nexen

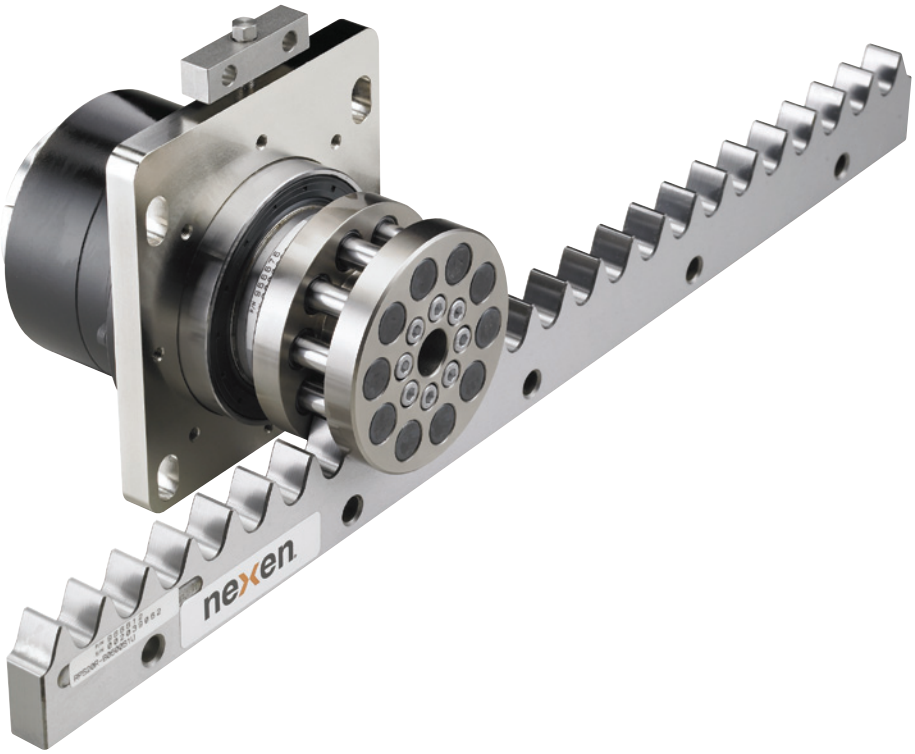
PRECISION MOTION CONTROL

THE ROLLER PINION SYSTEM

Application and Selection Guide

Index

Introducing Innovative, High-Performance, Motion Control Technology



The Roller Pinion System

Nexen offers an advanced technology that revolutionizes linear and rotary motion control. The Roller Pinion System (RPS) is based on an innovative pinion consisting of bearing-supported rollers and a unique tooth profile. This unique drive system provides very high positional accuracy, near-zero backlash, virtually no cumulative error, low-velocity ripple, unlimited length, very high speeds, high rigidity, low noise, low (in some cases no) maintenance, corrosion resistance, long life, and 99% efficiency. This opens up new machine design possibilities and provides the capability to achieve much higher levels of performance.

High Positional Accuracy

The RPS system is capable of positional accuracy up to ± 30 µm and repeatability of ± 5 µm at its meshing line or circle. Near-zero backlash of less than 3.2 µm is achieved by multiple rollers engaging the rack or gear teeth in opposition at all times. Due to the very high manufacturing precision of the RPS system and the special section joining tool, cumulative error is virtually nonexistent over any rack run length or segmented gear diameter. The RPS system also provides very low velocity ripple for applications where uniform motion is essential. This allows for high precision linear or rotary systems of any size that can rely on the servo encoder for positioning without the need for separate linear or rotary encoders in many applications. Unlike many other drive technologies, the RPS system's positional accuracy does not start to degrade progressively after a short time, but maintains its performance over its life until the pinion bearings reach the ends of their lives. In most applications the rack or gear life will far exceed the pinion life, allowing several pinion replacements restoring full rated system performance before needing replacement.

High Speeds

The Roller Pinion System is capable of speeds as high as 11 m/sec. Even at these speeds, the extremely low friction design does not create heat or significant wear on components.

High Rigidity

As machine performance increases, rigidity becomes more important. Unlike ballscrews with their long unsupported lengths, or traditional rack and pinion with their small teeth that flex, fatigue, and break out, the RPS's robust tooth and pinion design eliminate these issues allowing maximum performance.

The Nexen RPS Advantage

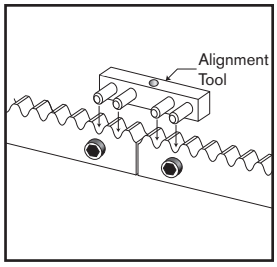
Long Life, Low Maintenance, and High Efficiency

The RPS system uses needle bearings to support the rollers that engage the teeth. This eliminates the sliding friction found in many other motion control systems and gives it an efficiency greater than 99%. This high efficiency means little is lost to friction, heat, and wear, providing a long life of 60,000,000 pinion revolutions (up to 36 million meters of travel). The rack or gear tooth life rating varies by product model, environmental conditions, and lubrication intervals. Typically the pinion can be replaced numerous times before the rack or gear will need replacement. In linear applications the rack can be run lubrication free if maximum speed is under 0.5 m/s and Premium or Endurance models of rack utilized with a small reduction in rack life. **This is a great advantage in:**

- Clean Environments such as food processing, pharmaceutical, coating, or clean room applications requiring low particle emissions.
- Dirty Environments such as wood processing, mining, or grinding where particles in the environment would be attracted to and mix with the rack lubrication, making an abrasive paste that can accelerate the wear rate.
- Inaccessible Applications where it is very difficult and/or hazardous to access machinery for periodic maintenance.

Modular System

Nexen offers the rack in standard meter and half-meter lengths that can also be cut as required. Standard product lengths make the RPS available for immediate shipment, eliminating the lead times required by other products, and make it easy for OEMs to keep a limited amount of product on hand while covering a wide range of applications. The rotary RPG system is available as solid rings up to 1.7 m diameter and segmented rings or arcs beyond this with no limits on the diameter possible. Rack and arc segments are joined with a special alignment tool that uses two tooth valleys on each section to minimize the introduction of positional inaccuracy. With these modular components, rack runs of any length can be easily created.



Low Noise

The pinion rollers approach the tooth face in a tangent path and then move smoothly along the face of each tooth. This reduces noise levels often associated with other motion control systems like tooth slap or ball return noise.

Product Options

The RPS rack is available in five models, Premium, Endurance, Standard, Universal, and Stainless Steel Universal. Each offers performance characteristics and price to suit a wide range of applications. Some pinion and rack models are available with corrosion resistant surface treatments and/or made from 17-4 stainless steel for difficult applications. Pinions are available in shaft mount with a keyless mechanical compression coupling or ISO 9409 flange mount versions for optimal machine design flexibility. The RPS ISO 9409 flange mount pinions make reducer selection and mounting easier, allows the use of Nexen pinion preloaders, and gives maximum system performance.

Overcomes the Limitations of Other Motion Control Technologies

The RPS's unique design eliminates many of the problems found in these other commonly used drive systems:

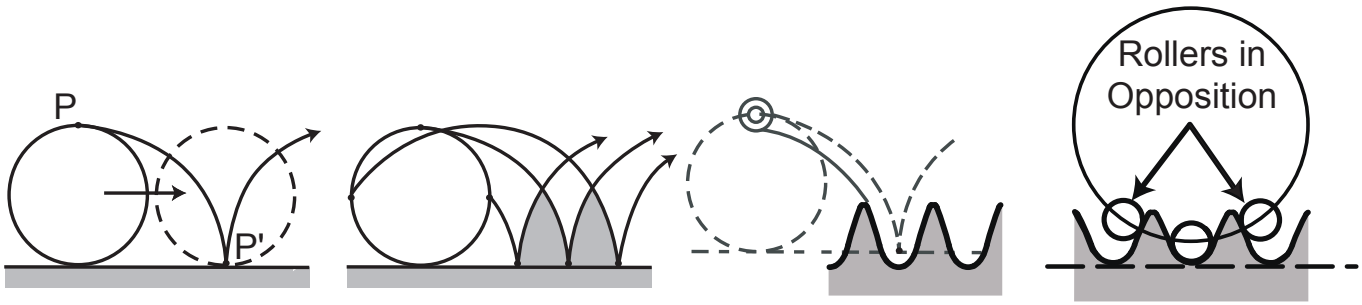
- Ball Screws *Limited by:* Length, maximum speed, cumulative error, rigidity, and thermal expansion. Also suffers from noise, vibration, particle emissions, low efficiency and life, high maintenance, and can require liquid cooling in demanding applications.
- Traditional Rack & Pinion or Gear Systems *Limited by:* Backlash, low accuracy, speed, and life. Positional accuracy continuously degrades due to tooth wear. Continuous lubrication is required to slow the wear rate and creates a mess that can be a problem in many applications. They also suffer from noise, vibration, particle emissions, velocity ripple, and tooth fatigue. Backlash is a problem unless expensive dual-pinion or split-pinion systems are employed, but they drive up the cost greatly and accelerate wear.
- Belt Drives *Limited by:* Low load capacity, accuracy, rigidity, length, and life. Also suffers from backlash, belt stretch, particle emissions, and chemical attack.
- Chain Drives *Limited by:* Backlash limits positional accuracy, meshing is noisy and can cause vibration that can effect control systems, and tend to have high wear and maintenance due to stretch and lubrication requirements.
- Linear Motors & Direct Drive Rotary Stages *Limited by:* Low load capacity and efficiency, high cost, strong magnetic fields, and liquid cooling in demanding applications. Typically is very expensive especially with long runs or large diameters.

How the RPS Technology Works

The RPS system achieves its incredible performance by using a pinion consisting of bearing-supported rollers that engage a unique tooth profile. Two or more rollers engage the teeth in opposition at all times, eliminating backlash. There is no tooth slap as with traditional rack and pinion or gearing, 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 or rotary-to-rotary motion conversion.

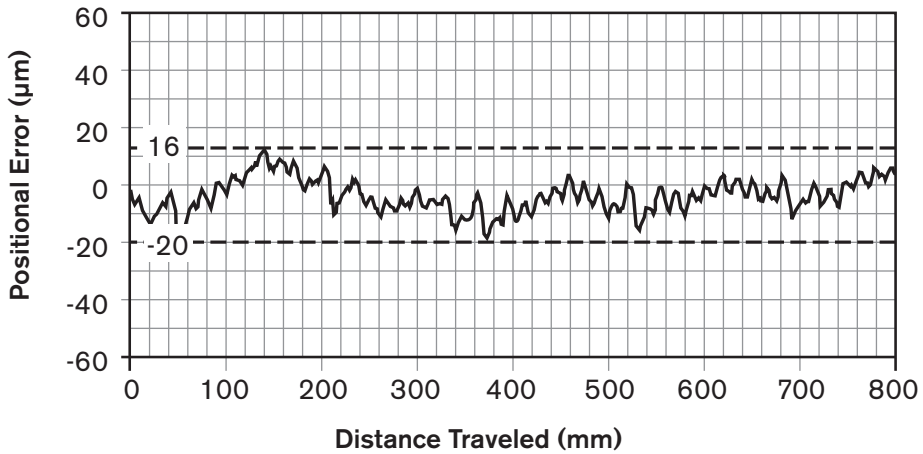
The RPS tooth design is conceptually different from traditional gearing. It behaves like a cam and follower versus the typical sliding spur gear used with traditional rack and pinion or gear sets. As illustrated in the figures below, a cycloidal curve is created when a point drawn on a circle at point P rolls on a flat plane to point P' 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 teeth. The rollers meet the tooth with a tangent path and smoothly roll down the tooth face. This eliminates tooth slap, sliding friction, fatigue, noise, and low precision associated with traditional gearing.



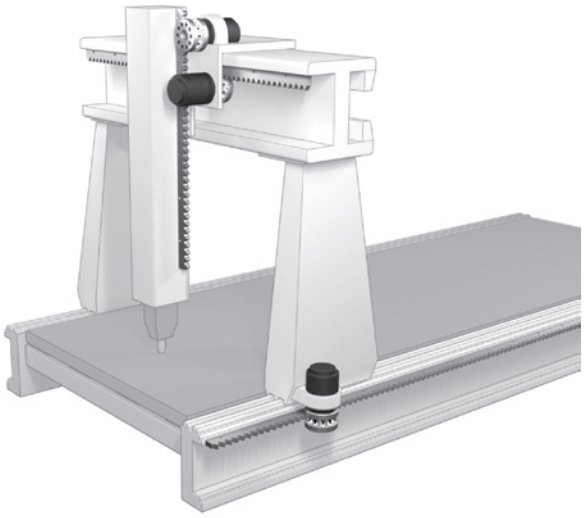
Rotary to Linear Transmission Precision

The variations shown in the graph below represent minor errors occurring throughout the pinion's travel. The individual waves indicate each roller/tooth meshing error, and larger wave patterns show pinion rotational error. As the horizontal limits illustrate, there is no cumulative error. This pattern continues regardless of distance, even when crossing joints due to the way the RPS alignment tool transfers the system accuracy from section to section.



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

Applications



Gantry Router

Robotic Arm

Indexer

Rotopod

Additional RPS and RPG Applications:

- Medical Imaging
- Measurement Systems
- Clean Rooms
- Vacuum Environments
- Welding
- Wood Cutting & Shaping
- Machine Tools
- Plasma and Laser Cutting
- Gantries
- Material Handling
- Food Processing
- Multihead on a Common Axis

RPS Linear Drive Selection Process

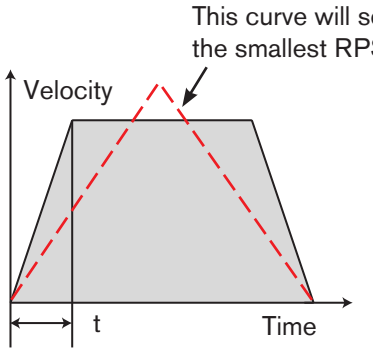
Proper RPS model size selection requires the application data listed below. These specifications are needed to determine: load mass, load acceleration, force due to acceleration, gravity, friction, and total force of the load. See page 6 for sample calculations to determine the correct RPS size for your application.

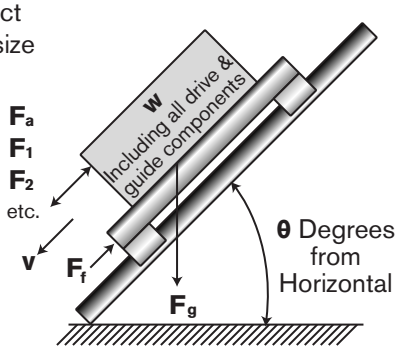
Typical Friction Coefficients (μ)

Profile Guide Rail	0.005
Ball Bearing Guide Rail	0.02
Polymer Bushing Guide	0.1
Bronze Bushing Guide	0.2

Shock Factor[3] (K)

Shockless Smooth Operation	1.0
Normal Operation	1.2
Operation with Impact	1.5
Operation with High Impact	2.5





Required Data for RPS Selection		Example Data	Customer Application Data
Weight to be Driven[1] (W)	kg	150.0 kg	
Maximum Velocity (v)	m/s	0.5 m/s	
Acceleration Time (t) or Known Acceleration (preferred)[2]	seconds m/s²	0.5 s	
Shock Factor[3] (K) See table above		1.2	
Other Forces[4] (F_1), (F_2) etc.	N	0 N	
Frictional Coefficient (μ) See table above		0.01	
Angle from Horizontal (θ°)	°	60°	
Travel Distance	m	5.4 m	
Cycles Per Day[5]		1000	

[1] Weight to be driven should include all drive components and structures being moved. If the axis is driven by more than one RPS system and has a movable or asymmetric mass, the load distribution's effect on the load each pinion must carry must be taken into account. For example: an X&Y axis gantry where the Y axis shifts on the X axis causing the mass the RPS systems on each side of the X axis to see to vary or other similar situation.

[2] Acceleration based on time is linear and may not be representative of actual curve. A known acceleration from the servo drive provider is preferred.

[3] Shock Factor indicates the smoothness of operation.

[4] Other Forces may include cutting forces, springs, counter balances, fluid dampening systems, wind resistance, etc.

[5] Cycles Per Day assumes going the full Travel Distance and returning to home each time.

General Application Information

Application Description	
Environmental Conditions	
Required Positional Accuracy	
Other Application Data	

Calculating RPS Requirements

Based on the information on the preceding page, perform the calculations listed below. If the acceleration or deceleration times are different, 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. Actual peak acceleration from a servomotor and reducer supplier is preferred to acceleration curves based on velocity/time since they may underestimate the true acceleration forces. The following example assumes a single pinion driving an axis. Axis driven by multiple pinions should take load distribution issues into account.

Calculations	Example
Load Mass: $w = m$	$m = 150.0$ kg
Load Acceleration: $a = v \div t$ or known acceleration	$a = 0.5$ m/s $\div$ 0.5 s $= 1.0$ m/s^2
Force Due to Acceleration: $F_a = m \times a$	$F_a = 150.0$ kg x 1.0 m/s^2 $= 150.0$ N
Force Due to Gravity: $F_g = m \times g \times \sin$(degrees from horizontal)	$F_g = 150.0$ kg x 9.81 m/s^2 x sin(60°)$= 1274.4$ N
Force Due to Friction: $F_f =$ mass x μ x gravity x cos(degrees from horizontal)	$F_f = 150.0$ kg x 0.01 x 9.81 m/s^2 x cos(60°) $= 7.4$ N
Total Force: $F_t = F_a + F_g + F_f + F_1 + F_2 +$,, ect.	$F_t = 150.0$ N + 1274.4 N + 7.4 N $= 1431.8$ N
Total Force with Shock Factor: $F_k = F_t \times K$	$F_k = 1431.8$ N x 1.2 $= 1718.2$ N

Now proceed to the RPS Rack Model Comparison Table at the top of page 7 and determine which rack model best fits your needs. Then compare the Total Force with a Shock Factor of 1718.2 N (as calculated above) to the rack model desired in the RPS Rack Model vs. Size vs. Thrust Capacity Table (also on page 7) to determine the correct RPS size.

If the Premium rack model is selected due to it's corrosion resistance and ability to run without lubrication at speeds 0.5 m/s or less, it requires an RPS size 25 or greater. If the Universal rack model is selected, then an RPS size 32 or greater is required.

Now review the RPS Rack Size Common Specifications Table at the bottom of page seven for other limiting factors like speed, life, temperature range, or other attributes that may effect RPS suitability. The following additional calculations are optional and assume that RPS25 Premium model rack has been selected.

Calculations	Example
Required Pinion Torque: $\tau_P = F_T \times$ Meshing Pitch Circle Diameter $\div 2000$	$\tau_P = 1718.2$ N x 79.6 mm $\div 2000 = 68.4$ Nm
Pinion RPM: $R_P = 60{,}000 \times v \div$ Linear Distance Per Pinion Revolution	$R_P = 60{,}000$ x 0.5 m/s $\div$ 250.0 mm $= 120.0$ RPM
Motor Power Required [1]: $P = T_P \times R_P \div 9549$	$P = 68.4$ Nm x 120.0 RPM $\div 9549 = 0.9$ kW
Daily Travel Distance: $T_P =$ Travel Distance x Cycles Per Day x 2	$T_D = 5.4$ m x 1000 CPD x 2 $= 10{,}800$ m
Estimated Rack Life [2]: $L_R =$ Tooth Contact Life $\div$ Cycles Per Day $\div 2$	$L_R = 30{,}000{,}000 \div 1000 \div 2 = 15{,}000$ Days
Estimated Pinion Life [2]: $L_P =$ Pinion Revolution Life x Distance Per Rev $\div T_D$	$L_P = 60{,}000{,}000$ x 0.25 m $\div$ 10,800 m $= 1389$ Days

[1] Motor Power Required is an estimate that does not include reducer inefficiencies.

[2] Estimated Life is based on the Life Rating criteria on page 19 and going the full Travel Distance each time. The combined rack and pinion system will have the life of the lower of the two. Individual components can generally be replaced prior to exceeding their Estimated Life, or when their performance diminishes and gaining the remaining life of the other components. If travel is variable, calculate each zone separately.

Note: Always consult the RPS Rack or Gear User Manual before beginning your machine design or installing RPS product to ensure obtaining the highest possible performance and easiest installation. User Manuals are available on www.nexengroup.com on the product pages for any of the product numbers in the left hand column under resources.

Selecting RPS Rack Models, Sizes, and Specifications

RPS Rack Model Comparison Table

Attributes \ RPS Model		Premium	Standard	Endurance	Universal (Stainless)	Universal
Positional Accuracy [1]	± µm	30	50	80	50	50
Meshing Error Per Pitch [1]	± µm	10	15	30	30	30
Repeatability [1]	± µm	5	10	20	10	10
Backlash [1]	< µm	3.2				
Dynamic Load Capacity Per RPS Size		100%	100%	100%	75%	75%
Static Load Capacity Per RPS Size		200%	200%	200%	75%	75%
Corrosion Resistant Surface Treatment [1]		Hard Chrome	None	Nitrided	None or Hard Chrome	None
Corrosion Resistance Rating [1]		High	None	Medium	High/Very High	None
Tooth Contact Life [1]	Millions	30	30	30	2: Size 40 & 4014 5: All Others	2: Size 40 & 4014 5: All Others
Lubrication Free Operation [1]	<30m/min	Yes	No	Yes	No	No
Noise Level [1]	db	0-75 Speed Dependent				
Temperature Range [1]	°C	-5 to 40				

Next, choose the RPS size from the table below using the load requirement calculated on the previous page and the RPS rack model desired.

RPS Rack Model vs. Size vs. Thrust Capacity Table

	RPS Rack Model and Size Load Capacities (N)									
	Premium		Standard		Endurance		Universal (Stainless)		Universal	
RPS Size	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static	Dynamic	Static
10	250	380	NA	NA	NA	NA	NA	NA	NA	NA
12	500	750	NA	NA	NA	NA	NA	NA	NA	NA
16	1000	2000	1000	2000	1000	2000	750	750	750	750
20	1500	3000	1500	3000	1500	3000	1125	1125	1125	1125
25	2200	4400	2200	4400	2200	4400	1650	1650	1650	1650
32	3600	7200	3600	7200	3600	7200	2700	2700	2700	2700
40	6000	12000	6000	12000	6000	12000	4500	4500	4500	4500
4014	14000	21000	14000	21000	14000	21000	10500	10500	10500	10500
50	19000	28500	NA	NA	NA	NA	NA	NA	NA	NA

Based on the rack model & RPS size selected, verify speed and other application parameters against the common RPS attributes below.

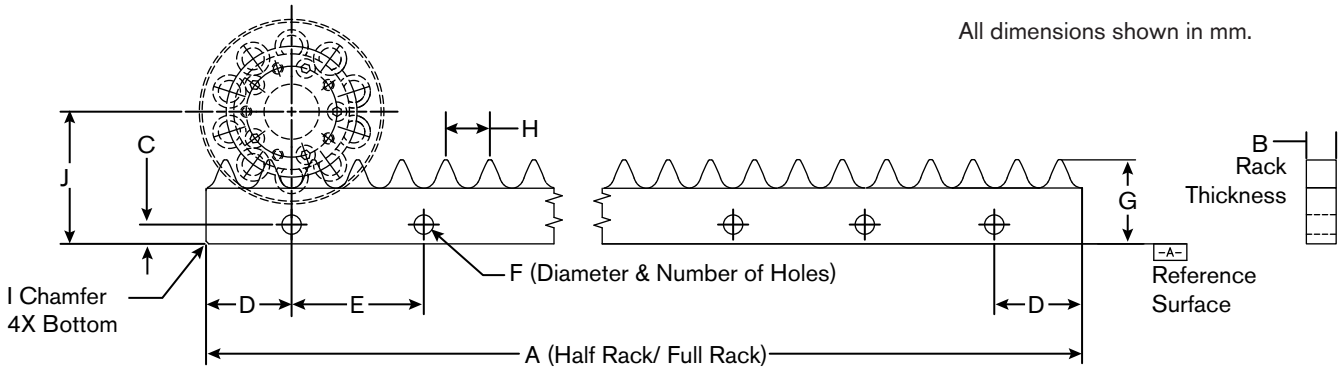
RPS Rack Common Specifications Comparison Table

Attribute \ Rack Size		RPS10	RPS12	RPS16		RPS20		RPS25		RPS32		RPS40		RPS4014		RPS50	
Max Pressure Angle	°	26.4	26.4	27.9		26.4		26.4		26.0		26.0		26.0		26.0	
Avg Pressure Angle	°	21.9	21.9	23.4		21.9		21.9		22.7		21.3		20.9		21.3	
Module	mm	3.0	3.6	4.8		6.0		7.5		9.5		12.0		12.0		15.0	
Maximum Speed	m/s	4	8	4		5		8		11		6		6		6	
Rack Tooth Pitch	mm	10	12	16		20		25		32		40		40		50	
Rack Height	mm	27	27	30.5		42.0		48.0		57.0		72.6		69.0		71.5	
Rack Width	mm	5.7	5.7	11.5		15.5		18.5		24.5		31.5		42.0		42.0	
Rack Section Size		Half	Half	Half	Full	Half	Full	Half	Full	Half	Full	Half	Full	Half	Full	Half	Full
Rack Length	mm	480	480	512	992	500	1000	500	1000	512	992	520	1000	520	1000	500	1000
Number of Rack Teeth		48	40	32	62	25	50	20	40	16	31	13	25	13	25	10	20
Rack Weight	kg	0.5	0.6	1.1	2.1	2.1	4.1	2.7	5.4	4.2	8.2	6.9	13.2	8.8	17.0	8.1	16.2

[1] See the Definitions Section on page 19 for more information on these attributes.

RPS Rack Dimensions

All dimensions shown in mm.



RPS Size	A		B	C	D	E	F			G	H	I	J
	Rack Length		Rack Thickness	Hole Height	Hole From End	Hole Spacing	Mounting Holes			Rack Height	Tooth Pitch	Rack Bottom Chamfer	Axis to Base
	Half	Full					Ø	# Half Rack	# Full Rack				
RPS10	480	NA	5.7	7	29.8	60	5.5	8	NA	27.0	10	1	37.5
RPS12	480	NA	5.7	7	29.8	60	5.5	8	NA	27.0	12	1	40
RPS16	512	992	11.5	7	16	96	7	6	11	30.5	16	1	48
RPS20	500	1000	15.5	10	50	100	9	5	10	42.0	20	1	64
RPS25	500	1000	18.5	12	50	100	11	5	10	48.0	25	1	75
RPS32	512	992	24.5	14	16	96	14	6	11	57.0	32	1	102
RPS40	520	1000	31.5	16	80	120	18	4	8	72.6	40	1	129
RPS4014	520	1000	42.0	16	60	80	18	6	12	69.0	40	2	140
RPS50	500	1000	42.0	15	31.25	62.5	18	8	16	71.5	50	2	145.5

See drawings or CAD models on Nexen's website for your specific product numbers for additional dimensions and tolerances.

RPS Rack Product Numbers

Next, choose the RPS rack product numbers based on the size and model determined in the previous steps.

RPS Size	Rack Length		Universal	Universal UnCoated Stainless	Universal Coated Stainless	Endurance	Standard	Premium	Pinions To Use See Page 13
10	Half	480 mm	N/A	Contact Nexen	Contact Nexen	N/A	N/A	966768	RPS10 B Series **Blue** Pinions
	Alignment Tool		966507						
12	Half	480 mm	N/A	Contact Nexen	Contact Nexen	N/A	N/A	966769	RPS 12 B Series **Blue** Pinions
	Alignment Tool		966508						
16	Half	512 mm	966801	966760	966742	Contact Nexen	966602	966652	RPS16 B Series **Blue** Pinions
	Full	992 mm	966800	966813	966741	966850	966601	966651	
	Alignment Tool		966503						
20	Half	500 mm	966803	Contact Nexen	Contact Nexen	Contact Nexen	966612	966662	RPS20 B Series **Blue** Pinions
	Full	1000 mm	966802	966625	966619	966851	966611	966661	
	Alignment Tool		966513						
25	Half	500 mm	966805	Contact Nexen	Contact Nexen	Contact Nexen	966622	966672	RPS25 B Series **Blue** Pinions
	Full	1000 mm	966804	966814	966755	966852	966621	966671	
	Alignment Tool		966523						
32	Half	512 mm	966807	Contact Nexen	Contact Nexen	Contact Nexen	966632	966682	RPS32 B Series **Blue** Pinions
	Full	992 mm	966806	966812	Contact Nexen	966853	966631	966681	
	Alignment Tool		966533						
40	Half	520 mm	966809	Contact Nexen	Contact Nexen	Contact Nexen	966642	966692	RPS40 B Series **Blue** Pinions
	Full	1000 mm	966808	966815	Contact Nexen	966854	966641	966691	
	Alignment Tool		966543						
4014	Half	520 mm	966811	Contact Nexen	Contact Nexen	Contact Nexen	966647	966695	RPS4014 B Series **Blue** Pinions
	Full	1000 mm	966810	966816	Contact Nexen	966855	966646	966694	
	Alignment Tool		966543						
50	Half	500 mm	N/A	Contact Nexen	Contact Nexen	N/A	N/A	966773	RPS 50 B Series **Blue** Pinions
	Alignment Tool		966775						
Rack Grease			853901						

Now proceed to page 13 to select the Blue, B-series pinion to use with the chosen RPS rack size and model.

RPG Gear Selection Process

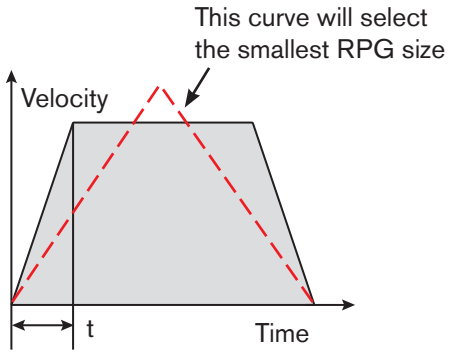
Proper RPG size selection requires the application data listed below. These specifications are needed to determine: load mass, angular acceleration, torque due to acceleration, gravity, friction and total torque required. Sample calculations are shown to calculate the RPG size for your application.

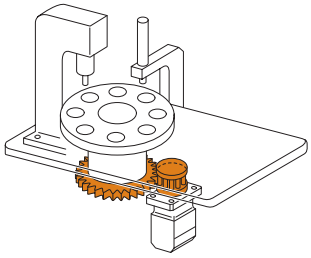
Typical Friction Coefficients (μ)

Rolling Bearing	0.005 ~ 0.02
Sliding Bearing	0.1 ~ 0.2

Shock Factor[2] (K)

Shockless Smooth Operation	1.0
Normal Operation	1.2
Operation with Impact	1.5
Operation with High Impact	3.0





Application Example:

Programmable electronics assembly indexing table
1 meter in diameter
8 stations equally spaced
60 indexes per minute desired
Dwell time 0.33 sec
Additional information below

Application Data

Required Specifications For RPG Selection		Example Data	Customer Application Data
Weight to be Driven[1] (W)	kg	20.0 kg	
Rotational Moment of Inertia (I)	kgm^2	10.0 kgm^2	
Indexes Per Revolution (R)	IPR	8 IPR	
Index Time (It)	seconds	0.66 sec	
or Known Angular Acceleration (θ) (preferred)	rad/sec^2		
Dwell Time (dt)	seconds	0.33 sec	
Shock/Service Factor[2] (K) see table above		1.2	
Coefficient of Friction (μ)			
Other Forces[3] (F_1), (F_2), etc.	Nm		
Angle Gear Rotates Relative To Horizontal Plane	°	0°	
Maximum Allowable Ring Gear OD	mm	400 mm	
Minimum Allowable Ring Gear ID	mm	200 mm	
Ring Gear Tooth Orientation	External/Internal	External	
Required Angular Positional Accuracy (P)	±arcsec	±60 arcsec	
Indexes Per Day		10800 RPD	

[1] ***Weight to be Driven*** should include everything in motion.

[2] ***Shock Factor*** indicates the smoothness of operation

[3] ***Other Forces*** may include gravitational forces if rotation is not in the horizontal plane with imbalanced loads, springs, counter balances, fluid dampening systems, wind resistance etc.

Selecting an RPG Gear Set

If the acceleration or deceleration times vary, or there are other changes in velocity, calculate the acceleration torque for each interval and use the highest one for RPG selection purposes.

Application Calculations

Calculations	Application Example	Customer Calculations
Acceleration Time A_t (s) = It (s) ÷ 2	$A_t = 0.66$ s ÷ 2 = 0.33 s	
Rotation Per Index θ (rad) = 2π ÷ IPR	$\theta = 2\pi \div 8 = 0.79$ rad	
Max Angular Speed $\omega = \theta$ (rad) ÷ It (s) x 2	$\omega = 0.79$ rad ÷ 0.66 s x 2 = 2.39 rad/s	
Angular Acceleration α (rad/s^2) = ω (rad/s) ÷ At (s)	$\alpha = 2.39$ rad/s ÷ 0.33 s = 7.25 rad/s^2	
Ring Gear Torque τ_G (Nm) = I (kg/m^2) x α (rad/s^2)	$\tau_G = 10$ kgm^2 x 7.25 rad/s^2 = 72.50 Nm	
Ring Gear Torque with Shock Factor τ_K (Nm) = τ_G x K	$\tau_K = 72.50$ Nm x 1.2 = 87.00 Nm	
Pinion Thrust Required At Max OD T_{PMax} (N) = T_K ÷ Max OD (mm) x 500	T_{PMax} (N) = 87.00 Nm ÷ 400 mm x 500 = 108.8 N	
Pinion Thrust Required at Min ID T_{PMin} (N) = T_K ÷ Min ID (mm) x 500	T_{PMin} (N) = 87.00 Nm ÷ 200 mm x 500 = 217.5 N	

Compare the pinion thrusts calculated above with the Premium Rack Model's Dynamic Thrust Ratings at the far left of the RPS Rack Model vs. Size vs. Thrust Capacity Table table on page 7 since gear performance is based on Premium rack performance. You will see that an RPS16 system rated at 1000 N can satisfy either extreme. In some applications, different RPS sizes may be required at the extremes. The trade-offs of cost, speed, and accuracy, and gear availability may need to be evaluated to find the optimal solution. Larger diameter gears will give better angular accuracy, and possibly a smaller RPS size where smaller diameter gears will give a higher RPM and generally a lower cost.

Now compare the Ring Gear Torque calculated above to the RPG16 Max Dynamic Torque row in the specifications table on page 11. From this we see that the RPS16G 7:1 has more than enough torque, and meets the ring gear ID and OD envelope requirements.

Next, verify that maximum pinion RPM is not exceeded. The maximum pinion RPM listed in the specifications table on page 13 for the RPS16 pinion is 1500 RPM and the gear ratio on page 11 7:1. Therefore the application RPM = w x Gear Ratio x 9.55 = 2.39 rad/sec x 7 x 9.55 = 159.8 RPM so the RPG16G 7:1 gear system is an acceptable choice.

Compare selected gear set accuracy with the application requirements. The RPS25G 7:1 gear set is rated for ±40 arcsec, which is more precise than the required ± 60 arcsec, so is acceptable.

If the application requirements call for a more powerful or larger diameter gear set than the listed offerings, contact Nexen to evaluate possible RPS custom gear sets.

Note:
Always consult the RPS Rack or Gear User Manual before beginning your machine design or installing RPS product to ensure obtaining the highest possible performance and easiest installation. User Manuals are available on www.nexengroup.com on the product pages for any of the product numbers in the left hand column under resources.

Standard Gears, Specifications and Product Numbers

Based on the previous calculations, choose the gear below that meets or exceeds your requirements. If none are a good match, Nexen can create one tailored to your needs.

RPG16 C Series Yellow										
Product Number		966550	966551	966552	966553	966554	966667	966657	966655	966555
Gear Ratio	#:1	3	4	5	6	7	15	15	40	93.6
Max Dynamic Torque	Nm	70	90	110	140	160	383	383	1020	2387
Max Static Torque	Nm	140	180	220	280	320	764	764	2036	4764
Arc Length/Full Ring?		360°/yes	360°/yes	360°/yes	360°/yes	360°/yes	72°/yes	91.2°/no	22.5°/yes	10°/yes
Teeth: internal or external		external	external	external	external	external	external	external	external	external
Number of Teeth: segment/ring		NA/30	NA/40	NA/50	NA/60	NA/70	30/150	38/NA	25/400	26/938
Max RPM		500	375	300	250	214	150	150	38	16
Inner Diameter (ID)	mm	70	120	160	190	260	652	656	1830	4444
Outer Diameter (OD)	mm	162	210	257	305	353	745	745	1954	4564
Weight	kg	1.8	2.6	3.7	5.3	5.1	2.2[2]	2.7[2]	2.6[2]	2.6[2]
Moment of Inertia	kgm²	0.006	0.017	0.039	0.080	0.116	0.260[2]	0.329[2]	2.300[2]	13.285[2]
Accuracy[1]	arcsec	±67	±66	±53	±44	±38	±17	±17	±7	±3
Error per Pitch[1]	arcsec	±29	±22	±18	±15	±13	±6	±6	±3	±1
Repeatability[1]	arcsec	±15	±11	±9	±8	±7	±3	±3	±2	±0.5
Maximum Backlash[1]	arcsec	<10	<7	<6	<5	<4	<2	<2	<1	<0.3
Alignment Tool Number		NA	NA	NA	NA	NA	966557	966557	966656	966556

		RPG20 C Series Yellow			RPG25 C Series Yellow					
Product Number		966705	966614	966733	966560	966561	966562	966563	966564	966739
Gear Ratio	#:1	14	15	18	3	4	5	6	7.5	48.6
Max Dynamic Torque	Nm	668	716	859	240	330	410	490	660	4277
Max Static Torque	Nm	1337	1432	1719	480	660	820	980	1320	8554
Arc Length/Full Ring?		72°/yes	60°/yes	60°/yes	360°/yes	360°/yes	360°/yes	360°/yes	360°/yes	20°/yes
Teeth: internal or external		external	internal	external	external	external	external	external	external	external
Number of Teeth: segment/ring		28/140	25/150	30/180	NA/30	NA/40	NA/50	NA/60	NA/75	27/486
Max RPM		107	100	83	640	480	384	320	256	40
Inner Diameter (ID)	mm	770	906	1020	120	190	260	330	460	3640
Outer Diameter (OD)	mm	880	1038	1120	254	331	405	481	596	3760
Weight	kg	3.7[2]	5.0[2]	3.8[2]	6.3	9.5	12.8	16.4	19.9	6.0[2]
Moment of Inertia	kgm²	0.624[2]	1.222[2]	1.080[2]	0.055	0.158	0.347	0.661	1.360	20.584[2]
Accuracy[1]	arcsec	±15	±14	±12	±56	±42	±34	±28	±22	±3.5
Error per Pitch[1]	arcsec	±5	±5	±4	±19	±14	±12	±10	±6	±1.2
Repeatability[1]	arcsec	±3	±3	±2	±10	±7	±6	±5	±4	±0.6
Maximum Backlash[1]	arcsec	<1.6	<1.5	<1.2	<6	<5	<4	<3	<2.5	<0.4
Alignment Tool Number		966706	966615	966734	NA	NA	NA	NA	NA	966740

		RPG32 B Series Blue		RPG40 B Series Blue		RPG4014 B Series Blue	
Product Number		966636	966763	966764	966549	966969	966725
Gear Ratio	#:1	4	37.5	4	16.7	5.14	13.7
Max Dynamic Torque	Nm	880	8250	1834	7640	6417	17107
Max Static Torque	Nm	1760	16,500	3667	15,280	9625	25,660
Arc Length/Full Ring?		360°/yes	14.4°/yes	360°/yes	19.8°/no	90°/yes	22.5°/yes
Teeth: internal or external		external	external	external	external	external	external
Number of Teeth: segment/ring		NA/48	18/450	NA/48	11/NA	19/72	12/192
Max RPM		188	46	188	45	125	47
Inner Diameter (ID)	mm	330	4220	460	2320	710	2230
Outer Diameter (OD)	mm	494	4399	623	2482	916	2392
Weight	kg	17.7	10.4[2]	28.5	6.4	17.2[2]	9.4[2]
Moment of Inertia	kgm²	0.730	48.068[2]	2.010	9.210[2]	2.804[2]	12.489[2]
Accuracy[1]	arcsec	±28	±3	±22	±6	±15	±5.5
Error per Pitch[1]	arcsec	±10	±1	±8	±2	±5	±2
Repeatability[1]	arcsec	±3	±0.5	±4	±1	±3	±1
Maximum Backlash[1]	arcsec	<3	<0.4	<3	<0.6	<1.5	<0.6
Alignment Tool Number		NA	966685	NA	966548	966547	966548

Common Attributes for All Gears		
Estimated Life[1]		30,000,000 Contacts Per Tooth
Operating Temperature Range[1]	C°	-5 to 40
Tooth Grease		853901

[1] See the Definitions Section on page 19 for more information on these attributes. [2] Per Segment

Gear Dimensions and Product Numbers

Figure A

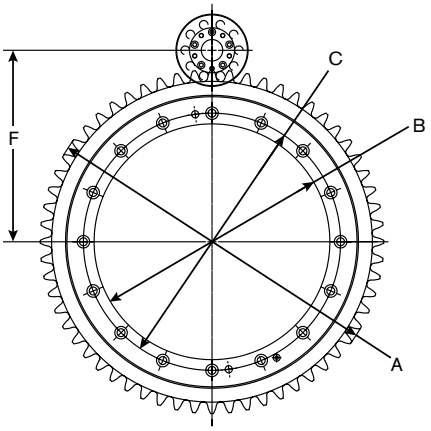


Figure B

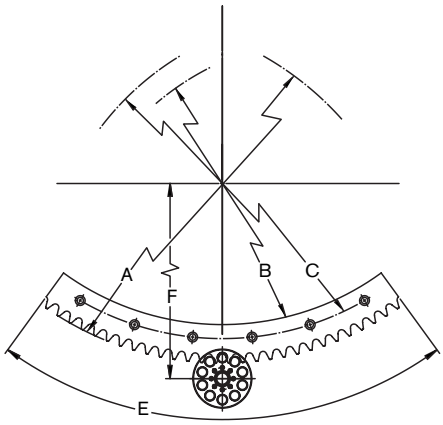
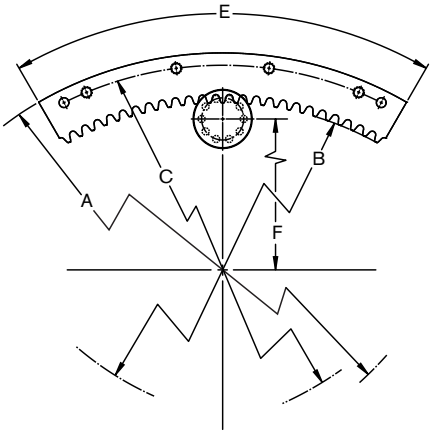


Figure C



Basic gear dimensions shown for selection purposes only and subject to change. Go to www.nexengroup.com for detailed drawings and CAD models. If none of the products below meet your needs, contact Nexen and one can be designed to your specifications.

					A	B	Not Shown	C	E	F
RPG Size	Product Number	Teeth Orientation	Figure	Pinion Series [1]	Outer Diameter	Inner Diameter	Maximum Thickness	Bolt Circle Diameter	Arc Length Degrees	Centers Distance
16	966550	external	A	C	162	70	20	90	360	98
	966551	external	A	C	210	120	20	145	360	122
	966552	external	A	C	257	160	20	180	360	146
	966553	external	A	C	305	190	20	220	360	170
	966554	external	A	C	353	260	20	285	360	194
	966667	external	B	C	745	652	16	670	72	390
	966657	external	B	C	744	656	16	672	91.2	390
	966655	external	B	C	1953	1830	16	1870	22.5	995
	966555	external	B	C	4564	4444	16	4461	10	2300
20	966705	external	B	C	880	770	20	810	72	462
	966614	internal	C	C	1038	906	20	1013	60	430
	966733	external	B	C	1120	1020	20	1060	60	582
25	966560	external	A	C	254	120	28	145	360	154
	966561	external	A	C	331	190	28	220	360	193
	966562	external	A	C	405	260	28	285	360	230
	966563	external	A	C	481	330	28	360	360	268
	966564	external	A	C	596	460	28	490	360	326
	966739	external	B	C	3760	3640	24	3684	20	1908
32	966636	external	A	B	494	330	29	360	360	292
	Contact Nexen	external	B	B	4400	4222	25	4280	43.2	2246
40	Contact Nexen	external	A	B	623	460	32	500	360	369
	Contact Nexen	external	B	B	2482	2320	32	2360	19.8	1300
4014	966696	external	B	B	916	710	42	785	90	529
	966725	external	B	B	2392	2230	42	2270	22.5	1268

[1] See the Definitions Section on page 19 for more information on these attributes.

After choosing a gear or arc segment, note the RPS size and series letter/color and proceed to pages 13-14 for pinion selection.

RPS Pinion Selection

Nexen's Roller Pinions are available in shaft-mount versions that use a keyless mechanical compression coupling to secure it to a shaft, or flange-mount versions that conform to the ISO 9409 specification. The shaft-mount pinions are only available in the one bore size listed. Nexen recommends using the flange-mount pinions when practical since they are easier to find reducers for, easier to install, and minimize reducer overhung load issues, make for a more rigid system, and allow the use of Nexen preloaders if you choose to not design your own. The pinion ratings differ from some of the rack or gear ratings, so the combined system would be the lesser of the two. The pinions are available in B and C series and must be matched to the same series called for by the specific size of rack or gear to work properly together. The rack uses B series on all sizes. The gears use C series pinions on RPS sizes 16 through 25 and B series pinions on RPS32 and larger. See page 14 for more information on the flange mount ISO 9409 system.

Roller Pinion Size	Number of Rollers	Max RPM	Max Torque [1] (Nm) Dynamic / Static	Distance per Revolution (mm)	Pitch Circle Diameter (mm)	Product Number	Series	Base Material/ Coating [2]	Mount Style	Bore Size (mm)	Mass (kg)	Moment of Inertia kgm^2x10^{-4}
10	10	2400	4.0/6.0	100	31.8	966480	B	Hard Chrome	Shaft	12	0.2	0.4
12	10	4000	9.5/14.3	120	38.2	966490	B	Hard Chrome	Shaft	16	0.3	1.0
16	10	1500	25.5 / 50.9	160	50.9	966687	B	Nickel	Flange	N/A	0.8	4.0
						966650	B	Nickel	Shaft	20	0.7	3.93
						966759	B	Stainless	Flange	N/A	0.8	4.0
						966761	B	Stainless	Shaft	20	0.7	3.9
						966715	C	Nickel	Flange	N/A	0.9	4.2
						966659	C	Nickel	Shaft	20	0.8	4.12
20	10	1500	47.7 / 95.5	200	63.7	966675	B	Nickel	Flange	N/A	1.2	10.2
						966660	B	Nickel	Shaft	25	1.3	10.5
						966766	B	Stainless	Flange	N/A	1.2	10.2
						966771	B	Stainless	Shaft	25	1.3	10.5
						966707	C	Nickel	Flange	N/A	1.2	10.2
						966669	C	Nickel	Shaft	25	1.3	10.5
25	10	1820	88 / 176	250	79.6	966673	B	Nickel	Flange	N/A	2.1	25.2
						966670	B	Nickel	Shaft	30	2.1	25.5
						Request	B	Stainless	Flange	N/A	2.1	25.2
						966758	B	Stainless	Shaft	30	2.1	25.2
						966678	C	Nickel	Flange	N/A	2.2	26.8
						966679	C	Nickel	Shaft	30	2.2	26.8
32	12	1719	220 / 440	384	122.2	966677	B	Nickel	Flange	N/A	6.6	168.0
						966680	B	Nickel	Shaft	45	6.4	169.0
						Request	B	Stainless	Flange	N/A	6.6	168.0
						Request	B	Stainless	Shaft	45	6.4	169.0
40	12	750	458.4 / 916.8	480	152.8	966697	B	Nickel	Flange	N/A	15.5	665.0
						966690	B	Nickel	Shaft	60	12.4	594.0
						Request	B	Stainless	Flange	N/A	15.5	665.0
						Request	B	Stainless	Shaft	60	12.4	594.0
4014	14	643	1247.8 / 1871.6	560	178.3	966700	B	Nickel	Flange	N/A	23.5	1306.0
						966693	B	Nickel	Shaft	60	20.9	1180.0
						Request	B	Stainless	Flange	N/A	23.5	1306.0
						Request	B	Stainless	Shaft	60	20.9	1180.0
50	12	600	1815/2721	600	191.0	966774	B	Hard Chrome	Shaft	70	26.0	1790.0

Common Attributes For All Pinions

Estimated Life [3]:	60,000,000 Revolutions or Contacts per Roller	Operating Temp Range [3]:	-5 to 40	Tooth Grease:	853901

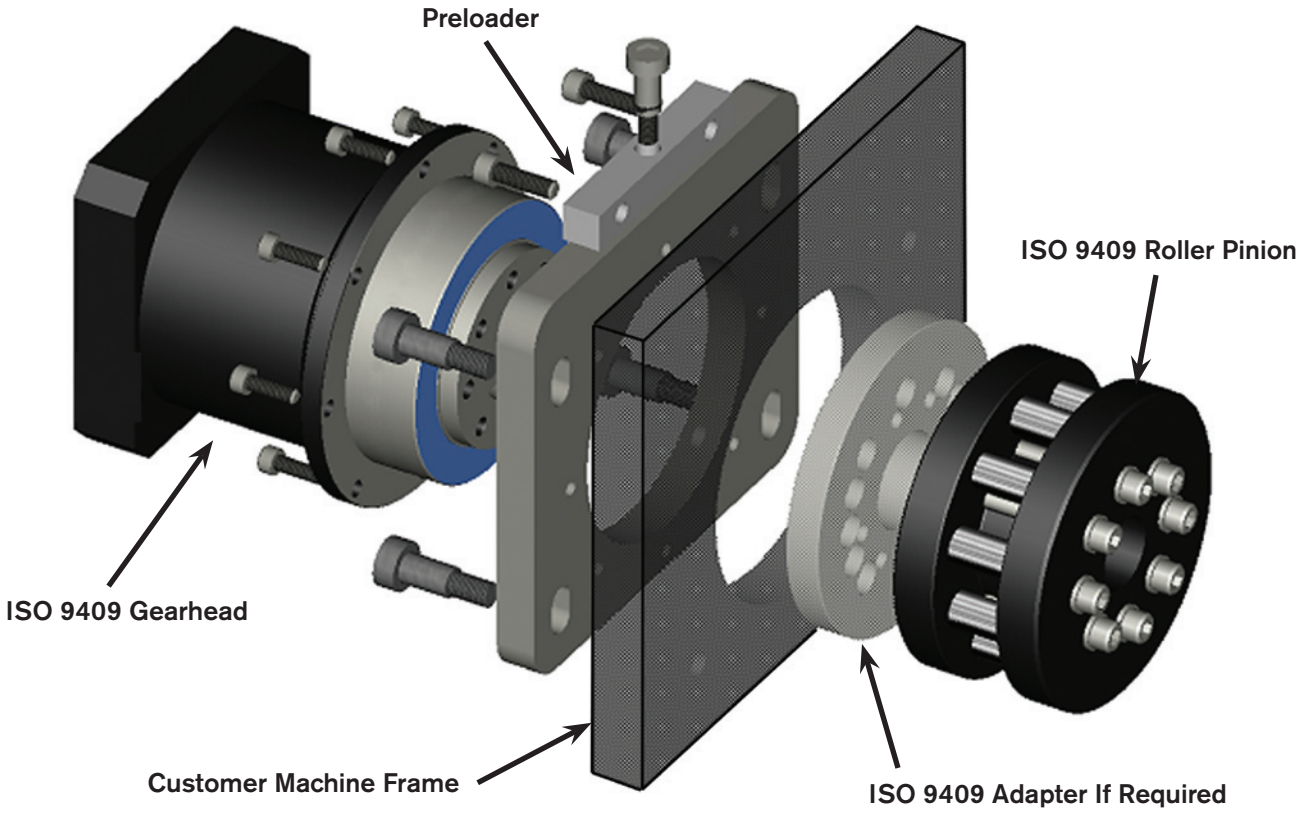
[1] Pinion torque is for reference only. Some rack models are not rated for full pinion torque.

[2] Hard Chrome is an alloy steel with a thin dense hard chrome coating, Nickel is an alloy steel with a nickel plating, and Stainless is stainless steel with or without a hard chrome coating. Other corrosion resistant options available upon request.

[3] See the Definitions section on page 19 for more information on these attributes.

ISO 9409 Flange Mount Pinion And Preloader

Nexen's RPS ISO 9409 flange mount pinion and pinion preloader simplifies the integration of the RPS rack or RPG system gear into your machine design and gives the highest level of performance. The preloader has high-precision ground surfaces and an adjuster that allows the pinion to be moved up or down into the rack while keeping the pinion properly oriented to the rack. The pilot in the adjuster plate accommodates common ISO 9409 servo gearhead sizes from your favorite servo gearhead manufacturer. The pinion adapter allows the pinion to fit one frame size larger than it would directly mount to, and is typically used for reducer availability or motor sizing reasons. The preloader and adapter components utilize nickel- and zinc-plated, and stainless-steel materials for corrosion resistance.



Gearhead to RPS ISO 9409 Flange Mount Pinion and Adapter Table

If directly mounting the pinion to the reducer start in left most column and work across disregarding the second column from the left. If going up a reducer frame size an adapter is required and you should start the selection process in the second column from the left.

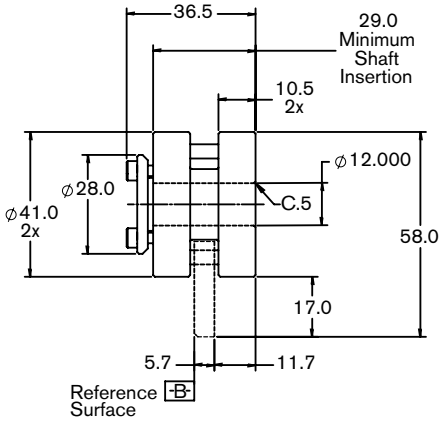
RPS Pinion Size & Adapter (If Required)		Pinion Preloader	Customer Provided Gearhead Brand, Series and Size						
Direct Pinion Mounting	Pinion with Adapter Mounting		Alpha/ Wittenstein	APEX	Mijno	Neugart	SEW-Euro	Sumitomo	Stöber
RPS16	N/A	N/A	N/A	AD047	N/A	N/A	N/A	N/A	N/A
RPS20	RPS16: & 966688	960851	TP004	AD064	BDB 085	PLFE/N 64	PSBF221/2	N/A	PH/A/KX 321/2
RPS25	RPS20: & 966676	960850	TP010	AD090	BDB 120	PLFE/N 90	PSBF321/2	PNFX080	PH/A/KX 421/2
RPS32	RPS25: & 966674	960852	TP025	AD110	BDB 145	PLFE/N 110	PSBF521/2	PNFX250	PH/A/KX 521/2
RPS40	RPS32: & 966668	960853	TP050	AD140	BDB 180	PLFN 40	PSBF621/2	PNFX450	PH/A/KX 721/2
RPS4014	RPS40: & 966698	960854	TP110	AD200	BDB 250	PLFN 200	PSBF721/2	N/A	PH/A/KX 821/2
N/A	RPS4014: & 966701	N/A	TP300	AD255	BDB 300	N/A	N/A	N/A	PH/A/KX 912/23

This is a partial list. Other gearheads may apply.

Pinion Dimensions

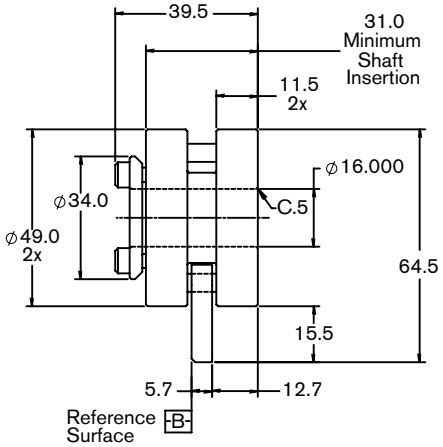
RPS10

Shaft Mounted Pinion



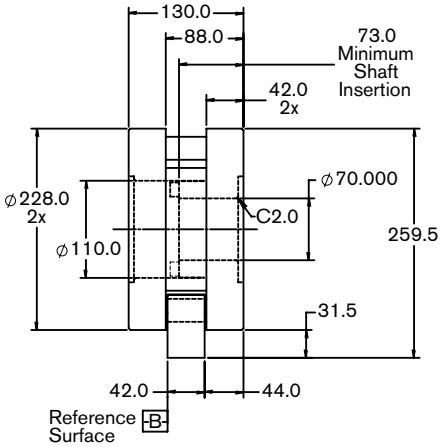
RPS12

Shaft Mounted Pinion



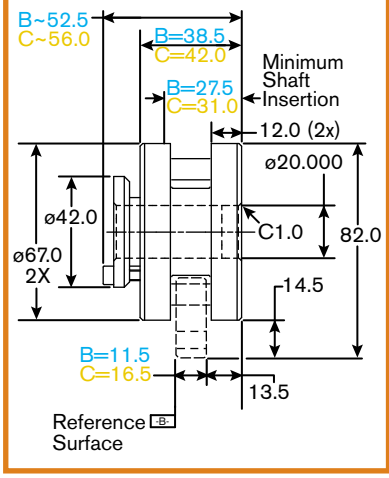
RPS50

Shaft Mounted Pinion

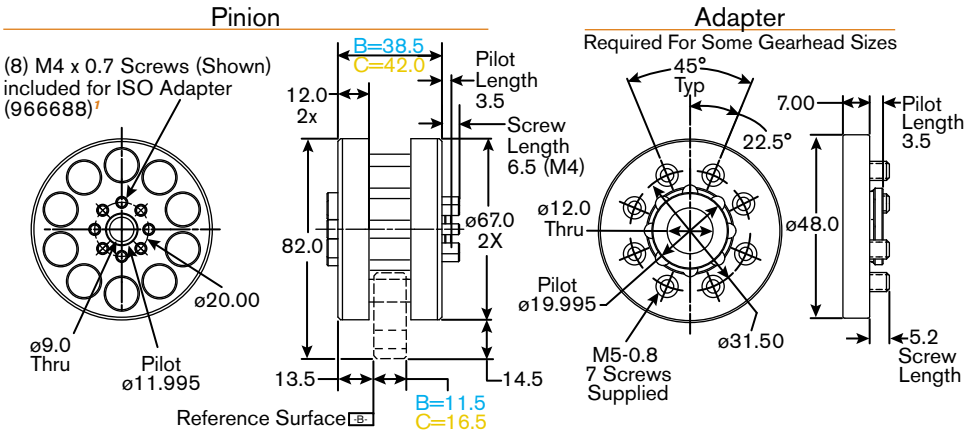


RPS16

Shaft Mounted Pinion



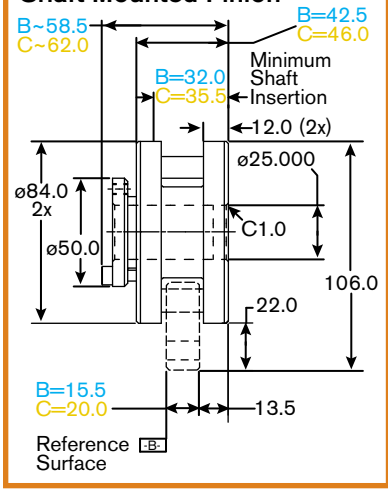
ISO 9409 Flange Mount Pinion



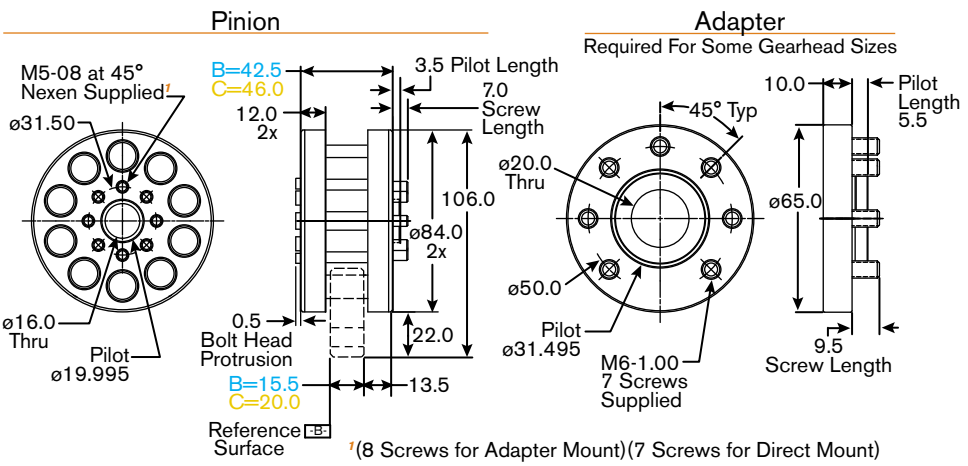
[1](4) M3 x 0.5 x 45 mm screws (Not Shown) included for use with APEX AD047

RPS20

Shaft Mounted Pinion



ISO 9409 Flange Mount Pinion



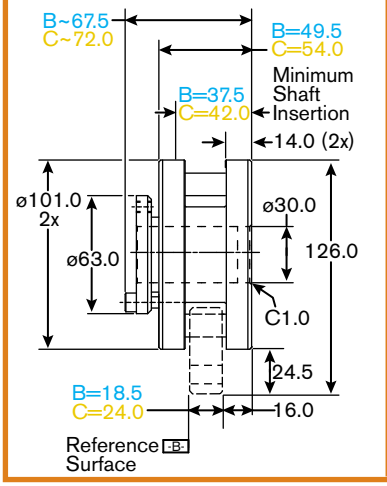
[1](8 Screws for Adapter Mount)(7 Screws for Direct Mount)

Note: Blue values are for B-series pinions used with rack and size 32 or larger gears. **Yellow:** C-series pinions with size 25 & smaller gears. See the Nexen engineering drawings for your specific product number for additional dimensions and tolerances.

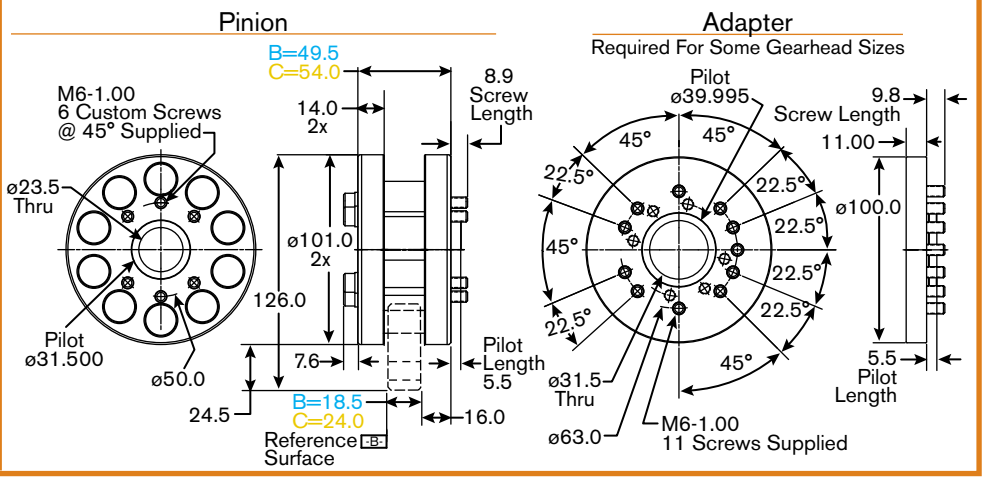
Pinion Dimensions

RPS25

Shaft Mounted Pinion

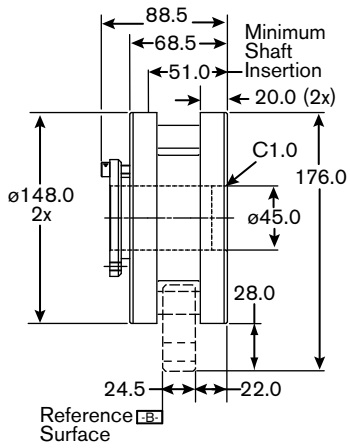


ISO 9409 Flange Mount Pinion

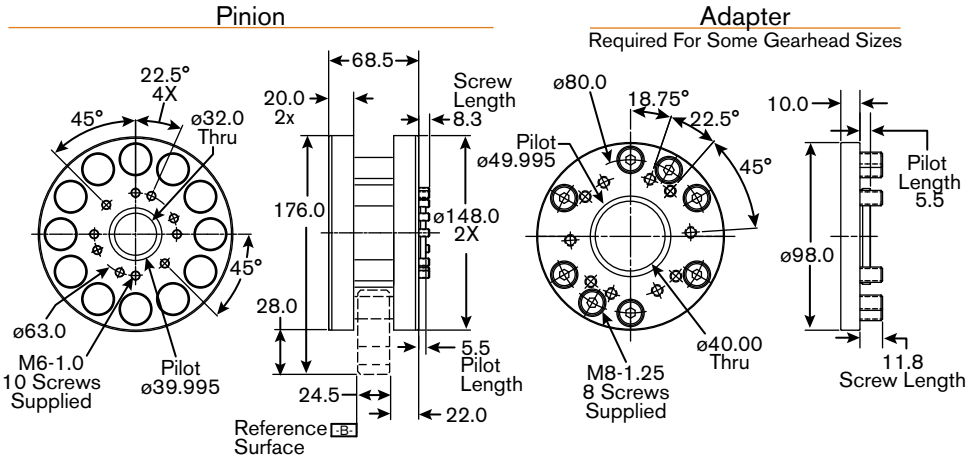


RPS32

Shaft Mounted Pinion

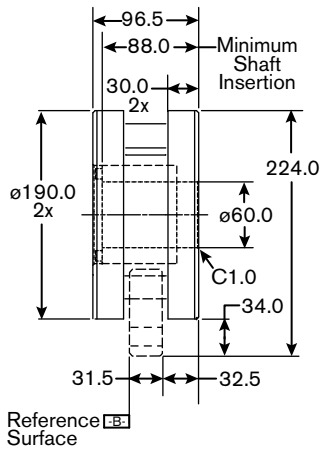


ISO 9409 Flange Mount Pinion

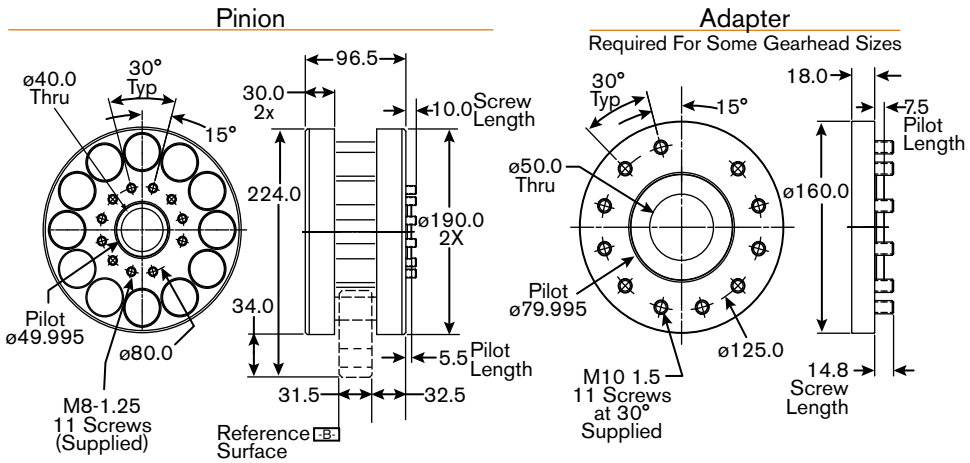


RPS40

Shaft Mounted Pinion



ISO 9409 Flange Mount Pinion

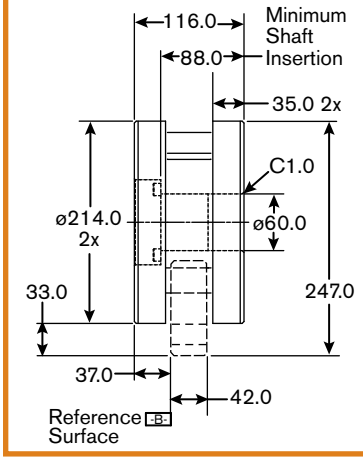


See the Nexen engineering drawings for your specific product number for additional dimensions and tolerances.

Pinion Dimensions

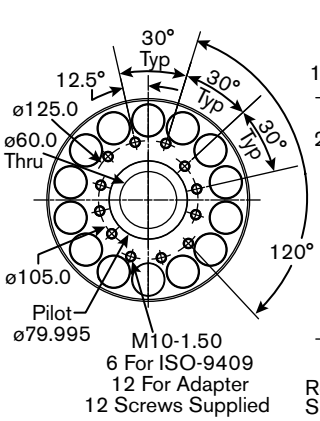
RPS4014

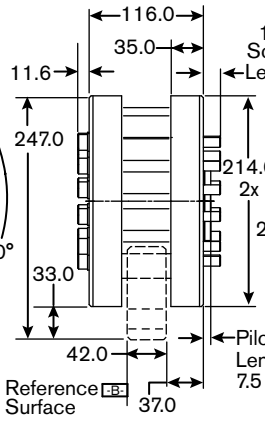
Shaft Mounted Pinion



ISO 9409 Flange Mount Pinion

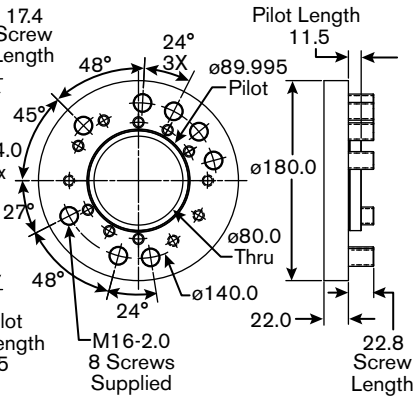
Pinion





Adapter

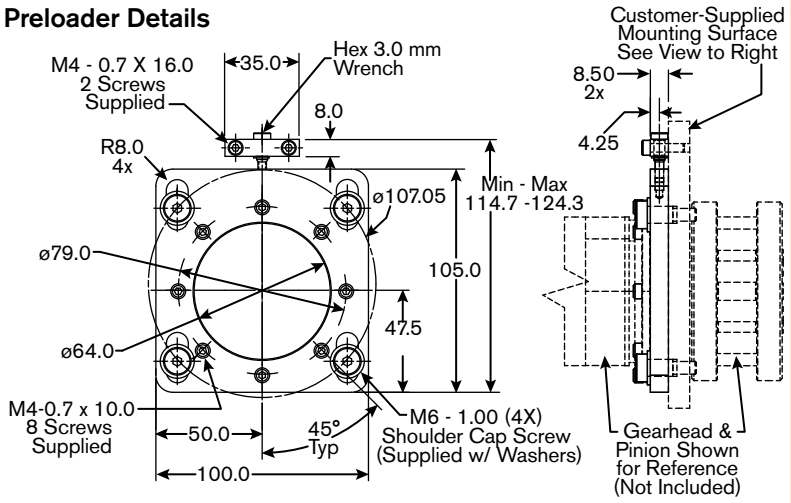
Required For Some Gearhead Sizes



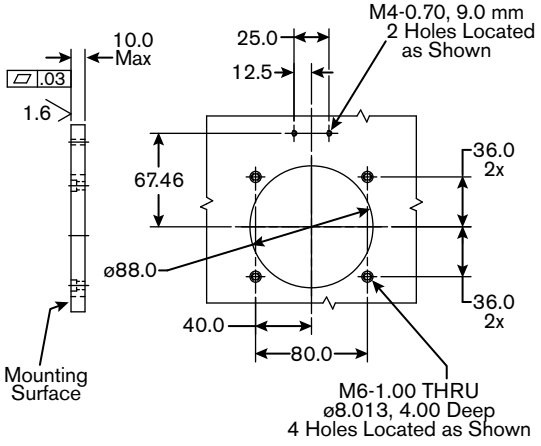
Preloader Dimensions

RPS-PRE-ISO-064-3 Product Number 960851

Preloader Details



Customer Mounting Surface Details



RPS-PRE-ISO-090-3 Product Number 960850

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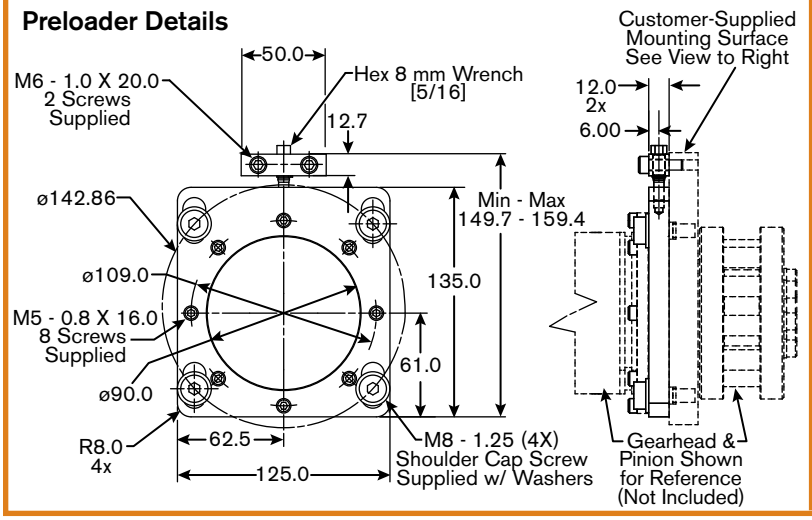
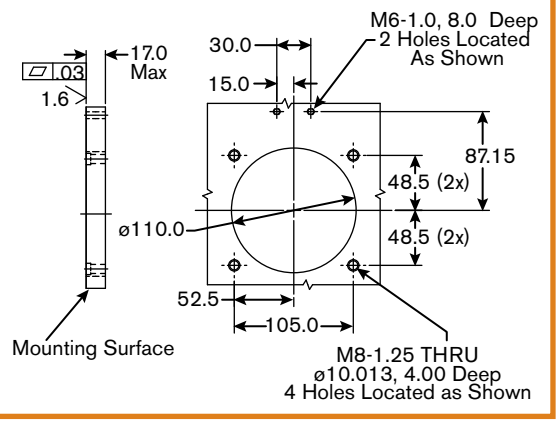


Customer Mounting Surface Details



Preloader Dimensions

RPS-PRE-ISO-110-3 Product Number 960852

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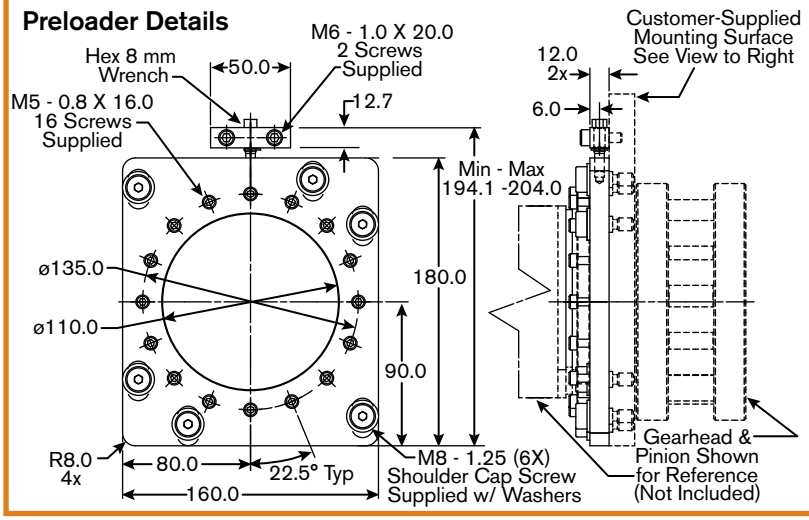
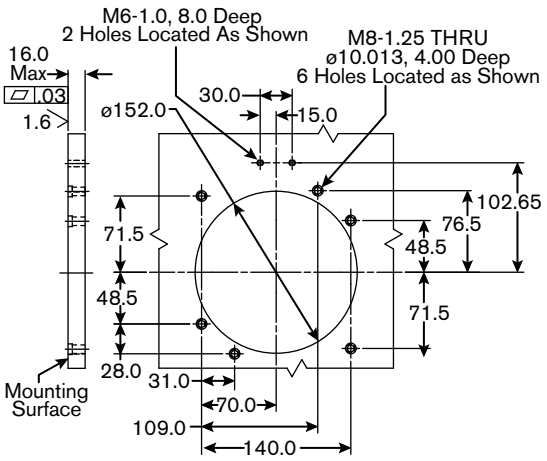
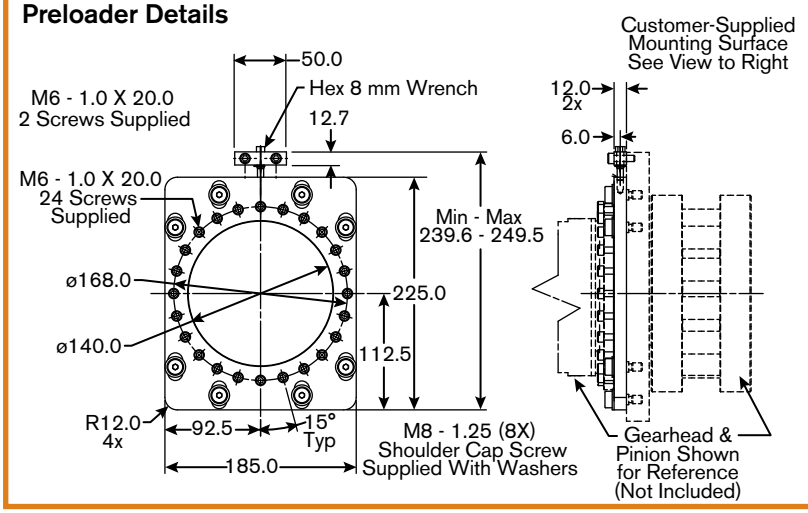


Customer Mounting Surface Details

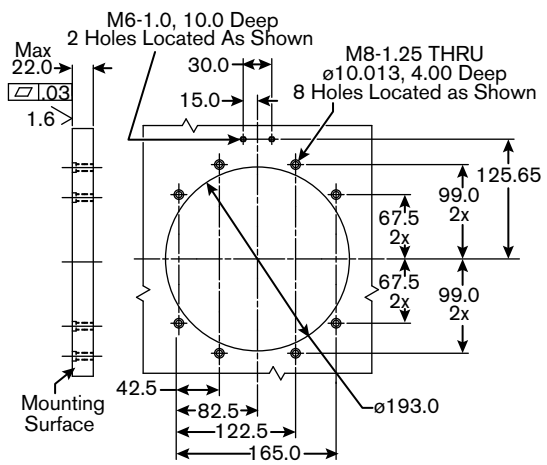


RPS-PRE-ISO-140-3 Product Number 960853

Preloader Details

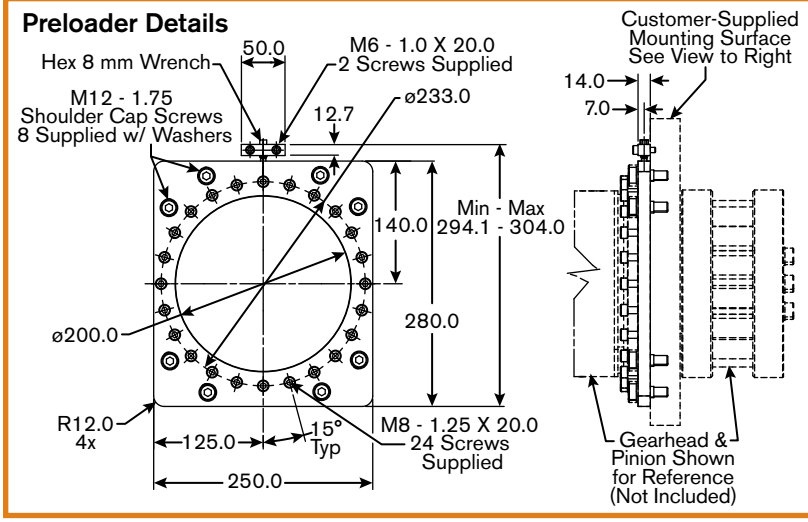


Customer Mounting Surface Details

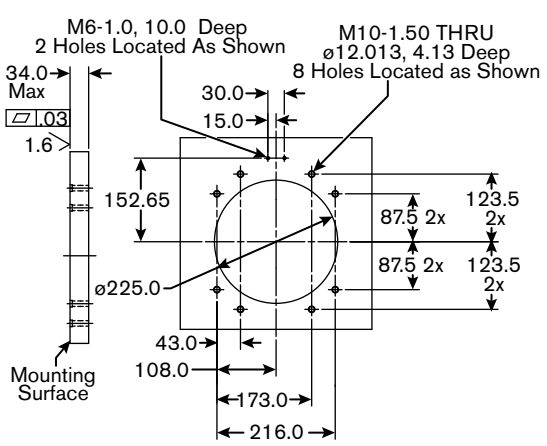


RPS-PRE-ISO-200-3 Product Number 960854

Preloader Details



Customer Mounting Surface Details



Definitions

Corrosion Resistance: Nexen makes no corrosion resistance claims for specific applications but does offer various corrosion countermeasures that include stainless steel and various surface treatments or coatings. Nexen will convey all material and coating specifications, but it is up to the customer to determine application suitability based on this information and/or thorough sample testing.

Life Rating: Pinion life is an estimate rounded down to the next 1,000 revolutions, and based on maintaining published accuracy specifications when operated with allowable dynamic loading for 60,000,000 pinion revolutions or individual roller contacts (10,000 hours) at a constant 100 rpm. The rack and gears have their own specific life ratings depending on model, and in some cases RPS size, and is based on tooth contacts at allowed loads and speeds. The combined pinion and rack or gear that makes up a given RPS or RPG system will have the combined life of the lower-rated component and will be greatly effected by machine design, RPS or RPG installation, operating patterns, and receiving recommended lubrication intervals while operated in a clean, dry, 20° C environment. Pinion performance tends to be constant over its life with a rapid deterioration at the end of life as the needle bearings supporting the rollers fail. Rack wear is more linear over its life. Application and environmental conditions and lubrication intervals will impact expected product life. Depending on the length of the rack or diameter of the gear and usage patterns, it is often possible to replace the pinion several times, restoring full system performance before the rack or gear would need replacement if the pinion is replaced before reaching the point where its failure starts damaging rack or gear teeth.

Lubrication Free Operation: In some cases the RPS rack can be operated without lubrication on the rack teeth or pinion rollers. This is dependent on the specific rack model and the maximum speed being less than 30 m/min. The no-lubrication option generally applies to rack that has received a surface treatment and does not apply to bare steel models of rack or any gearing. See specifications for the specific rack model you are considering to know if this is possible. Operating without tooth/roller lubrication will reduce tooth life but can be beneficial in food, pharmaceutical, clean room, and other applications where the grease could contaminate the environment, or applications with high levels environmental contaminates that would be attracted to the grease and accelerate the wear rate. Nexen can not calculate a life rating when running without lubrication due to the number of variables that impact life, but based on past experience, the reduction has been modest and far exceeds other mechanical drive alternatives.

Noise Rating: The RPS system is nearly silent at low speeds and typically less than 75 db at full speed. This is dependent on machine design, proper RPS installation, whether lubrication is used or not, and is difficult to isolate from other drive train and guiding system noise, so your results may vary.

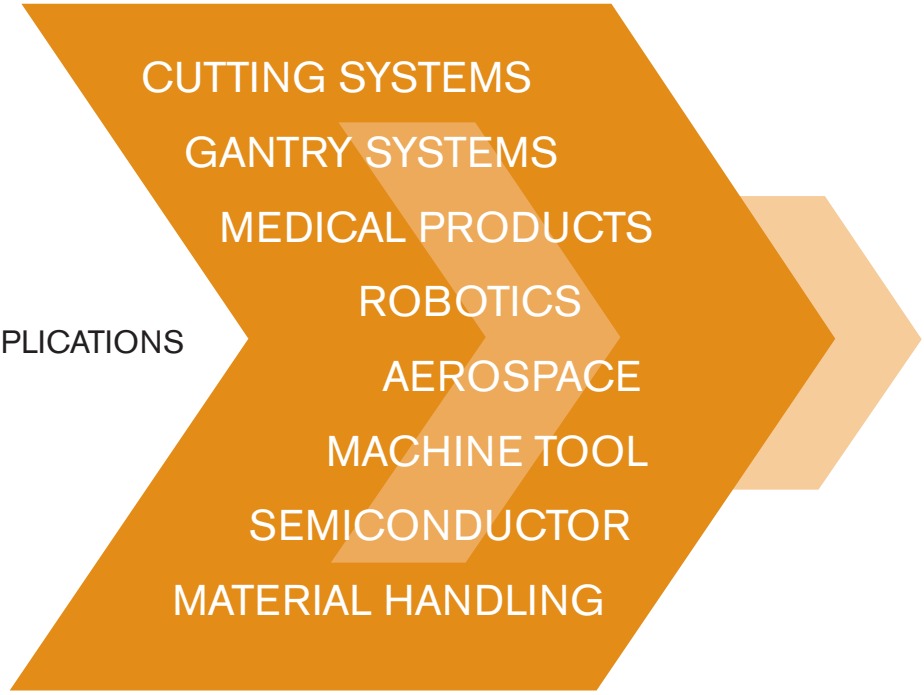
Operating Temperature Range: This is the range that the RPS system will function in. Accuracy specifications are based on 20° C and thermal expansion/contraction will effect the accuracy of the RPS system. It is recommended the RPS system be installed at the highest temperature the system will be operated at and avoid wide temperature swings for maximum accuracy and performance. For applications outside of this temperature range, or with wide temperature swings, contact Nexen for more information.

Positional Accuracy: This is dependent on proper machine design and RPS product installation. Positional accuracy is measured at 20° C and subject to variations due to mounting surface irregularities, rigidity, installation accuracy, proper maintenance, and ambient temperature. To be conservative, the RPS rack transmitting accuracy has been rounded up to the next ±10 µm. Other rack positional accuracy specifications have been rounded up to the next ±5 µm. For RPG gearsets, the angular accuracy rating is increased (less accurate) by 5% and then rounded to the next whole number, except in the case of very large gears where rounding may be fractional. This allows customers to achieve Nexen accuracy ratings with reasonable effort. Higher performance can be obtained if machine design and tolerances are optimized.

Backlash: The innovative design of the RPS tooth allows for a true zero-backlash drive system. As with any high-precision component, proper setup and installation is critical. Following Nexen's recommended installation procedures, practices, and tolerances, ensures proper performance of your RPS drive components. The backlash rating is measured upon setup at the point of preload.

Series: The RPS and RPG pinions, racks and gears are made in different series (thicknesses) depending on the specific product and should not be mixed when matching a pinion to a given rack or gear. Series A pinions (discontinued) are interchangeable with C-series pinions and have a wider body with longer rollers than the B-series pinions. The current rack products only use B-series pinions, and the gears could use either depending on the RPG size. B-series pinions will not physically fit on a C-series gear, and a C-series pinion would be compromised if used on a B-series rack or gear due to a higher bending moment on the rollers, which would reduce their lives.

INDUSTRIES & APPLICATIONS



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In accordance with Nexen's established policy of constant product improvement, the specifications contained in this document are subject to change without notice. Technical data listed in this document are based on the latest information available at the time of printing and are also subject to change without notice. For current information, please consult www.nexengroup.com or contact Nexen's Technical Support Group at the location to the right.

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FORM NO. L-21262-C-0113