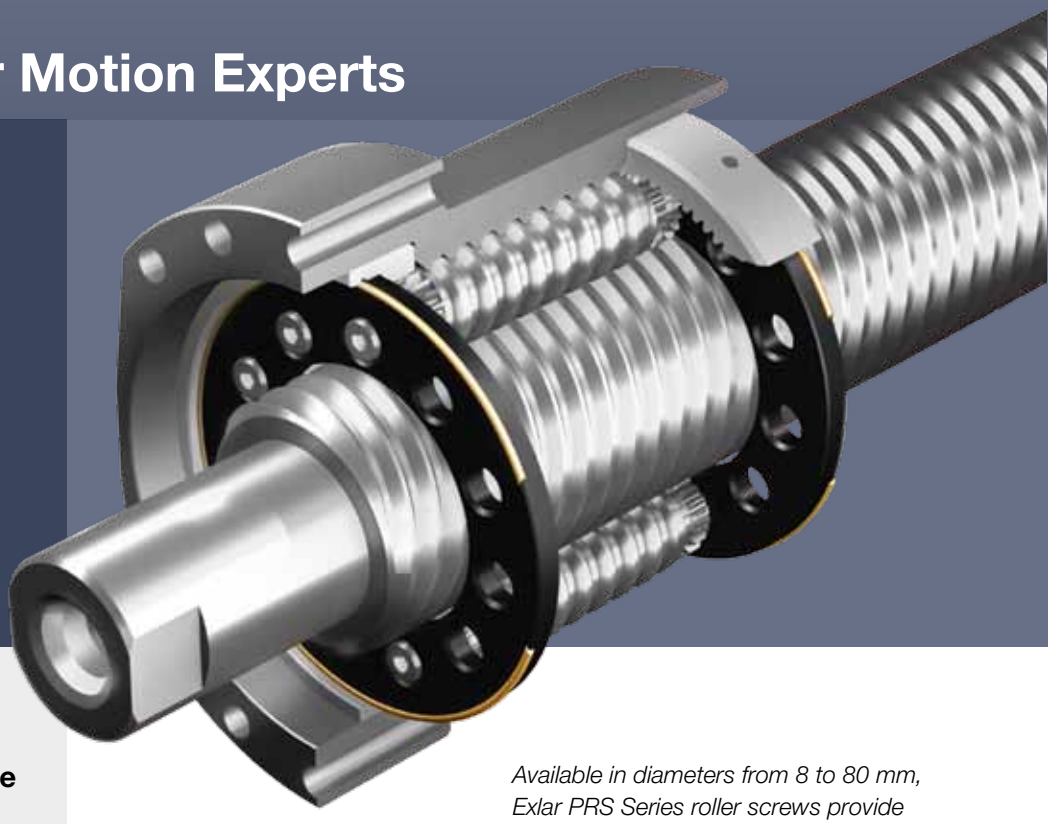
A superior alternative to hydraulic or pneumatic motion providing 15 times the life of a ball screw

Planetary Roller Screws

EXLAR

Exlar—Your Linear Motion Experts

Exlar Corporation is committed to providing innovative solutions to motion control problems through the use of roller screw technology. We offer a complete line of roller screw products designed to work faster, longer, smoother and more reliably than other technologies providing linear motion.



Available in diameters from 8 to 80 mm, Exlar PRS Series roller screws provide solutions to a wide range of applications—from the most compact and precise to the largest and extremely high load requirements.

The Roller Screw Advantage

A roller screw is a mechanism for converting rotary torque into linear motion, in a similar manner as acme screws or ball screws. However, unlike acme or ball screws, roller screws are capable of carrying heavy loads for thousands of hours in the most arduous conditions. This makes roller screws the ideal choice for demanding, continuous-duty environments.

- Roller screw design provides high speeds, stiffness and shock load resistance
- Static Load ratings to hundreds of thousands of pounds
- Up to 15 times longer life than comparably sized ball screws—ideally suited for continuous duty applications
- Roller screws can perform at rotational speeds above 5000 rpm
- Preloaded nut options for zero backlash
- Variety of flange designs
- Many other configurations are available to meet your application requirements

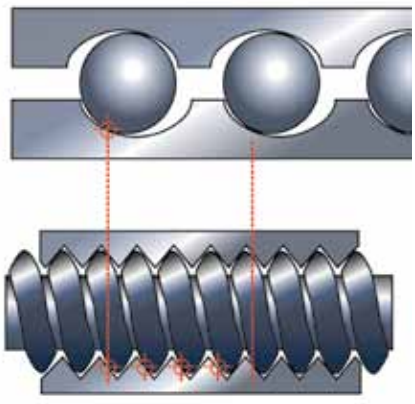
Superior Alternative to Hydraulic or Pneumatic Motion

In applications where high loads are anticipated or faster cycling is desired, Exlar's roller screw actuators provide an attractive alternative to the hydraulic or pneumatic options. Electro-mechanical units using roller screws have major advantages. They do not require a complex support system of valves, pumps, filters and sensors. Thus, Exlar units take up much less space and deliver extremely long working lives with virtually no maintenance. Hydraulic fluid leaks are non-existent. Noise levels are reduced significantly. Additionally, the flexibility of computer programmed positioning can be very desirable in many applications.

Planetary Roller Screws

Unique Design

This robust roller screw design is composed of rollers that are manufactured with precisely the same thread angle as the nut. This construction is particularly well-suited to applications that require very high loads and high speeds. This is possible because Exlar's planetary roller screw designs provide many more contact points than possible on comparably sized ball screws. The result is higher stiffness, higher load capacity and 15 times the travel life of similarly sized ball screws. The diagram below shows the number of contact points in a ball screw compared to the number of contact points in a roller screw.



Compare a similar size ball screw to Exlar's planetary roller screw design and see many more contact points on the roller screw. This results in higher load-carrying capacity and improved stiffness.

Typical Applications

Planetary roller screws are used in the most critical, demanding and precise applications requiring linear motion. Roller screws offer a perfect replacement for hydraulics because of the load and cycle capability. Examples of industries and applications for planetary roller screws include:

Medical Assembly
- Artificial Hearts
- Patient Positioning Tables
- Automated High-Force Syringes

Machine Tool
- Presses
- Broaching
- Grinding
- Dressing
- Cutting

Plastics, Glass and Textile
- Mold Closing
- Toggle Drives
- Eject Axes
- Transfers
- Shifting

Military
- Weapons Positioning
- Door Control
- Artillery Handling

Assembly
- Riveting
- Fastening
- Joining
- Clamping
- Part Positioning
- Weld Guns

Food and Beverage
- Volumetric Filling
- Paletizing
- Cartoning
- Sealing

Standard Features

- Available in two classes of screws (PRS, PRR)
- Non-recirculating rollers
- Available tolerance classes G5 (PRS) and G9 (PRR)
- Single nuts
- Three standard nut flanges
  (no flange, end flange, center flange)

In addition to these standard features and sizes (see tables on pages 4-5), Exlar can design a custom roller screw specifically tailored to your application. Please contact Exlar's Engineering Department for more information.

Planetary Roller Screw Specifications

Lead Accuracy

Exlar roller screws are grouped in tolerance classes according to DIN 69051, part 3. These manufacturing tolerances are expressed as lead errors per distance of linear travel, as shown below.

Tolerance Class	Lead Accuracy
G5	23 µm/300 mm (0.00096 in/ft)
G9	200 µm/1000 mm (0.0024 in/ft)

Refer to DIN69051 for more details on lead accuracy.

Lubrication

Exlar roller screws can be used with either grease or oil lubrication.

Grease Lubrication

Bearing greases of KP (DIN 51825, part 3) consistency factor of 2 should be used. Optional wipers can be installed on each end of the nut to protect it from contamination in dirty environments. Grease lubrication intervals depend on screw size and operating conditions. Exlar's Applications Engineering Department can provide grease lubrication recommendations for any application conditions.

Oil Lubrication

If oil lubrication is desired, a high performance gear oil with an EP additive is recommended. The oil lubrication rate is dependent on the screw diameter, number of rollers, and the amount of heat dissipated; oil consumption will generally range from about 1 to 30 ml/hr.

Immersion oil lubrication can also be used. In this case, the oil level must be such that the bottom-most roller is fully submerged in oil.

Backlash

Exlar single nut roller screws are ideal for applications where maximum life and minimal backlash are required. The single nuts have backlash limits of 0.01 - 0.03 mm (0004 - 0.001 inches).

PRS Series Planetary Roller Screw Specifications

Screw Diameter mm	Lead[1] mm (inch)	Dynamic Load Rating[2] kN (lbf)	Static Load Rating[3] kN (lbf)	Lead Accuracy
8	1.5 (0.05)	10 (2,248)	11.1 (2,495)	G5
12	5 (0.20)	10.5 (2,360)	18.1 (4,069)	
	10 (0.39)	6.2 (1,394)	12.5 (2,810)	
15	5 (0.20)	14.7 (3,300)	27.8 (6,250)	
	10 (0.39)	12.9 (2,900)	24.4 (5,485)	
20	5 (0.20)	37.1 (8,340)	64.0 (14,388)	
	10 (0.39)	42.9 (9,644)	61.9 (13,916)	
27	5 (0.20)	70.3 (15,804)	116.4 (26,168)	
	10 (0.39)	95.7 (21,514)	117.4 (26,393)	
30	5 (0.20)	90.7 (20,390)	147.5 (33,159)	
	10 (0.39)	88.1 (19,806)	150.6 (33,856)	
	20 (0.79)	106.7 (23,987)	153.8 (34,575)	
48	8 (0.31)	220.7 (49,615)	442.7 (99,523)	
	15 (0.59)	219.3 (49,301)	415.7 (93,453)	
60	6 (0.24)	257.7 (57,933)	474.9 (106,761)	
	12 (0.47)	221.3 (49,750)	510.8 (114,832)	
	30 (1.18)	284.5 (63,958)	530.5 (119,261)	
64	12 (0.47)	264.7 (59,507)	604.9 (135,987)	
80	6 (0.24)	399.8 (89,879)	738.9 (116,111)	
	12 (0.47)	374.0 (84,079)	968.5 (217,728)	
	30 (1.18)	426.9 (95,970)	954.6 (214,603)	

PRR Series Planetary Roller Screw Specifications

Screw Diameter mm	Lead[1] mm (inch)	Dynamic Load Rating[2] kN (lbf)	Static Load Rating[3] kN (lbf)	Lead Accuracy
12	5 (0.20)	7.3 (1,641)	12.7 (2,855)	G9
	10 (0.39)	8.3 (1,865)	15.7 (3,529)	
15	5 (0.20)	10.5 (2360)	19.5 (4,383)	
	10 (0.39)	13.9 (3,125)	25.3 (5,688)	
20	5 (0.20)	25.9 (5,822)	44.8 (10,071)	
	10 (0.39)	20.0 (4,496)	43.3 (9,734)	
27	5 (0.20)	49.2 (11,060)	81.5 (18,321)	
	10 (0.39)	67.0 (15,062)	82.2 (18,479)	

[1] Other custom leads may be available. Consult Exlar Applications Engineering for details.

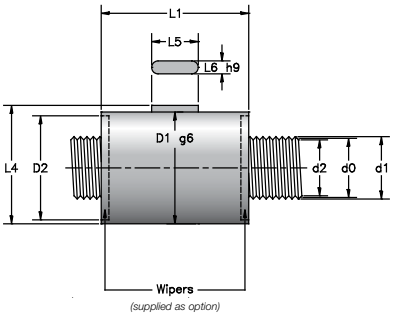
[2] Dynamic load rating is a constant used for life estimation and is not necessarily representative of the allowable loading of the screw.

[3] Static load rating is the maximum allowable load capacity of the nut under non-moving conditions. Recommended maximum application load of a screw is 0.25-0.33 of the static load rating.

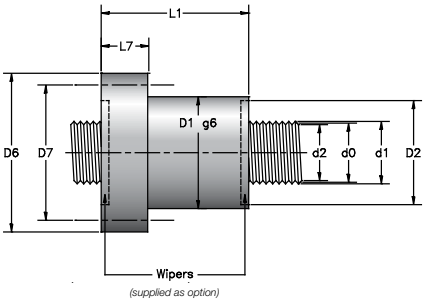
Nut Mating Types

Exlar roller screws are available in three types. Cylindrical (no flange) and end or central flange. Cylindrical nuts are designed to be captured in an abore, whereas flanged nuts are designed to attach to a mating flange on surface.

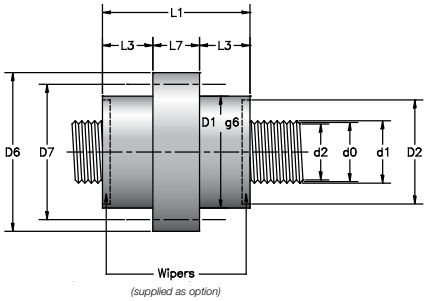
Cylindrical Nut with Key



End Flange



Center Flange



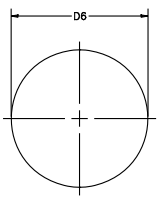
Dimensions

Dia/Lead mm	do	d1	d2	D1	D2	D5	D6	D7	L1[1]	L1[2]	L3	L4	L5	L6	L7	L8
8 x 1.5	8	8.09	7.89	21	19	4.8	41	31	31	41	14	22.3	10	3	13	24
12 x 5	12	12.35	11.56	26	23	4.8	46	36	31	41	14	27.3	10	3	13	28
12 x 10	12	12.63	11.36	26	23	4.8	46	36	31	41	14	27.3	10	3	13	28
15 x 5	15	15.32	15.56	34	30	5.8	56	45	35	51	16.5	35.7	14	4	18	36
15 x 10	15	20.76	19.24	34	30	5.8	56	45	35	51	16.5	35.7	14	4	18	36
20 x 5	19.5	19.83	19.02	42	39	5.8	64	53	55	65	22.5	43.7	20	4	20	44
20 x 10	19.5	20.04	18.62	42	39	5.8	64	53	55	65	22.5	43.7	20	4	20	44
20 x 15	20	20.76	19.24	42	39	5.8	64	53	55	65	22.5	43.7	20	4	20	44
27 x 5	27	27.28	26.49	53	50	7	83	68	65	79	23.5	55.2	20	5	22	55
27 x 10	27	27.52	25.96	53	50	7	83	68	65	79	23.5	55.2	20	5	22	55
30 x 5	30	30.37	29.56	62	58	9	92	77	71	85	29	64.7	20	6	27	64
30 x 10	30	30.49	28.99	62	58	9	92	77	71	85	29	64.7	20	6	27	64
30 x 20	30	30.49	28.99	62	58	9	92	77	71	85	29	64.7	20	6	27	64
48 x 8	48	48.40	47.35	99.86	80	11	122	104	113	127	46	88.7	45	6	35	88
48 x 15	48	48.90	46.84	99.99	89.97	13.5	150	127	113	127	45	103	45	8	37	102
60 x 6	60	60.37	59.56	110	100	13.5	150	130	106	124	47	113.2	40	8	30	112
60 x 12	60	60.67	59.05	110	100	13.5	150	130	106	124	47	113.2	40	8	30	112
60 x 30	60	61.24	58.25	110	100	13.5	150	130	106	124	47	113.2	40	8	30	112
64 x 12	64	64.68	63.06	115	106	13.5	180	150	118	129	45	8	45	8	40	117
80 x 6	80	80.37	79.56	138	130	13.5	180	160	130	158	61.5	141.7	50	10	35	140
80 x 12	80	80.74	79.12	138	130	13.5	180	160	130	158	61.5	141.7	50	10	35	140
80 x 30	80	81.53	77.48	138	130	13.5	180	160	130	158	61.5	141.7	50	10	35	140

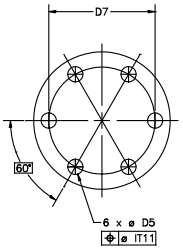
[1] Without wipers
[2] With wipers

Flange Hole Patterns

Standard Flange Dia.



Type 1



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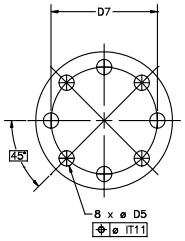
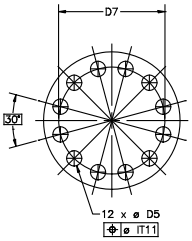


Type 3



Design Guidelines

Lifetime

The estimated 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:

Single (Non-preloaded) Nut:

$$L_{10} = \left(\frac{C}{F}\right)^3 \times S$$

Where:

L_{10} = Estimated travel life in millions of inches (mm)

C = Dynamic load rating, lbs (N)

F = Cubic mean applied load, (lbs lN)

S = Lead, in (mm)

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 manufactured are expected to meet or exceed. For higher than 90% reliability, the result should be multiplied 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 and these charts should be used for estimation purposes only.

All estimates represent properly lubricated and maintained actuators.

Mechanical Speed Limit

In addition to being dependent on screw length and mounting configuration, roller screw nut speeds also have a mechanical speed limit that must not be exceeded. The maximum mechanical nut speed for PRS or PRR models is 140,000/d_o rpm (d_o = nominal shaft diameter).

Critical Speed

The critical speed of a roller screw is dependent on the length of the screw and the type of bearing supporting the screw. The rotational speed of the roller screw should always be maintained below the critical speed, which is determined by the following relationship:

$$n_{crit} = \frac{86.4 \times 10^6 \, d_o f_s}{l^2}$$

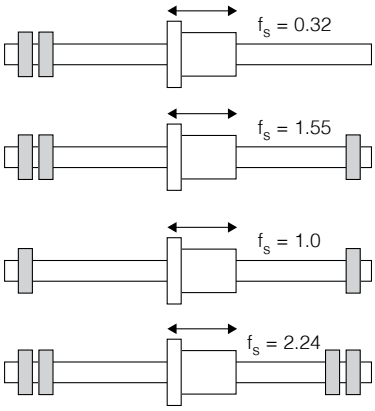
Where:

n_{crit} = critical rotational speed under zero axial load, rpm

d_o = Screw diameter, mm

f_s = Support bearing factor, from the figures below

l = Length of the screw, mm



Critical speeds are also reduced by compressive axial loads and increased by tensile loading. Consult Exlar's Applications Engineering Department for more information.

Linear Speed

The linear speed of the follower (nut) is a function of the rotational speed of the shaft and the lead of the roller screw. The linear speed of a follower is calculated by:

$$V - nS$$

Where:

V = Linear velocity, in/s (mm/s)

N = Follower rotational speed, rev/s

S = Screw lead, in (mm)

Buckling Force

Buckling of a roller screw can occur when the compressive load on the screw shaft becomes too great. Like critical speeds, the buckling force is a function of the screw length, diameter and the type of bearing supporting the screw. When sizing a roller screw, the application's maximum applied compressive load must be less than the buckling force. This buckling force is determined by:

$$F_b = \frac{81.3 \, f_b d_o^4}{l^2}$$

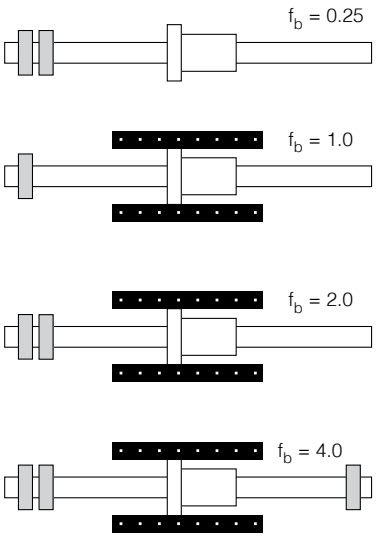
Where:

F_b = Buckling force, kN

f_b = Buckling force bearing factor, from the figures below

d_o = Screw diameter, mm

l = Length of the screw, mm



Torque

In order to size the appropriate motor for a given application, the required torque must be calculated. These numbers are then compared against the torque ratings of the motor/drive that will be used to control the roller screw's velocity and position. The load torque and the acceleration torque must both be less than the proposed motor's torque rating.

Under Load:

$$I = \frac{SF}{2\pi h}$$

Where:

I = Torque, lbf-in (Nm)

F = Applied load, lbf (N)

S = Screw lead, in (m)

h = Screw efficiency (71 - 90%)

Under Acceleration:

$$I = (I_1 + I_m)\, a$$

Where:

I = Torque, lbf-in (Nm)

I_1 = Reflected inertia due to load, as defined in the equation below, in-lb-s^2 (N-m-s^2)

I_m = Inertia of proposed motor's armature; obtain from motor specifications, in-lb-s^2 (N-m-s^2)

a = Acceleration of the motor, rad/S^2

Where:

$$I_1 = \frac{(S/2p)^2\, m}{g}$$

I_1 = Reflected inertia due to load, in-lb-s^2 (N-m-s^2)

S = Screw lead, in (m)

m = Mass of the applied load, lb (N)

g = Gravitational constant, 384 in/s^2 (9.75 m/s^2)

Sample Calculation

Application Information

- Cubic Mean Load = 500 lbf (2225 N)
- Max speed = 6 in/sec (152 mm/sec)
- Min time to max speed = 0.1 sec
- Stroke length = 18 in (457 mm)
- Required lifetime = 5 million inches (127 million mm)

Proposed PRS roller screw with the following specifications:

- Diameter = 0.79 in (20 mm)
- Lead = 0.1969 in (5 mm)
- Dynamic load rating = 7120 lb (31.7 kN)
- Non preloaded
- Screw supported by 2 bearings on one side; none on the other
- Nut performs no guidance function

Lifetime

$$L_{10} = \left(\frac{7120}{500}\right)^3 0.1969 = 568 \text{ million inches of travel}$$

Critical Speed

The application rotational speed must be less than both the critical and mechanical speed limits. The application's rotational speed is determined from the linear speed equation:

$$n = \left(\frac{152}{5}\right) 60 = 1824 \text{ rpm}$$

Using $f_s = 0.32$ from the figures on page 6, the critical speed is:

$$n_{crit} = \frac{86.4E6 \times 20 \times 0.32}{457^2} = 2648 \text{ rpm}$$

The mechanical speed limit, with oil cooling, is:

$$\frac{140{,}000}{20} = 7{,}000 \text{ rpm}$$

Buckling Force

The applied load of 500 lbf must be below the force required to buckle the screw. In this case $f_b = 0.25$:

$$F_b = \frac{81.3 \times 0.25 \times 20^4}{457^2} = 15.6\text{kN} = 3500 \text{ lbs}$$

Torque

Under load, the required torque is:

$I = 0.1969 \times 500/2 \times 3.14 \times 0.75 = 20.89$ lbf-in

An Exlar SLM090 motor with a continuous torque rating of 30 lbf-in may be appropriate. To determine if the proposed motor can accommodate the inertial load under acceleration (assume I_m for the SLM090 servo motor is 0.00058 in-lb-s^2; a = 1884 rad/sec^2), use the reflected inertia equation:

$$I_1 = \frac{(0.1969/2p)^2}{384} 500 = 0.0013 \text{ in-lb-s}^2;$$

$$\text{then } I = (0.00058 + 0.0013)\, 1884 = 3.54 \text{ in-lbs}$$

From the above calculations, the proposed roller screw with an SLM090 motor from Exlar will be acceptable under both constant velocity and acceleration for the given application conditions.

PRS/PRR Series Roller Screw Ordering Information

AAA-BCDE-FFF-GGHI-JJJJ-KKKK-00000

AAA = Roller Screw Type
PRS = High Capacity
PRR = Economy Capacity

B = Nut Type
1 = Single nut

C = Nut Flange Style
N = Standard nut; no flange
E = Standard nut; end flange
C = Standard nut; center flange
X = Non-standard nuts

D = Flange Hole Pattern
0 = No Flange
1 = Type 1
2 = Type 2
3 = Type 3
X = Special

E = Wipers
0 = No Wipers
W = Wipers installed at both nut ends

FFF = Screw Diameter
008 = 8mm (PRS)
012 = 12mm (PRS, PRR)
015 = 15mm (PRS, PRR)
020 = 20mm (PRS, PRR)
027 = 27mm (PRS, PRR
030 = 30mm (PRS)
048 = 48mm (PRS)
060 = 60mm (PRS)
064 = 64mm (PRS)
080 = 80mm (PRS)

GG = Screw Lead
01.5 = 1.5mm (8 mm dia)
05 = 5mm (12, 15, 20, 27, 30, mm dia)
06 = 6mm (60, 80 mm dia)
08 = 8mm (48mm dia)
10 = 10mm (12, 15, 20, 27, 30, mm dia)
12 = 12mm (60, 64, 80mm dia)
15 = 15mm (15, 20, 48 mm dia)
20 = 20mm (30mm dia)
25 = 25mm (27 mm dia)
30 = 30mm (60, 80mm dia)

H = Lead Direction
R = Right Hand

I = Lead Accuracy
5 = G5, PRS
9 = G9, PRR

JJJJ = Screw Length
Total Screw Length in millimeters

KKKK = Threaded Length
Total threaded length in millimeters

00000 = Part Number
Factory assigned PN for specific roller screw configuration

Headquartered at our manufacturing and motion control research center in suburban Minneapolis, MN, Exlar serves a global customer base with an extensive standard product line and complete engineering support for custom applications.

Exlar provides sales and support world-wide. To find your local representative, visit our website at www.exlar.com or call our headquarters at 952-500-6200.

Request a free copy of our literature by calling **952-500-6200** or download the pdf at **www.exlar.com**. In addition to the 2011 Product Catalog, brochures are available on Exlar's Tritex and Tritex II Actuators with Embedded Electronics, Extrak Rodless Actuators, and Roller Screws. Process control and defense industry brochures are also available.

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