nexen

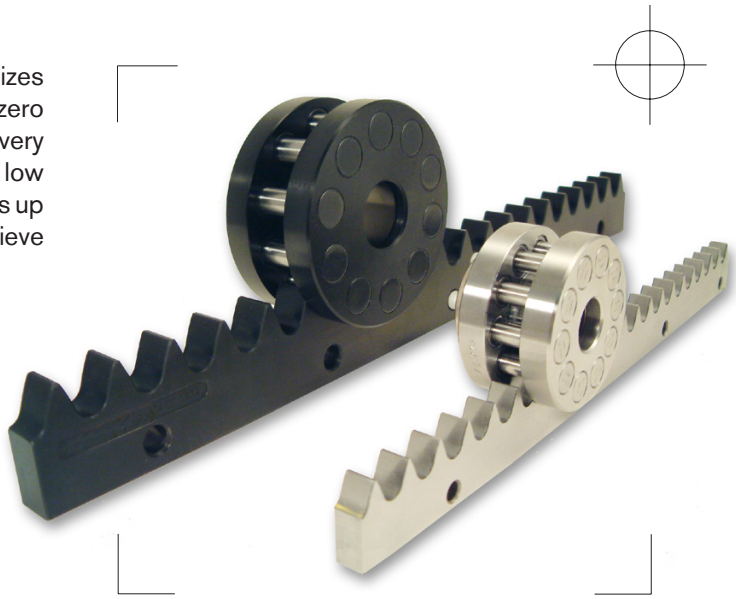
LINEAR MOTION CONTROL

Technical Data Sheet

Precision Roller Pinion System

Premium and Standard Models

Nexen offers an advanced new technology that revolutionizes linear motion. The Roller Pinion System (RPS) provides zero backlash, very high positional accuracy, unlimited length, very high speeds, 99% efficiency, high rigidity, low noise, low maintenance, corrosion resistance, and long life. This opens up new design possibilities and provides the capability to achieve much higher levels of performance in machine designs.



Precision Operation Maintains Accurate Positioning

The RPS line features an innovative rack and roller pinion technology that provides extremely accurate positioning. This design eliminates the cumulative error and thermal expansion error problems experienced with ball screw systems. The Roller Pinion System also offers backlash-free performance in both directions by maintaining opposing contact with two or more teeth at all times. This design eliminates the costly and complex split and dual pinion systems required by most traditional rack and pinion systems to achieve zero backlash.

Patented Tooth Design Ensures Quiet Operation

The RPS line is designed with bearing supported rollers that move smoothly along the face of each tooth. This reduces noise levels often associated with other linear motion systems like tooth slap or ball return noise.

Segmented Rack Provides Easy Integration and Unlimited Travel

Nexen offers the rack in standard segmented lengths, making it easy to accommodate your application requirements. Supplied in meter and half meter increments, length can also be custom cut as required. The basic system is comprised of just two parts, a rack and roller, making it easy to adapt to any application.

Rugged Design Capable of High Speeds

The Roller Pinion System maintains accurate positioning at speeds as high as 11 m/sec (36.1 ft/sec). Even at these speeds, the extremely-low friction design does not create heat or wear on components.

The Nexen Advantage

Surpasses the Limitations of Other Linear Motion Products

The RPS's unique design eliminates many of the limitations of current linear drive systems like:

Ball Screws: Limited by critical speed, maximum speed, cumulative error, vibration, thermal expansion, supplemental cooling, noise, low efficiency, maintenance, and life.

Traditional Rack and Pinion: Limited by low accuracy and speed, backlash, tooth fatigue, noise, high cost of dual and split pinion systems, high maintenance, and short life.

Belt Drives: Limited by low accuracy, backlash, low load capacity, short lengths, belt stretch, and low rigidity.

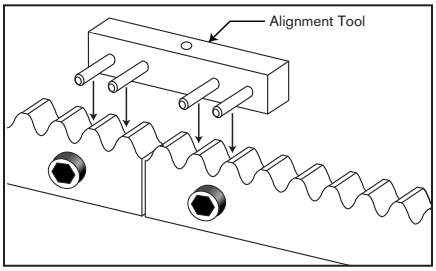
Linear Motors: Limited by low load capacity, high cost, strong magnetic fields, and liquid cooling.

Zero Backlash/High Precision

The RPS's innovative meshing action provides backlash of less than 3.2 um [0.00013 in.] and due to the extremely precise manufacturing process provides positional accuracy up to ± 20 um [± 0.00079 in.]. Each tooth profile is precisely measured relative to the first to ensure that high positional accuracy is maintained and cumulative error is eliminated.

Unlimited Run Lengths Possible

The RPS system is modular in design with 1 meter and 1/2 meter segments that can be combined as needed to meet your application requirements. Segments can also be cut to shorter lengths as needed. This greatly improves stocking, availability, cost, and replaceability. Segments are joined with a special tool that uses the rack teeth to transfer the positional accuracy of the previous rack to the next.



Speed

The RPS system can achieve speeds, up to 11 m/sec (36.1 ft/sec), that can normally only be obtained by linear motors while providing high positional accuracy. Ball screws speed capabilities are much lower and diminish with length.

Noise

Due to the smooth, backlash free way that the roller engages the teeth the RPS system is very quiet with 62 db at low speeds and 75 Db at full speed. This is much lower than ball screws with their recirculating ball paths, and traditional rack and pinions with their tooth slap, and more like belt drives and linear motors.

Maintenance/Life

The RPS system has very low maintenance. Typically lubrication is required every 2 million pinion revolutions or 6 six months. In special applications, the RPS can be run lubrication free with a small sacrifice in life.

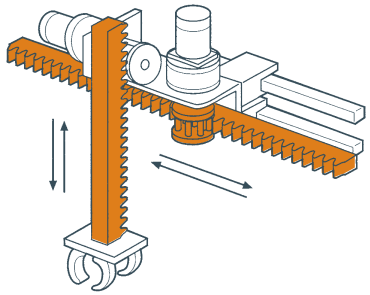
Surface Treatments

The RPS system is available with the Raydent surface treatment that provides stainless steel like performance without the high cost and low wear surface hardness. Raydent is not like typical blackening or other surface treatments that coat surfaces and rely on adhesion that can break down and flake off. Instead, Raydent is a cryogenic process that permeates the metal and permanently bonds with it forming an oxide ceramic surface layer 1 mm deep without adding any surface buildup. Raydent will not flake off and is highly resistant to acids, alkalies, and solvents. This surface treatment is standard on the Premium grade RPS and optional on the Standard grade RPS.

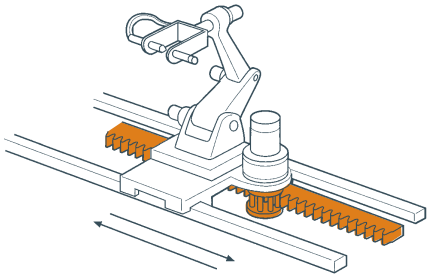
Grades

The RPS is available in two grades Standard and Premium. Both are zero backlash and share all of the same outstanding performance characteristics with the Premium Grade models offering the highest positional accuracy and Raydent coating at no extra cost.

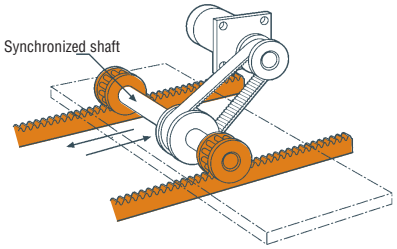
Applications



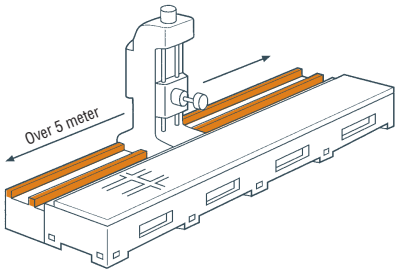
Gantry loader



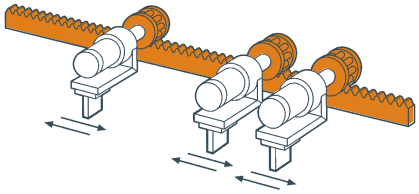
Long run robots



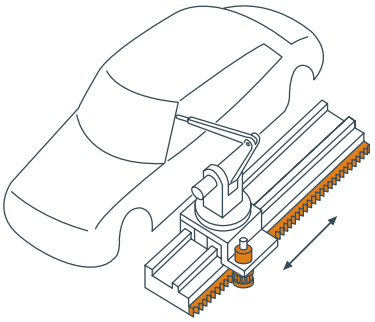
Synchronized feeding
(Maintain alignment of wide carriages)



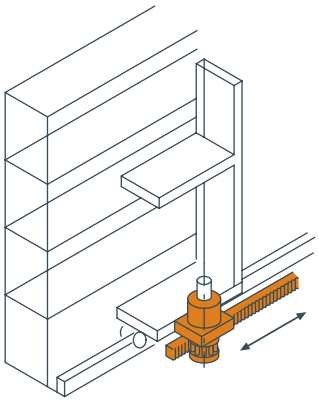
Long stroke machining tool



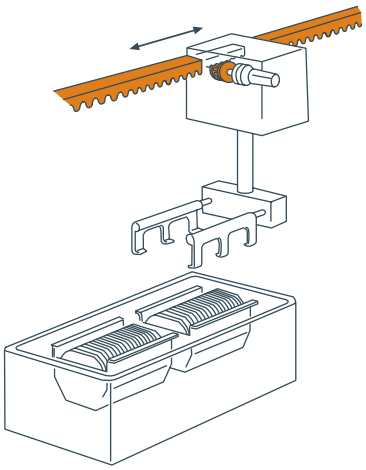
Multiple heads
〈 Applied to a slitter apparatus 〉



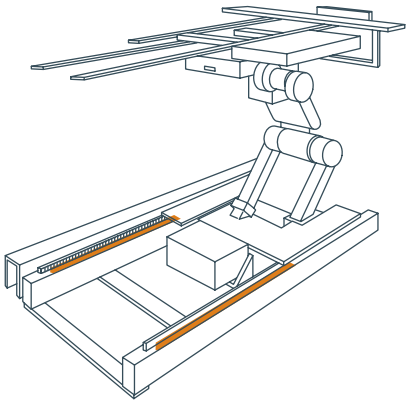
Measurement device



Stocker transfer



Semiconductor wafer transfer



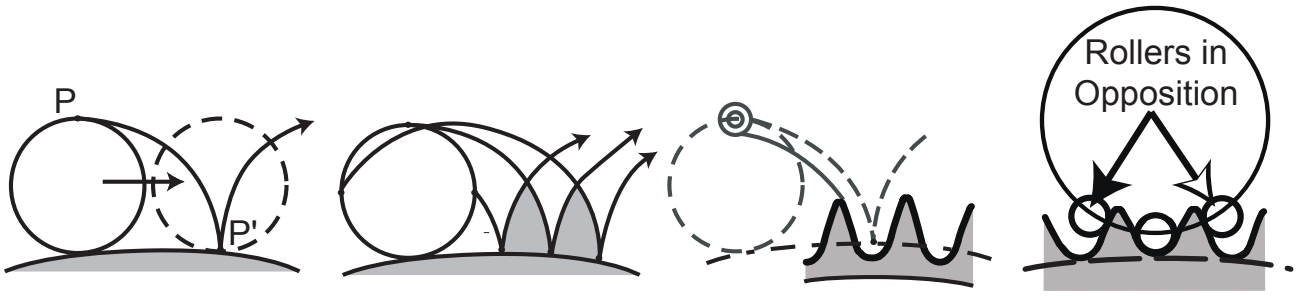
Robot transfer in clean room

How the RPS Works

The RPS system achieves its incredible performance by using a pinion consisting of bearing supported pins that engage a unique tooth profile. Two or more rollers engage the rack teeth in opposition at all times eliminating backlash. There is no tooth slap as with traditional rack and pinion, instead the RPS rollers approach the tooth face in a tangent path and then roll smoothly down the tooth face. This provides a smooth, quiet, low friction, fatigue free, high efficiency rotary to linear motion conversion.

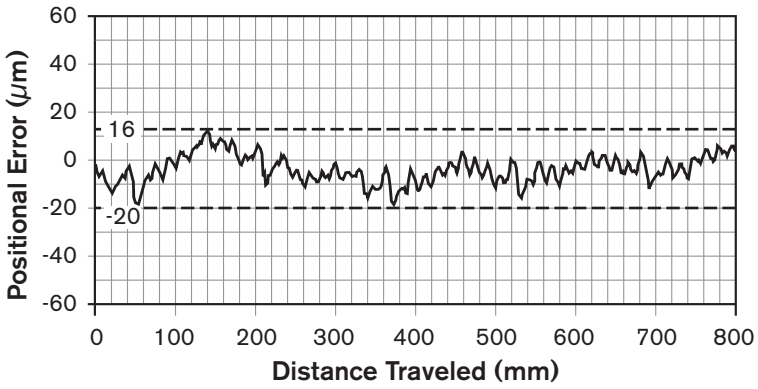
The RPS tooth design is conceptually different from traditional rack and pinion designs. It behaves like a cam and follower versus the typical sliding spur gear used with traditional rack and pinion. As illustrated in the figures below, a cycloidal curve is created when a point drawn on a circle at point “P” rolls on a flat plane without slipping. When multiple points are placed on the circle at regular intervals, the cycloidal curves are repeatedly created on the flat plane, and develop into a tooth like profile.

A roller then is placed at each point P to act as pinion teeth and modifies the tooth profile to create the rack teeth. Normally, this concept will not provide zero backlash, but a technical innovation was developed to modify the tooth geometry allowing two rollers to remain loaded in opposition at all times eliminating the backlash as the rollers engage the rack. As you can see, the rollers meet the rack smoothly and eliminate the tooth slap, sliding friction, fatigue, noise, and low precision associated traditional rack and pinion. Both the rollers and teeth are hardened for exceptionally long service lives.



PRECISION OPERATION ELIMINATES CUMULATIVE ERROR

The variations shown below represent minor errors occurring throughout the pinion’s travel. The small waves indicate meshing errors and larger wave patterns demonstrate pinion rotational error. As the horizontal limits demonstrate, there is no cumulative error. This pattern continues regardless of distance, even when crossing rack joints due to the way the RPS alignment tool sets the rack segment spacing.



Regardless of the distance traveled, positional accuracy remains constant with the RPS System.

Specifications

General Specifications

Common Specifications		RPS16		RPS20		RPS25		RPS32		RPS40		RPS4014	
Maximum Dynamic Thrust	N [lbf]	1000 [225]		1500 [337]		2200 [495]		3600 [809]		6000 [1349]		14000 [3147]	
Maximum Static Thrust	N [lbf]	2000 [450]		3000 [674]		4400 [990]		7200 [1618]		12000 [2698]		21000 [4721]	
Pressure Angle (Max)		30.7°		30.1°		30.7°		30.1°		30.0°		30.0°	
Module	mm [in]	4.8 [0.19]		6.0 [0.24]		7.5 [0.30]		9.5 [0.37]		12.0 [0.47]		12.0 [0.47]	
Maximum Speed	m/s [ft/s]	4 [13.1]		5 [16.4]		8 [26.2]		11 [36.1]		6 [19.7]		6 [19.7]	
System Life *	m [ft]	9,600,000 [31,496,000]		12,000,000 [39,370,000]		15,000,000 [49,230,000]		23,040,000 [75,590,000]		28,800,000 [94,480,000]		336,000,000 [1,102,200,000]	
Roller Pinion		**RPS16**		**RPS20**		**RPS25**		**RPS32**		**RPS40**		**RPS4014**	
Number of Rollers		10		10		10		12		12		14	
Maximum Dynamic Torque	Nm [in-lb]	25.5 [226]		47.7 [422]		88.0 [774]		220.0 [1946]		458.4 [4057]		1247.8 [11044]	
Maximum Static Torque	Nm [in-lb]	50.9 [450]		95.5 [884]		176.0 [1558]		440.0 [3894]		916.8 [8119]		1871.6 [16565]	
Linear Distance per Revolution	mm [in]	160 [6.3]		200 [7.9]		250 [9.8]		384 [15.1]		480 [18.9]		560 [22.1]	
Meshing Pitch Circle Diameter	mm [in]	50.9 [2.00]		63.7 [2.51]		79.6 [3.13]		121.7 [4.79]		152.7 [6.01]		178.3 [7.02]	
Bore Size	mm [in]	20 [0.79]		25 [0.98]		30 [1.18]		45 [1.77]		60 [2.36]		60 [2.36]	
Mass	kg [lb]	0.71 [1.57]		1.3 [2.87]		2.1 [4.63]		6.4 [14.11]		12.4 [27.34]		20.9 [46.08]	
Moment of Inertia	$kg\text{-}m^2$ $[lb\text{-}in^2]$	3.93×10^{-4} [1.34]		10.5×10^{-4} [3.59]		25.5×10^{-4} [8.71]		169×10^{-4} [57.80]		594×10^{-4} [203.00]		1180×10^{-4} [403.27]	
Rack		**RPS16**		**RPS20**		**RPS25**		**RPS32**		**RPS40**		**RPS4014**	
Rack Tooth Pitch	mm [in]	16 [.0630]		20 [0.787]		25 [0.984]		32 [1.260]		40 [1.575]		40 [1.575]	
Standard Lengths	mm [in]	512 [20.16]	992 [39.06]	500 [19.69]	1000 [39.37]	500 [19.69]	1000 [39.37]	512 [20.16]	992 [39.06]	520 [20.47]	1000 [39.37]	520 [20.47]	1000 [39.37]
Number of Teeth		32	62	25	50	20	40	16	31	13	25	13	25
Rack Mass	kg [lb]	1.1 [2.43]	2.1 [4.63]	2.1 [4.63]	4.1 [9.04]	2.7 [5.95]	5.4 [16.90]	4.2 [9.26]	8.2 [18.09]	6.9 [15.21]	13.2 [29.10]	8.8 [19.40]	17.0 [37.48]

* Life rating is an approximation based on maintaining published accuracy specifications and operated with allowable dynamic loading at a constant 100 rpm for 60,000,000 pinion revolutions (10,000 hours) over distances greater than 0.5 m [1.6 ft] and receiving recommended lubrication intervals while operated in a clean, dry, 20° C [68° F] environment. Application and environmental conditions, and lubrication intervals will impact expected product life. The RPS system will continue to operate beyond this point with deteriorating accuracy.

PRECISION ROLLER PINION SELECTION PROCESS

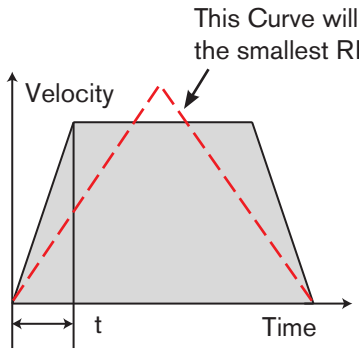
Proper RPS model size selection requires the application data listed below. These specifications are needed to determine: load mass, load acceleration, force due to acceleration, force due to gravity, force due to friction, and total force of the load. Sample calculations using both metric and imperial units are shown along with worksheet space to calculate your own application.

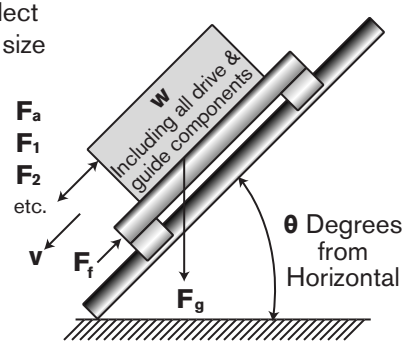
Friction Coefficient (μ)

Rolling Guide	0.005 ~ 0.02
Sliding Guide	0.1 ~ 0.2

Shock Factor* (K)

Shock-less Smooth Operation	1.0 ~ 1.2
Normal Operation	1.2 ~ 1.5
Operation with Impact	1.5 ~ 2.5





Required Specification for Proper RPS Selection	Customer Application Specifications		Metric Units (Examples on the next page)	Imperial Units (Examples on the next page)
Weight to be Driven** (W)	kg [lb]	Sample Data	226.8 kg	500 lb
Maximum Velocity (V)	m/s [ft/s]		0.91 m/s	3 ft/s
Acceleration Time (t)	seconds		0.5 s	0.5 s
Shock Factor (K) See table above			1.2	1.2
Other Forces *** (F_1), (F_2) etc.	N [lb]		0 N	0 lbf
Gravitational Acceleration **** (g)	9.81 m/s² [32.2 ft/s²]		9.81 m/s²	32.2 ft/s²
Frictional Coefficient (μ) See table above			0.01	0.01
Angle from Horizontal (θ°)	°		60°	60°

* ***Shock Factor*** indicates the smoothness of operation
** ***Weight to be Driven*** should include the servomotor, reducer, guide rail bearings, platform, etc. when applicable.
*** ***Other Forces*** may include springs, counter balances, fluid dampening systems, wind resistance etc.
**** ***Gravitational Acceleration*** is a constant value. Use 9.81 m/s² for metric applications and 32.2ft/s² for imperial appliations

General Application Information

Application Type	
Shaft Diameter	
Environmental Conditions	
Distance of Travel	
Cycles Per Day	
Required Positional Accuracy	
Other Application Data	

SELECTING AN RPS MODEL

If the acceleration and deceleration times are different or or there are other changes in velocity over the run, calculate the acceleration forces for each interval and use the highest one for RPS selection purposes. Compare the Total Force calculation to the Maximum Dynamic Force ratings in the Specifications table on page 3 to select the ideal RPS size. Verify maximum speed.

Calculations	Metric Worksheet with Example		Imperial Worksheet with Example	
Load Mass Metric: **m = w** Imperial: **m = w ÷ g**	**m** = kg		**m** = lb ÷ (ft/s²) = Slug	
	226.8 kg		500 lb ÷ 32.2 ft/s² = 15.5 Slug	
Load Acceleration **A = v ÷ t**	**A** = (m/s) ÷ s = m/s²		**A** = (ft/s) ÷ s = ft/s²	
	0.91 m/s ÷ 0.5 s = 1.8 m/s²		3.0 f t/s ÷ 0.5 s = 6.0 ft/s²	
Force Due to Acceleration **F_a = m • A**	**F_a** = kg • m/s² = N		**F_a** = Slug • ft/s² = lbf	
	226.8 kg • 1.8 m/s² = 408.2 N		15.5 Slug • 6.0 ft/s² = 93.0 lbf	
Force Due to Gravity **F_g = m • g • sin (θ°)**	**F_g** = kg • m/s² • sin (θ°) = N		**F_g** = Slug • ft/s² • sin (θ°) = lbf	
	226.8 kg • 9.81 m/s² • sin (60°) = 1926.8 N		15.5 Slug • 32.2 ft/s² • sin (60°) = 432.2 lbf	
Total Force with Shock Factor **F_S = K • Ft**	**F_S** = K • Ft = N		**F_S** = K • Ft = lbf	
	1.2 • 2346.1 N = 2815.3 N		1.2 • 527.7 lbf = 633.2 lbf	
Force Due to Friction **F_f = m • μ • g • cos (θ°)**	**F_f** = kg • **μ** • m/s² • cos (θ°) = N		**F_f** = Slug • **μ** • ft/s² • cos (θ°) = lbf	
	226.8 kg • 0.01 • 9.81 m/s² • cos (60°) = 11.1 N		15.5 Slug • 0.01 • 32.2 ft/s² • cos (60°)= 2.5 lbf	
Total Force of the Load **$F_t = F_a + F_g + F_f + F_1$**	**F_t = N + N + N + N** = N		**F_t = lbf + lbf + lbf + lbf** = lbf	
	408.2 N + 1926.8 N + 11.1 N + 0 N =	**2346.1 N**	93.0 lbf + 432.2 lbf + 2.5 lbf + 0 lbf =	**527.7 lbf**

The sample application requires an RPS32 which can accommodate a maximum total load force of 3600 N [809 lbf] (See SPECIFICATIONS Table).

Determine the applications speed and refer to the Maximum Speed listed in the Specifications table.

RPS32

SELECTING THE DRIVE MOTOR/REDUCER SIZE

Refer the calculations above and the SPECIFICATIONS Table to perform the following calculations:

Calculations	Metric Worksheet with Example	Imperial Worksheet with Example
Required Torque:	**F_t** • Meshing Pitch Circle Diameter ÷ 2000	**F_t** • Meshing Pitch Circle Diameter ÷ 2
	2346.1 N • 121.7 mm ÷ 2000 = 42.8 Nm	527.7 lbf • 4.79 in ÷ 2 = 263.8 in-lb
RPM:	60000 • **V** ÷ Linear Distance Per One Rotation	720 • **V** ÷ Linear Distance Per One Rotation
	60000 • 0.91 m/s ÷ 384 mm = 142.2 RPM	720 • 3 ft/s ÷ 15.1 in = 143.0 RPM
Motor Power Required* P = T • RPM ÷ Factor	T • RPM ÷ 9549 = Kw	T • RPM ÷ 63025 = Hp
	142.8 Nm • 142.2 RPM ÷ 9549 = 2.13 Kw	1263.8 inlb • 143.0 RPM ÷ 63025 = 2.9 Hp

* “Motor power is an estimate that does no include reduction inefficiencies or non-linear acceleration curves”

Specifications

	Premium Grade	Standard Grade
Transmitting Accuracy µm [in]	± 20 [0.00079]	± 50 [0.00197]
Meshing Error per Pitch µm [in]	20 [0.00079]	30 [0.00128]
Repetitive Positioning Precision µm [in]	10 [0.00039]	20 [0.00079]
Backlash µm [in]	Less than 3.2 [0.00013]	
Noise db	62 - 75*	
Operating Temperature Range C [F]	-5 to 40° [23 to 104°]**	

Specifications are with systems assembled to Nexen specifications and operated at 20°C [68° F]. Specifications are subject to variations due to drive and guiding system rigidity, installation accuracy, proper maintenance, and ambient temperature.

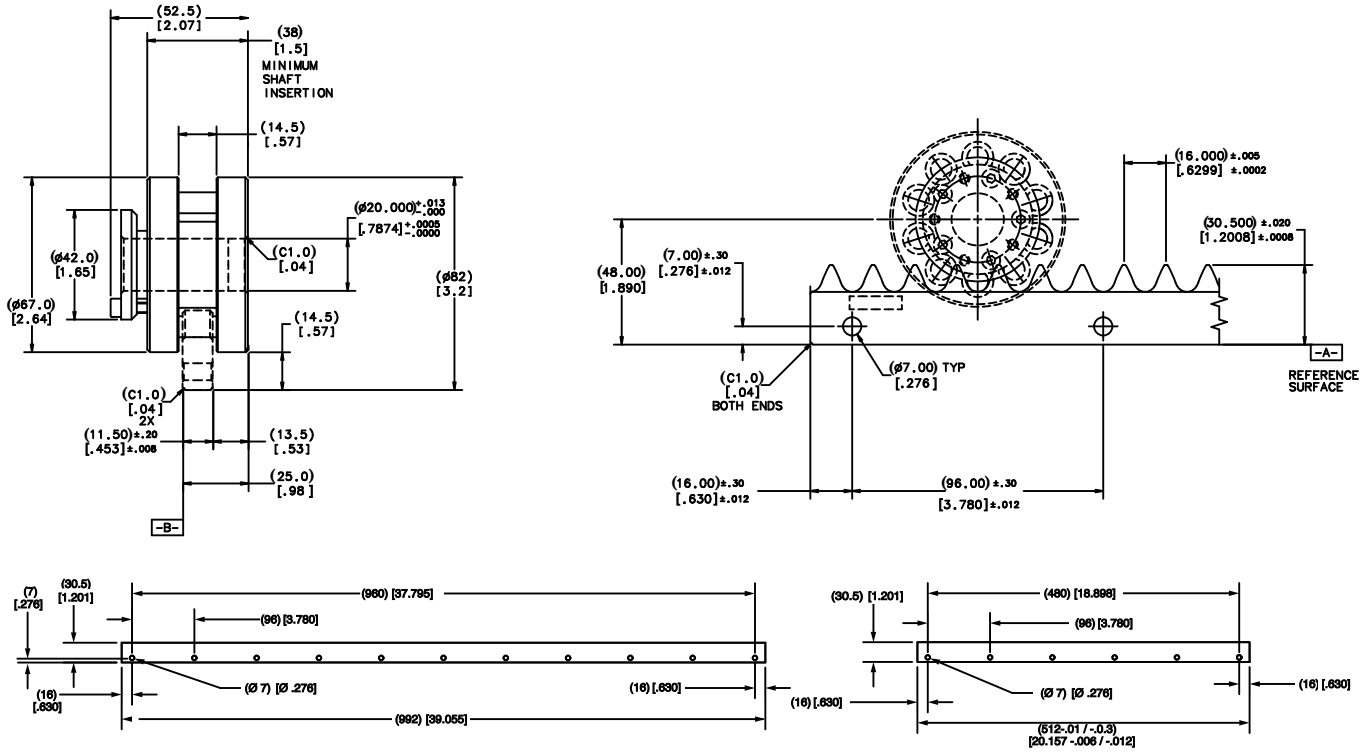
* Dependent on machine design and difficult to isolate from other drive and guiding component noise.
** For applications outside of this temperature range or with wide temperature swings contact Nexen.

Product Numbers

Model	Component		Product Number	
			Premium	Standard
RPS16	Roller Pinion	Bore: 20 mm [0.79 in]	966650	966600
	Rack Length	992 mm [39.06 in]	966651	966601
		512 mm [20.16 in]	966652	966602
	Alignment Tool		966503	966503
RPS20	Roller Pinion	Bore: 25 mm [0.98 in]	966660	966610
	Rack Length	1000 mm [39.37 in]	966661	966611
		500 mm [19.68 in]	966662	966612
	Alignment Tool		966513	966513
RPS25	Roller Pinion	Bore: 30 mm [1.18 in]	966670	966620
	Rack Length	1000 mm [39.37 in]	966671	966621
		500 mm [19.68 in]	966672	966622
	Alignment Tool		966523	966523
RPS32	Roller Pinion	Bore: 45 mm [1.77 in]	966680	966630
	Rack Length	992 mm [39.06 in]	966681	966631
		512 mm [20.16 in]	966682	966632
	Alignment Tool		966533	966533
RPS40	Roller Pinion	Bore: 60 mm [2.36 in]	966690	966640
	Rack Length	1000 mm [39.37 in]	966691	966641
		520 mm [20.47 in]	966692	966642
	Alignment Tool		966543	966543
RPS4014	Roller Pinion	Bore: 60 mm [2.36 in]	966693	966645
	Rack Length	1000 mm [39.37 in]	966694	966646
		520 mm [20.47 in]	966695	966647
	Alignment Tool		966543	966543

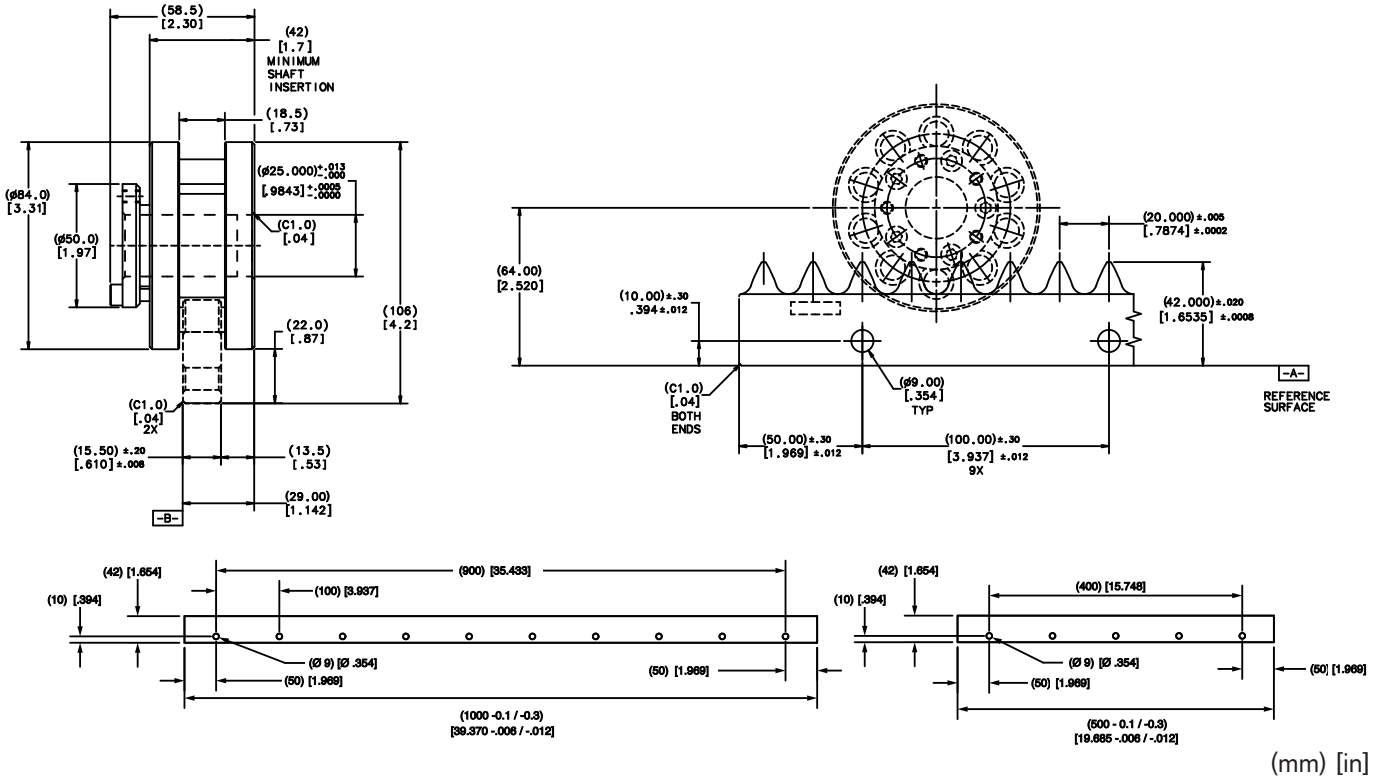
Dimensions

RPS16



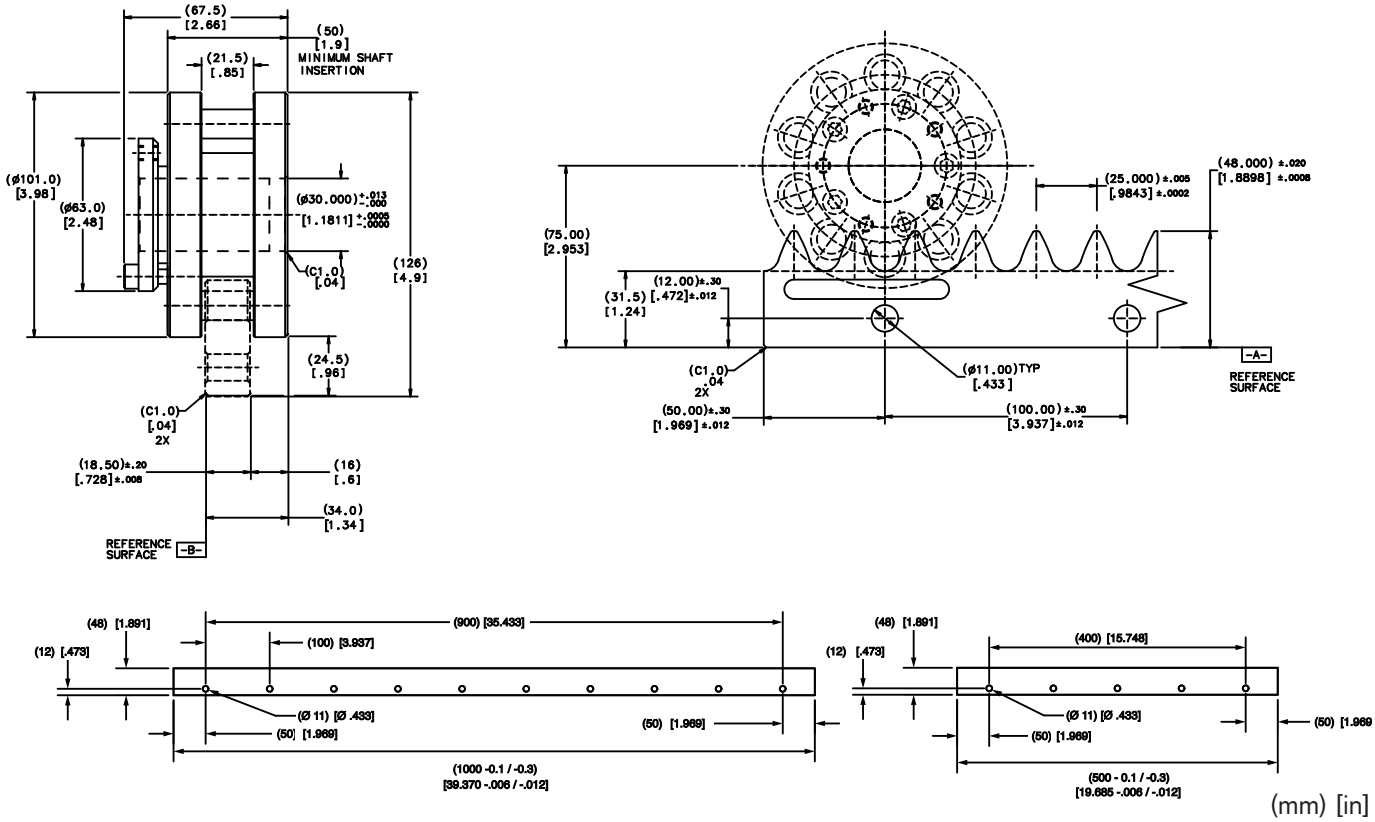
(mm) [in]

RPS20



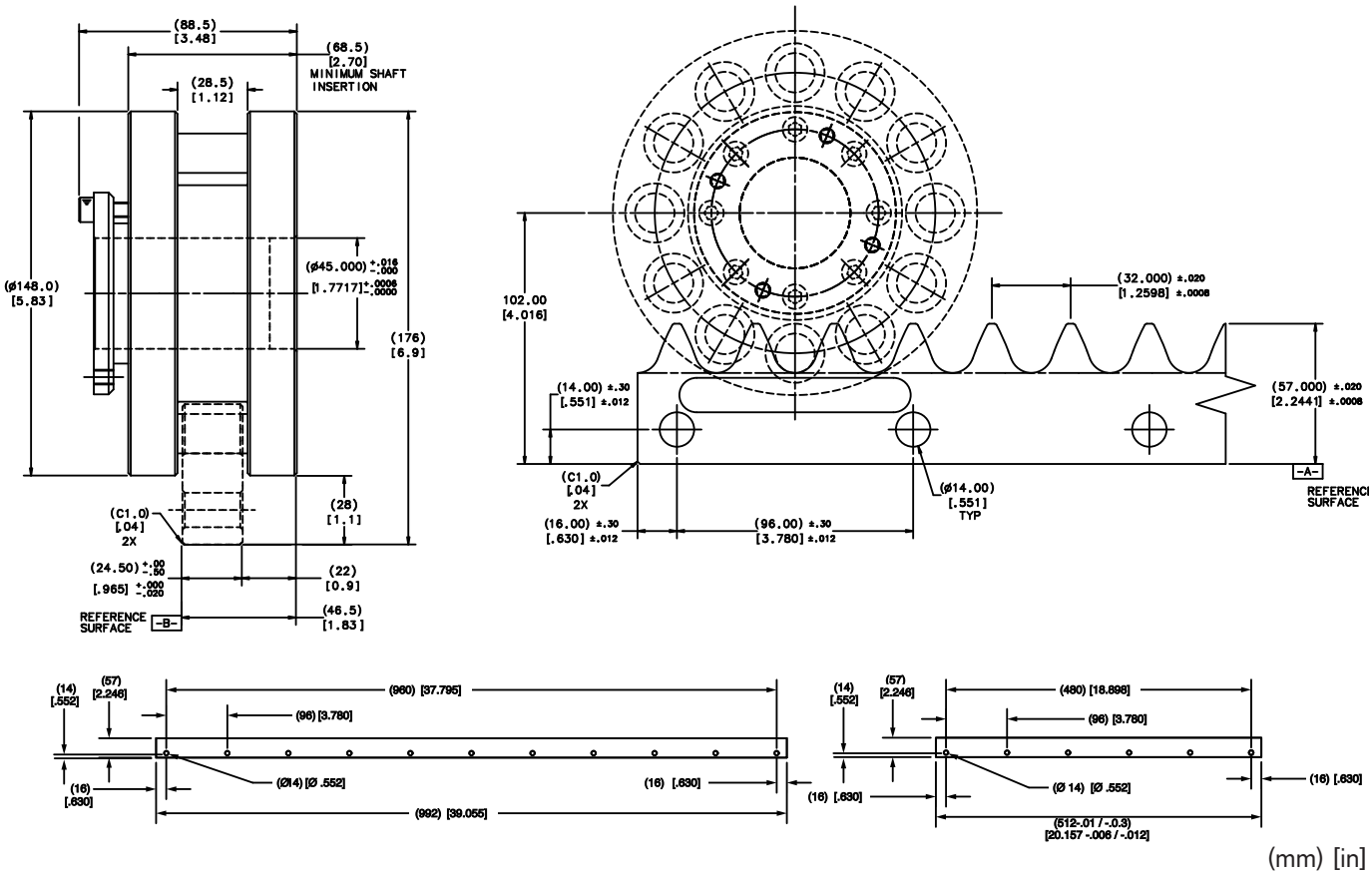
(mm) [in]

RPS25



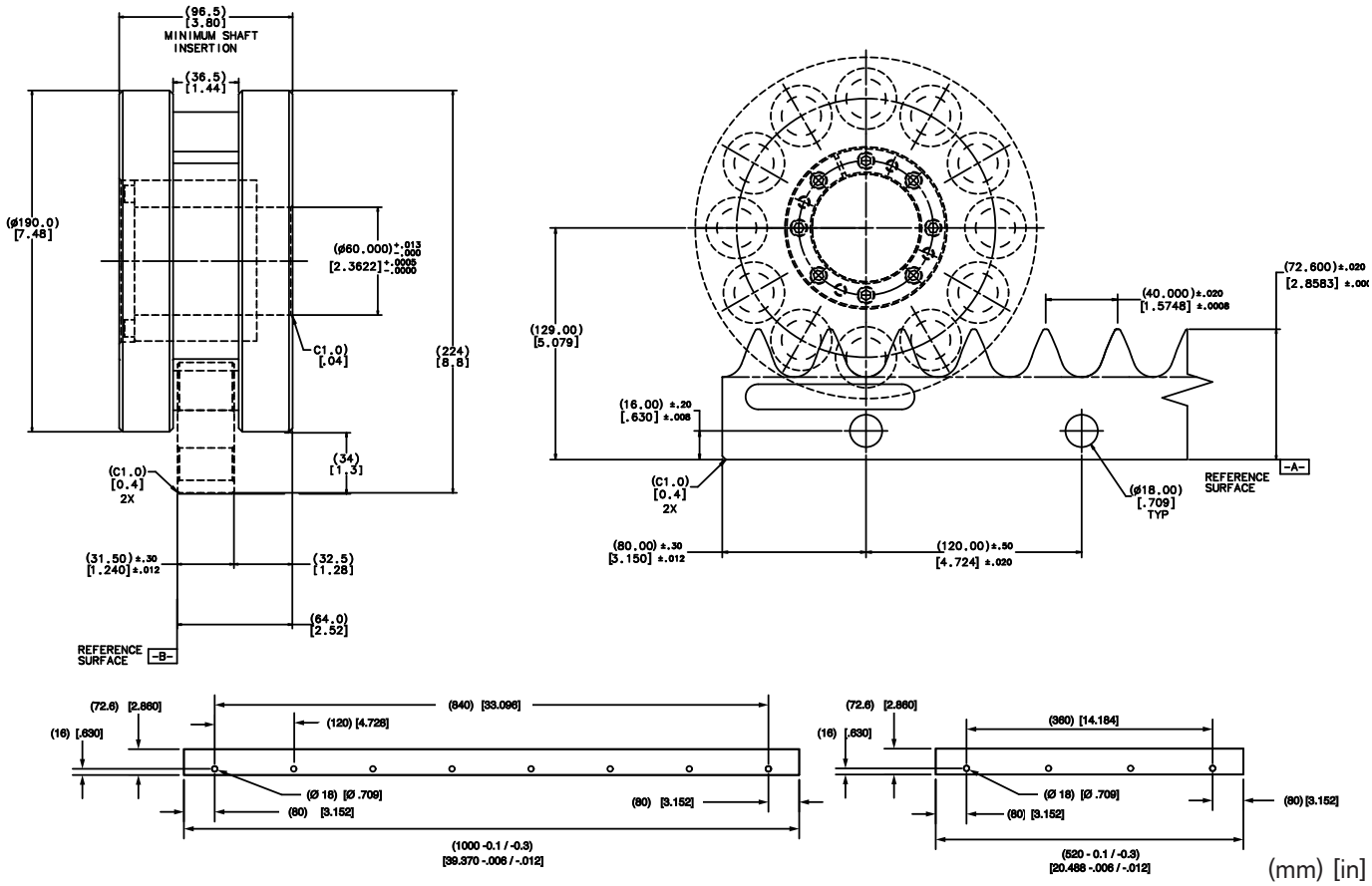
(mm) [in]

RPS32



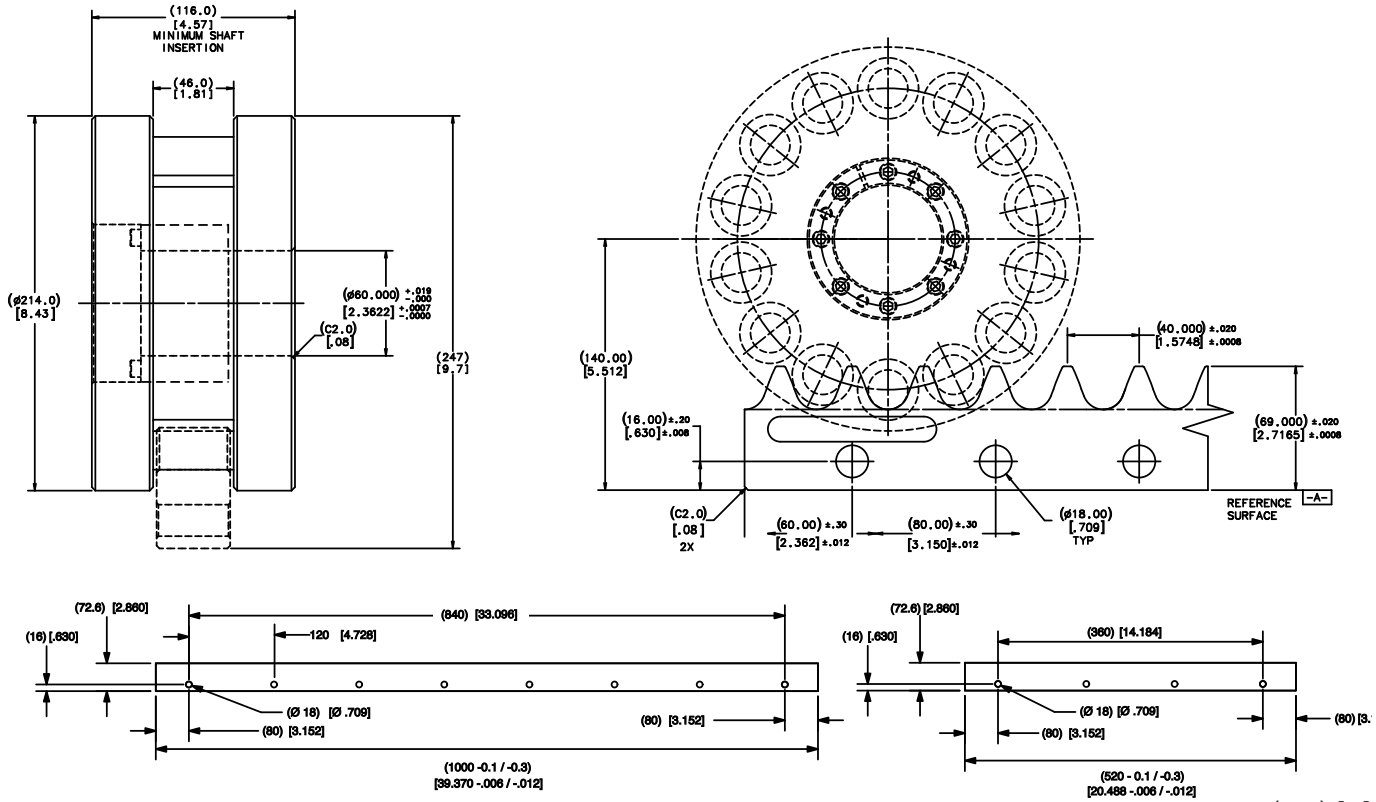
(mm) [in]

RPS40



(mm) [in]

RPS4014



(mm) [in]

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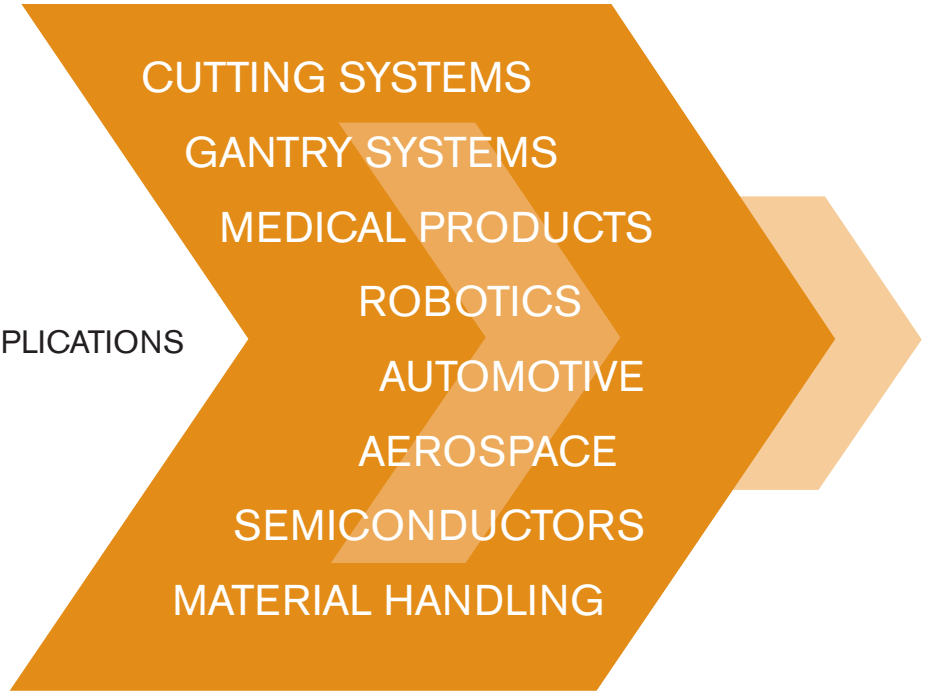

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For additional information and product specifications, please contact Allan Conway at the Nexen corporate office listed below.

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21238-B-0807