in-s^2 (N-m-s^2)
Js	=	Reflected Inertia due to external screw, lbf-in-s^2 (N-m-s^2)
Jm	=	Motor armature inertia, lbf-in-s^2 (N-m-s^2)
L	=	Length of screw, in (m)
ρ	=	Density of screw material, lb/in^3 (kg/m^3)
r	=	Radius of screw, in (m)
π	=	pi (3.14159)
C	=	Dynamic load rating, lbf (N)

Velocity Equations

Screw drive: $\mathbf{V}_L = \omega m * S/2\pi$ in/sec (m/sec)

Belt or gear drive: $\omega m = \omega_L * R$ rad/sec

Torque Equations

Torque Under Load

Screw drive (GS, FT or separate screw): $\lambda = \frac{S \bullet F}{2 \bullet \pi \bullet \eta}$ lbf-in (N-**m**)

Belt and Pulley drive: $\lambda = \mathbf{T}_L / R\,\eta$ lbf-in (N-**m**)

Gear or gear reducer drive: $\lambda = \mathbf{T}_L / R\,\eta$ lbf - in (N-**m**)

Torque Under Acceleration

$\lambda a = (\mathbf{J}_m + \mathbf{J}_R + (\mathbf{J}_s + \mathbf{J}_L)/R^2)\alpha$ lbf-in

α = angular acceleration = ((RPM / 60) x 2π) / $\mathbf{t}_{acc}$, rad/sec^2.

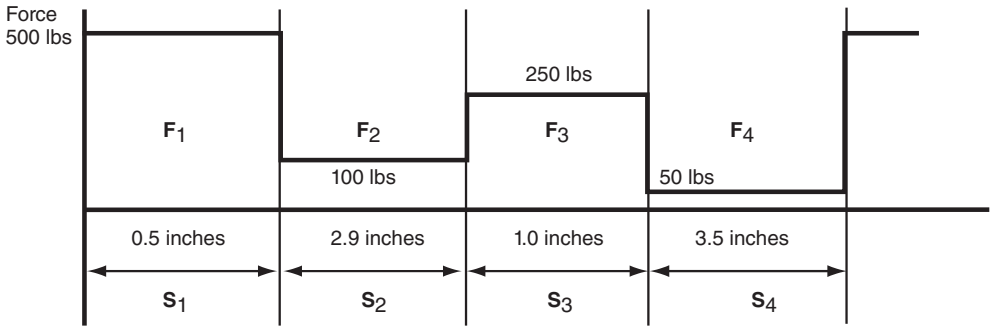
$\mathbf{J}_S = \frac{\pi \bullet \mathbf{L} \bullet \rho \times r^4}{2 \bullet g}$ lb - in - s^2 (N - **m** - s^2)

Total Torque per move segment

$\lambda T = \lambda a + \lambda$ lbf-in (N-m)

Mean Load Calculations

For accurate lifetime calculations of a roller screw in a linear application, the cubic mean load should be used. Following is a graph showing the values for force and distance as well as the calculation for cubic mean load. Forces are shown for example purposes. Negative forces are shown as positive for calculation.



S = Distance traveled during each move segment

Cubic Mean Load Equation

$$F_{cml} = \sqrt[3]{\frac{F_1^3 S_1 + F_2^3 S_2 + F_3^3 S_3 + F_4^3 S_4}{S_1 + S_2 + S_3 + S_4}}$$

Value from example numbers is 217 lbs.

Lifetime Calculations

The expected L_{10} life of a roller screw is expressed as the linear travel distance that 90% of the screws are expected to meet or exceed before experiencing metal fatigue. The mathematical formula that defines this value is below. The life is in millions of inches (mm). This standard L_{10} life calculation is what is expected of 90% of roller screws manufactured and is not a guarantee. Travel life estimate is based on a properly maintained screw that is free of contaminants and properly lubricated. Higher than 90% requires de-rating according to the following factors:

95% x 0.62 96% x 0.53
97% x 0.44 98% x 0.33
99% x 0.21

Single (non-preloaded) nut:

$$L_{10} = \left(\frac{C_a}{F_{cml}} \right)^3 \times \ell$$

If your application requires high force over a stroke length shorter than the length of the nut, please contact Exlar for derated life calculations. You may also download the article “Calculating Life Expectency” at www.exlar.com.

Note: The dynamic load rating of zero backlash, preloaded screws is 63% of the dynamic load rating of the standard non-preloaded screws. The calculated travel life of a preloaded screw will be 25% of the calculated travel life of the same size and lead of a non-preloaded screw for the same application.

Total Thrust Calculations

Terms and (units)

THRUST = Total linear force-lbf (N)

$\mathbf{F}_{friction}$ = Force from friction-lbf (N)

$\mathbf{F}_{acc}$ = Acceleration force-lbf (N)

$\mathbf{F}_{gravity}$ = Force due to gravity-lbf (N)

$\mathbf{F}_{applied}$ = Applied forces-lbf (N)

386.4 = Acceleration of gravity - in/sec^2 (9.8 m/sec^2)

Variables

Ø = Angle of inclination - deg..... = _____

tacc = Acceleration time - sec..... = _____

v = Change in velocity - in/sec (m/s)..... = _____

μ = Coefficient of sliding friction ..... = _____

$\mathbf{W}_L$ = Weight of Load-lbm (kg)..... = _____

$\mathbf{F}_{applied}$ = Applied forces-lbf (N) ..... = _____

Thrust Calculation Equations

THRUST = [$\mathbf{F}_{friction}$] + [$\mathbf{F}_{acceleration}$] + $\mathbf{F}_{gravity}$ + $\mathbf{F}_{applied}$

THRUST = [$\mathbf{W}_L$ x μ x cosø] + [($\mathbf{W}_L$ /386.4) x (**v** / $\mathbf{t}_{acc}$)] + $\mathbf{W}_L$sinø + $\mathbf{F}_{applied}$

THRUST = [( )x( )x( )] + [(/386.4) x (/)] + [( ) ( )] + ( )

THRUST = [ ] + [( ) x ( )] + [ ] + ( )

= _____ lbf.

Calculate the thrust for each segment of the move profile. Use those values in calculations below.
Use the units from the above definitions.

Cubic Mean Load Calculations

$$\sqrt[3]{\frac{F_1^3 S_1 + F_2^3 S^2 + F_3^3 S_3 + F_4^3 S_4}{S_1 + S_2 + S_3 + S_4}}$$

F_1= _____ S_1= _____ $F_1^3 S_1$ = _____

F_2= _____ S_2= _____ $F_2^3 S_2$ = _____

F_3= _____ S_3= _____ $F_3^3 S_3$ = _____

F_4= _____ S_4= _____ $F_4^3 S_4$ = _____

Move Profiles may have more or less than four components. Adjust your calculations accordingly.

Torque Calculations

Terms and (units)

λ = Torque, lb-in (N-m) ..... = ----------

F = Applied Load, non inertial, lbf (N) ..... = ----------

S = Screw lead, in (m) ..... = ----------

η = Screw or ratio efficiency (~85% for roller screws) ..... = ----------

g = Gravitational constant, 386 in/s2 (9.8 m/s2) ..... = ----------

α = Acceleration of motor, rad/s2 ..... = ----------

R = Belt or reducer ratio ..... = ----------

$\mathbf{T_L}$ = Torque at driven load, lbf-in (N-m) ..... = ----------

$\mathbf{V_L}$ = Linear velocity of load, in/sec (m/sec) ..... = ----------

ω_L = Angular velocity of load, rad/sec ..... = ----------

ω_m = Angular velocity of motor, rad/sec ..... = ----------

m = Mass of the applied load, lbm (kg) ..... = ----------

$\mathbf{J_R}$ = Reflected Inertia due to ratio, lb-in-s2 (N-m-s2) ..... = ----------

$\mathbf{J_S}$ = Reflected Inertia due to screw, lb-in-s2 (N-m-s2) ..... = ----------

$\mathbf{J_L}$ = Reflected Inertia due to load, lb-in-s2(N-m-s2) ..... = ----------

$\mathbf{J_M}$ = Motor armature inertia, lb-in-s2 (N-m-s2) ..... = ----------

π = pi ..... = 3.14159

$\mathbf{K_t}$ = Motor Torque constant, lb-in/amp (N-m/amp) ..... = ----------

* For the GS Series J_S and J_M are one value from the GS Specifications.

Torque Equations

Torque From Calculated Thrust.

$\lambda = \frac{SF}{2 \cdot \pi \cdot \eta}$ lb - in (N - m) = ( ) x ( )/2π (0.85) = ( ) x ( )/5.34 = ----------

Torque Due To Load, Rotary.

Belt and pulley drive: $\lambda = T_L / R \eta$ lbf-in (N-m)

Gear or gear reducer drive: $\lambda = T_L / R\eta$ lbf-in (N-m)

Torque During Acceleration due to screw, motor, load and reduction, linear or rotary.

$I = (\mathbf{J_m} + (\mathbf{J_S} + \mathbf{J_L}) / \mathbf{R}^2) \alpha$ lb-in (N-**m**) = [( ) + (+) / ( )] ( ) = ----------

Total Torque = Torque from calculated Thrust + Torque due to motor, screw and load

( ) + ( ) + ( ) = _____

Motor Current = $\lambda / \mathbf{K_t}$ = ( ) / ( ) = _____

Exlar Application Worksheet

FAX to:
Exlar Actuation Solutions
(952) 368-4877
Attn: Applications Engineering

Date: _____ Company Name: _____

Address: _____

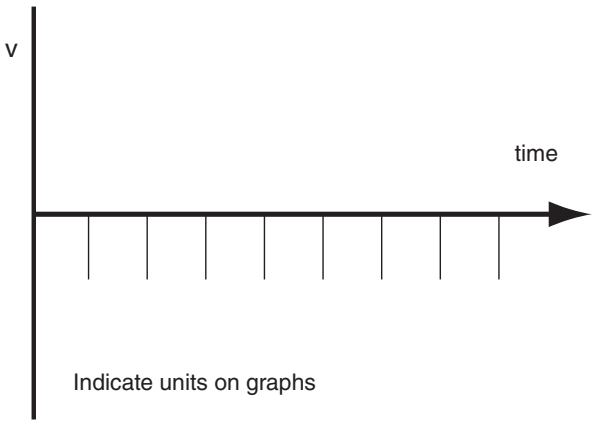
City: _____ State: _____ Zip Code: _____

Phone: _____ Fax: _____

Contact: _____ Title: _____

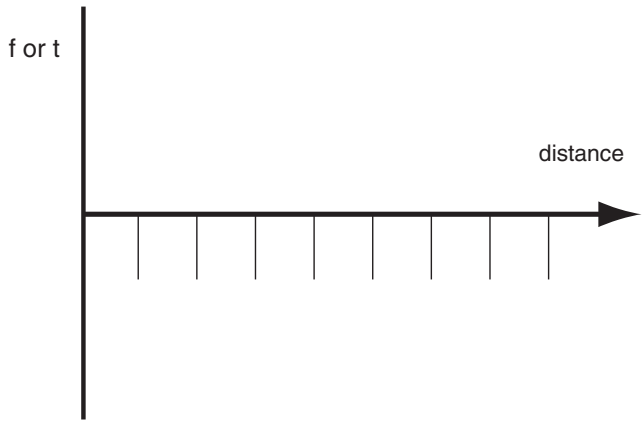
Sketch/Describe Application

Velocity vs. Time



Indicate units on graphs

Force or Torque vs. Distance



Exlar Application Worksheet

Date: _____ Contact: _____ Company: _____

Stroke & Speed Requirements

Maximum Stroke Needed	_____	inches (mm), revs
Index Stroke Length	_____	inches (mm), revs
Index Time	_____	sec
Max Speed Requirements	_____	in/sec (mm/sec), revs/sec
Min Speed Requirements	_____	in/sec (mm/sec), revs/sec
Required Positional Accuracy	_____	inches (mm), arc min

Load & Life Requirements

Gravitational Load	_____	lb (N)
External Applied Load	_____	lbf (N)
Inertial Load	_____	lbf (N)
Friction Load	_____	lbf (N)
Rotary Inertial Load	_____	lbf-in-sec^2 (Kg-m^2)
or rotary mass, radius of gyr. lb (kg)	_____	in (mm)
Side Load (rot. or lin. actuator)	_____	lb (N)

Force Direction _____ Extend _____ Retract _____ Both

Actuator Orientation _____ Vertical Up _____ Vertical Down _____ Horizontal

_____ Fixed Angle _____ Degrees from Horizontal

_____ Changing Angle _____ to _____

Cycling Rate	_____	Cycles/min/hr/day
Operating Hours per Day	_____	Hours
Life Requirement	_____	Cycles/hr/inches/mm

Configuration

Mounting: _____ Side _____ Flange _____ Ext Tie Rod _____ Clevis _____ Trunnion

Rod End: _____ Male _____ Female _____ Sph Rod Eye _____ Rod Eye _____ Clevis

Rod Rotation Limiting: _____ Appl Inherent _____ External Required

Holding Brake Required: _____ Yes _____ No

Cable Length: _____ ft (m)

Rotary Inertia To obtain a conversion from A to B, multiply by the value in the table.

B	Kg-m²	Kg-cm²	g-cm²	kgf-m-s²	kgf-cm-s²	gf-cm-s²	oz-in²	ozf-in-s²	lb-in²	lbf-in-s²	lb-ft²	lbf-ft-s²
A												
Kg-m²	1	10^4	10^7	0.10192	10.1972	$1.01972x10^4$	$5.46745x10^4$	$1.41612x10^2$	$3.41716x10^3$	8.850732	23.73025	0.73756
Kg-cm²	10^{-4}	1	10^3	$1.01972x10^5$	$1.01972x10^3$	1.01972	5.46745	$1.41612x10^{-2}$	0.341716	$8.85073x10^{-4}$	$2.37303x10^{-3}$	$7.37561x10^{-5}$
g-cm²	10^{-7}	10^{-3}	1	$1.01972x10^{-8}$	$1.01972x10^{-6}$	$1.01972x10^{-3}$	$5.46745x10^{-3}$	$1.41612x10^{-5}$	$3.41716x10^{-4}$	$8.85073x10^{-7}$	$2.37303x10^{-6}$	$7.37561x10^{-8}$
kgf-m-s²	9.80665	$9.80665x10^4$	$9.80665x10^7$	1	10^2	10^5	$5.36174x10^5$	$1.388674x10^3$	$3.35109x10^4$	86.79606	$2.32714x10^2$	7.23300
kgf-cm-s²	$9.80665x10^{-2}$	$9.80665x10^2$	$9.80665x10^5$	10^{-2}	1	10^5	$5.36174 x10^3$	13.8874	$3.35109x10^{-2}$	0.86796	2.32714	$7.23300x10^{-2}$
gf-cm-s²	9.80665x10-5	0.980665	$9.80665x10^2$	10^{-5}	10^{-3}	1	5.36174	$1.38874 x10^{-2}$	0.335109	$8.67961x10^{-4}$	$2.32714x10^{-3}$	$7.23300x10^{-5}$
oz-in²	$1.82901x10^{-5}$	0.182901	$1.82901x10^2$	$1.86505x10^{-6}$	$1.86505x10^{-4}$	0.186506	1	$2.59008 x10^{-3}$	$6.25 x10^{-2}$	$1.61880x10^{-4}$	$4.34028x10^{-4}$	$1.34900x10^{-3}$
oz-in-s²	$7.06154x10^{-3}$	70.6154	$7.06154x10^4$	$7.20077x10^4$	$7.20077x10^{-2}$	72.0077	$3.86089x10^2$	1	24.13045	$6.25 x10^{-2}$	0.167573	$5.20833x10^{-4}$
lb-in²	$2.92641x10^{-4}$	2.92641	$2.92641x10^3$	$2.98411x10^5$	$2.98411x10^3$	2.98411	16	$4.14414 x10^2$	1	$2.59008x10^{-3}$	$6.94444x10^{-3}$	$2.15840x10^{-4}$
lbf-in-s²	0.112985	$1.129x10^3$	$1.12985x10^6$	$1.15213x10^2$	1.15213	$1.51213 x10^3$	$6.1774 x10^3$	16	$3.86088x10^2$	1	2681175	$8.3333x10^{-2}$
lbf-ft²	$4.21403x10^{-2}$	$4.21403x10^2$	$4.21403x10^5$	$4.29711x10^3$	0.429711	4.297114	$2.304 x10^3$	5.96755	144	0.372971	1	$3.10809x10^{-2}$
lbf-ft-s²	1.35583	$1.35582x10^4$	$1.35582x10^7$	0.138255	13.82551	$1.38255x10^4$	$7.41289x10^4$	192	$4.63306x10^3$	12	32.17400	1

Torque To obtain a conversion from A to B, multiply A by the value in the table.

B	N-m	N-cm	dyn-cm	Kg-m	Kg-cm	g-cm	oz-in	ft-lb	in-lb
A									
N-m	1	10^{-2}	10^7	0.109716	10.19716	$1.019716 x10^4$	141.6199	0.737562	8.85074
N-cm	102	1	10^5	$1.019716 x10^3$	0.1019716	$1.019716 x10^2$	1.41612	$7.37562 x10^{-3}$	$8.85074 x10^{-2}$
dyn-cm	10-7	10^{-5}	1	$1.019716 x10^{-8}$	$1.019716 x10^{-6}$	$1.019716 x10^{-3}$	$1.41612 x10^{-5}$	$7.2562 x10^{-8}$	$8.85074 x10^{-7}$
Kg-m	9.80665	$980665x10^2$	$9.80665 x10^7$	1	10^2	10^5	$1.38874 x10^3$	7.23301	86.79624
Kg-cm	9.80665x10-2	9.80665	$9.80665 x10^5$	10^{-2}	1	10^3	13.8874	$7.23301 x10^{-2}$	0.86792
g-cm	9.80665x10-5	$9.80665x10^{-3}$	$9.80665 x10^2$	10^{-5}	10^{-3}	1	$1.38874 x10^{-2}$	$7.23301 x10^{-5}$	$8.679624 x10^{-4}$
oz-in	7.06155x10-3	0.706155	$7.06155 x10^4$	$7.20077 x10^{-4}$	$7.20077 x10^{-2}$	72,077	1	$5.20833 x10^{-3}$	$6.250 x10^{-2}$
ft-lb	1.35582	$1.35582x10^2$	$1.35582 x10^7$	0.1382548	13.82548	$1.382548 x10^4$	192	1	12
in-lb	0.113	11.2985	$1.12985 x10^6$	$1.15212 x10^{-2}$	1.15212	$1.15212 x10^3$	16	$8.33333 x10^{-2}$	1

Common Material Densities

Material	oz/in³	gm/cm³
Aluminum (cast or hard drawn)	1.54	2.66
Brass (cast or rolled)	4.80	8.30
Bronze (cast)	4.72	8.17
Copper (cast or hard drawn)	5.15	8.91
Plastic	0.64	1.11
Steel (hot or cold rolled)	4.48	7.75
Wood (hard)	0.46	0.80
Wood (soft)	0.28	0.58

Coefficients of Sliding Friction

Materials in contact	μ
Steel on Steel (dry)	0.58
Steel on Steel (lubricated)	0.15
Aluminum on Steel	0.45
Copper on Steel	0.36
Brass on Steel	0.44
Plastic on Steel	0.20
Linear Bearings	0.001

Standard Ratings for Exlar Actuators

The standard IP rating for Exlar Actuators is IP54S or IP65S. Ingress protection is divided into two categories: solids and liquids.

For example, in IP65S the three digits following "IP" represent different forms of environmental influence:

- The first digit represents protection against ingress of solid objects.
- The second digit represents protection against ingress of liquids.
- The suffix digit represents the state of motion during operation.

Digit 1 - Ingress of Solid Objects	
The IP rating system provides for 6 levels of protection against solids.	
1	Protected against solid objects over 50 mm e.g. hands, large tools.
2	Protected against solid objects over 12.5 mm e.g. hands, large tools.
3	Protected against solid objects over 2.5 mm e.g. large gauge wire, small tools.
4	Protected against solid objects over 1.0 mm e.g. small gauge wire.
5	Limited protection against dust ingress.
6	Totally protected against dust ingress.

Digit 2 - Ingress of Liquids	
The IP rating system provides for 9 levels of protection against liquids.	
1	Protected against vertically falling drops of water or condensation.
2	Protected against falling drops of water, if the case is positioned up to 15 degrees from vertical.
3	Protected against sprays of water from any direction, even if the case is positioned up to 60 degrees from vertical.
4	Protected against splash water from any direction.
5	Protected against low pressure water jets from any direction. Limited ingress permitted.
6	Protected against high pressure water jets from any direction. Limited ingress permitted.
7	Protected against short periods (30 minutes or less) of immersion in water of 1m or less.
8	Protected against long durations of immersion in water.
9	Protected against high-pressure, high-temperature wash-downs.

Suffix			
S	Device standing still during operation	M	Device moving during operation

Notes

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1. OFFER AND ACCEPTANCE: These terms and conditions constitute Seller's offer to Buyer and acceptance by Buyer and any resulting sale is expressly limited to and conditioned upon Seller's terms and conditions as set forth below. If Buyer objects to any of Seller's terms and conditions, such objections must be expressly stated and brought to the attention of Seller in a written document which is separate from any purchase order or other printed form of Buyer. Such objections, or the incorporation of any additional or different terms or conditions by Buyer into a resulting order shall constitute non-acceptance of these Terms and Conditions, releasing Seller from any obligation or liability hereunder and a proposal for different terms and conditions which shall be objected to by Seller unless expressly accepted in writing by an authorized representative of Seller. Acknowledgment copy, if any, shall not constitute acceptance by Seller of any additional or different terms or conditions, nor shall Seller's commencement of effort, in itself, be construed as acceptance of an order containing additional or different terms and conditions.

2. PRICES: Published prices and discount schedules are subject to change without notice. They are prepared for the purpose of furnishing general information and are not quotations or offers to sell on the part of the company.

3. TRADE TERMS: Shipment terms are FCA, shipping point (Exlar, Chanhassen, MN). FCA (Free Carrier) per Incoterms 2010 means the Seller delivers the goods, cleared for export into the custody of the first carrier named by the buyer at the named place, above. This term is suitable for all modes of transport, including carriage by air, rail, road, and containerized/multi-modal transport. Title of the merchandise transfers from Exlar Corporation to the Buyer when it is received from Exlar by the carrier. Where allowable, Exlar will arrange the transportation via the carrier specified by the Buyer. The Buyer is responsible for all costs associated with the shipment.

4. PAYMENT TERMS: Subject to approval of Buyer's credit, the full net amount of each invoice is due and payable in cash within thirty (30) days of shipment. No payment discounts are offered, and minor inadvertent administrative errors contained in an invoice are subject to correction and shall not constitute reason for untimely payment. If, in the judgment of the Seller, the financial credit of Buyer at any time does not justify continuance of production or shipment of any product(s) on the payment terms herein specified, Seller may require full or partial payment prior to completion of production or shipment, or may terminate any order, or any part thereof, then outstanding. Custom products and blanket orders are subject to payment terms: 30% due at time of order, 70% due net 30 days from shipment.

5. MINIMUM BILLING: Minimum billing will be $50.00.

6. DELAYS: Exlar shall not be liable for any defaults, damages or delays in fulfilling any order caused by conditions beyond Seller's control, including but not limited to acts of God, strike, lockout, boycott, or other labor troubles, war, riot, flood, government regulations, or delays from Seller's subcontractors or suppliers in furnishing materials or supplies due to one or more of the foregoing clauses.

7. CANCELLATIONS: All cancelled orders for standard products are subject to order cancellation charges. The minimum cancellation charge will be 20% of the order total. Standard products, if unused may be returned in accordance with the current return policy. All returns are subject to prior approval by Exlar, and return charges may apply. No return credit for any product will be issued or authorized prior to evaluation of the product by Exlar. Custom product is not returnable. Orders for custom product are not cancelable.

8. QUANTITY PRICING AND BLANKET ORDER PRICING TERMS: Blanket order quantity pricing requires a complete delivery schedule for the volume being ordered, with all units scheduled to deliver within a 15 month period from the placement of the purchase order to the final scheduled shipment. Any requests to change the delivery schedule of a blanket order must be received in writing 60 days prior to the requested change. Failure to take delivery of the entire ordered volume will result in back charges equal to the difference in quantity price between the volume ordered and the volume received times the number of units received. A cancellation charge in accordance with the cancellation policy (item 7) will apply to any reduction in delivered volume from the original ordered quantity.

For orders receiving quantity discounts, but not as scheduled blanket orders, the same quantity pricing rules apply. Failure to take delivery of the entire quantity ordered will result in back charges equal to the difference in quantity price between the volume ordered and the volume received times the number of units received. Cancellation charges in accordance with the cancellation policy (item 7) will apply to any reduction in delivered volume from the original ordered quantity. For either blanket orders or quantity orders, in addition to any applicable cancellation charges, the customer is responsible for the value of any additional inventory allocated specifically to their order. Charges for this inventory will be invoiced in addition to cancellation charges, along with any back charges for quantity variance.

9. DESTINATION CONTROL STATEMENT: Exlar products, technology or software are exported from the United States in accordance with the Export Administration Regulations (EAR) or International Traffic in Arms Regulations (ITAR) as applicable. Diversion, transfer, transshipment or disposal contrary to U.S. law is prohibited.

10. EXPORT CONTROL AND SHIPMENT REGULATIONS: Purchaser agrees at all times to comply with all United States laws and regulations as well as International Trade Laws, as they may exist from time to time, regarding export licenses or the control or regulation of exportation or re-exportation of products or technical data sold or supplied to Distributor. Seller may terminate or suspend this order, without remedy, should the Purchaser become an entity identified on any US export denial listing. Products ordered may require authorization and/or validated export license from a U.S. government agency. Seller may terminate or suspend this order, without remedy, should a government agency approval be denied.

11. GOVERNING LAW AND VENUE: This order shall be governed by, and construed in accordance with the laws of the State of Minnesota, U.S.A. All disputes shall be resolved by a court of competent jurisdiction in the trial courts of Carver County, in the State of Minnesota.

12. ATTORNEY FEES: Reasonable attorney's fees and other expenses of litigation must be awarded to the prevailing party in an action in which a remedy is sought under this order.

13. NON-WAIVER: The failure by the Seller to require performance of any provision shall not affect the Seller's right to require performance at any time thereafter, nor shall a waiver of any breach or default of this Order constitute a waiver of any subsequent breach or default or a waiver of the provision itself.

14. MERGER AND INTEGRATION: These Terms and Conditions contain the entire agreement of the parties with respect to the subject matter of this order, and supersede all prior negotiations, agreements and understandings with respect thereto. Purchase orders may only be amended by a written document duly executed by buyer and seller.

15. INDEMNITY: Buyer agrees to indemnify, defend and hold harmless Exlar from any claims, loss or damages arising out of or related to Seller's compliance with Buyer's designs, specifications or instructions in the furnishing of products to Buyer, whether based on infringement of patents, copyrights, trademark or other right of others, breach of warranty, negligence, or strict liability or other tort.

WARRANTY AND LIMITATION OF LIABILITY: Products are warranted for two years from date of manufacture as determined by the serial number on the product label. Labels are generated and applied to the product at the time of shipment. The first and second digits are the year and the third and fourth digits represent the manufacturing week. Product repairs are warranted for 90 days from the date of the repair. The date of repair is recorded within the Exlar database and tracked by individual product serial number.

Exlar Corporation warrants its product(s) to the original purchaser and in the case of original equipment manufacturers, to their original customer to be free from defects in material and workmanship and to be made only in accordance with Exlar standard published catalog specifications for the product(s) as published at the time of purchase. Warranty or performance to any other specifications is not covered by this warranty unless otherwise agreed to in writing by Exlar and documented as part of any and all contracts, including but not limited to purchase orders, sales orders, order confirmations, purchase contracts and purchase agreements. In no event shall Exlar be liable or have any responsibility under such warranty if the product(s) has been improperly stored, installed, used or maintained, or if Buyer has permitted any unauthorized modifications, adjustments and/or repairs to such product(s). Seller's obligation hereunder is limited solely to repairing or replacing (at its opinion), at the factory any product(s), or parts thereof, which prove to Seller's satisfaction to be defective as a result of defective materials, or workmanship and within the period of time, in accordance with the Seller's stated product warranty (see Terms and Conditions above), provided, however, that written notice of claimed defects shall have been given to Exlar within thirty (30) days from the date of any such defect is first discovered. The product(s) claimed to be defective must be returned to Exlar, transportation prepaid by Buyer, with written specification of the claimed defect. Evidence acceptable to Exlar must be furnished that the claimed defects were not caused by misuse, abuse, or neglect by anyone other than Exlar.

Components such as seals, wipers, bearings, brakes, bushings, gears, splines, and roller screw parts are considered wear parts and must be inspected and serviced on a regular basis. Any damage caused by failure to properly lubricate Exlar products and/or to replace wear parts at appropriate times, is not covered by this warranty. Any damage due to excessive loading is not covered by this warranty.

The use of products or components under load such that they reach the end of their expected life is a normal characteristic of the application of mechanical products. Reaching the end of a product's expected life does not indicate any defect in material or workmanship and is not covered by this warranty.

Costs for shipment of units returned to the factory for warranty repairs are the responsibility of the owner of the product. Exlar will return ship all warranty repairs or replacements via UPS Ground at no cost to the customer.

For international customers, Exlar will return ship warranty repairs or replacements via UPS Expedited Service and cover the associated shipping costs. Any VAT or local country taxes are the responsibility of the owner of the product.

The foregoing warranty is in lieu of all other warranties (except as Title), whether expressed or implied, including without limitation, any warranty of merchantability, or of fitness for any particular purpose, other than as expressly set forth and to the extent specified herein, and is in lieu of all other obligations or liabilities on the part of Exlar.

Seller's maximum liability with respect to these terms and conditions and any resulting sale, arising from any cause whatsoever, including without limitation, breach of contract or negligence, shall not exceed the price specified of the product(s) giving rise to the claim, and in no event shall Exlar be liable under this warranty otherwise for special, incidental or consequential damages, whether similar or dissimilar, of any nature arising or resulting from the purchase, installation, removal, repair, operation, use or breakdown of the product(s) or any other cause whatsoever, including negligence.

The foregoing warranty shall also apply to products or parts which have been repaired or replaced pursuant to such warranty, and within the period of time, in accordance with Seller's stated warranty.

NO PERSON INCLUDING ANY AGENT OR REPRESENTATIVE OF EXLAR CORPORATION IS AUTHORIZED TO MAKE ANY REPRESENTATION OR WARRANTY ON BEHALF OF EXLAR CONCERNING ANY PRODUCTS MANUFACTURED BY EXLAR, EXCEPT TO REFER PURCHASERS TO THIS WARRANTY.