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RPS SYSTEM LIFE

The RPS system offers an efficiency greater than 99% with a long life of up to 60,000,000 pinion revolutions (up to 36 million meters of travel). Typically the rack/gear lasts through several pinion changes.

Calculating RPS System Life

The calculations in the following section will allow you to calculate the expected rack and pinion life. These calculations will result in the same values as the charts on the following pages.

RPS Pinion Life Data & Calculations

Table 7 RPS Pinion Life Values

		RPS10	RPS12	RPS16		RPS20		RPS25		RPS32	RPS40	RPS4014
				premium	value	premium	value	premium	value			
Max Torque (T_{max})	Nm	4.0	9.5	61.1	12.8	92.3	23.9	159.2	43.8	385.0	458.4	1247.8
Torque at Max Life (T_{final})	Nm	4.0	9.5	33.7	12.8	52.5	23.9	89.5	43.8	218.7	458.4	1247.8
Distance Per Revolution (L_{rev})	meters	0.1	0.12	0.16	0.16	0.2	0.2	0.25	0.25	0.384	0.48	0.56
Transition Point (E_T)	million contacts	60	60	8	2	8.2	2	8.5	2	9.2	60	60
Max Life ($N_{max\ contacts}$)	million contacts	60	60	60	2	60	2	60	2	60	60	60
Constant (C)		NA	NA	115.30	NA	179.43	NA	305.91	NA	747.91	NA	NA

STEP 1: GATHER APPLICATION DATA

Before you begin calculations, there are three key measurements that you will need from your application. Collect the data and record it in space provided to the right.

Measurements Required for Pinion Calculations	Customer Data (record your values below)	*Sample Data*
Average Torque (T_{avg})	Nm	*85 Nm*
Distance Per Cycle (L) (single direction move)	m	*1.3 m*
Average Speed (V_{avg})	m/s	*2 m/s*

STEP 2: CALCULATE THE TOTAL NUMBER OF PINION CONTACTS ($N_{CONTACTS}$)

Perform the following calculations using the data collected from your application data in Step 1.

PINION ROLLER CONTACTS ($N_{contacts}$)

The total number of roller contacts ($N_{contacts}$) that an RPS Pinion can sustain before needing replacement is based on the average torque of your application. Determine which equivalency or inequality statement below is true for the average torque (T_{avg}) of your application. Then complete the corresponding pinion roller contact equation and record your value below.

IF T_{avg} is:	THEN $N_{contacts}$:
$\leq T_{final}$	$= N_{max\ contacts}$
$> T_{final}$ AND $< T_{max}$	$= (C \div T_{avg})^{3.333} = (\quad \div \quad \text{Nm})^{3.333}$
$= T_{max}$	$= E_T$

Pinion Life in Roller Contacts

$N_{contacts} =$ million contacts

Sample: *(Evaluating RPS20 size)* $N_{contacts} = (179.43 \div 85\ \text{Nm})^{3.333} = 12$ *million contacts*

STEP 3: CONVERT ROLLER CONTACTS TO HOURS, METERS OR REVOLUTIONS

There are two options for converting contacts to other units: exact and estimated. Exact should be used whenever possible. The estimation is available for customers who do not have a well-defined distance per cycle.

EXACT OPTION: PINION LIFE IN HOURS (N_{hours})

Use Table 7 along with the data you collected above to calculate the total number of service hours your pinion can provide before needing replacement. First calculate E_1 to use in the N_{hours} equation.

$$E_1 = L \div L_{rev}$$

Must round E_1 up to the nearest whole integer.

E_1 = round up (____ m ÷ ____ m) = ____

Sample: *E_1 = 1.3 m ÷ 0.2 m = 6.5 m ⟶ Round up to 7.*

$$N_{hours} = (N_{contacts} \cdot 10^6 \cdot L) \div (3600 \cdot E_1 \cdot V_{avg})$$

N_{hours} = (____ million contacts • 10^6 • ____ m) ÷ (3600 • ____ • ____ m/s)

Sample: *$N_{hours} = (12 \cdot 10^6 \cdot 1.3\ m) \div (3600 \cdot 7 \cdot 2\ m/s) = 309.5\ hrs$*

Pinion Life in Hours

N_{hours} = ____ hrs

ESTIMATION OPTIONS: PINION LIFE IN METERS & LIFE IN REVOLUTIONS

These calculations assume the pinion travels nonstop in one direction throughout its whole life.

PINION LIFE IN METERS (N_{meters})

$$N_{meters} = N_{contacts} \cdot L_{rev} \cdot 10^6$$

N_{meters} = ____ • ____ m • 10^6

Sample: *$N_{meters} = 12 \cdot 0.2\ m \cdot 10^6 = 2{,}400{,}000\ m$*

Pinion Life in Meters

N_{meters} = ____ m

PINION LIFE IN REVOLUTIONS (N_{rev})

$$N_{rev} = N_{contacts}$$

Sample: *N_{rev} = 12 million revolutions*

Pinion Life in Revolutions

N_{rev} = ____ million revolutions

RPS Rack Life Data

Table 8 RPS Rack Life Values

	RPS Rack Size	Unit	RPS10	RPS12	RPS16	RPS20	RPS25	RPS32	RPS40	RPS4014
	Pitch (**P**)	meters	0.01	0.012	0.016	0.02	0.025	0.032	0.04	0.04
	Distance Per Revolution (L_{rev})	meters	0.1	0.12	0.16	0.2	0.25	0.384	0.48	0.56
Premium & Standard	Max Dynamic Thrust (F_{max})	N	250	500	2400	2900	4000	6300	6000	14000
Premium & Standard	Thrust at Max Life (F_{final})	N	250	500	1000	1500	2200	3600	6000	14000
Premium & Standard	Transition Point (E_T)	million contacts	30	30	5	5	5	5	30	30
Premium & Standard	Max Life ($N_{max\ contacts}$)		30 Million Contacts							
Premium & Standard	Slope (**m**)		NA	NA	-56	-56	-72	-108	NA	NA
Premium & Standard	Intercept (**b**)	N	NA	NA	2680	3180	4360	6840	NA	NA
Endurance	Max Dynamic Thrust (F_{max})	N	NA	NA	1500	2250	3300	5 400	6000	14000
Endurance	Thrust at Max Life (T_{final})	N	NA	NA	1000	1500	2200	3600	6000	14000
Endurance	Transition Point (E_T)	million contacts	NA	NA	5	5	5	5	30	30
Endurance	Max Life ($N_{max\ contacts}$)		NA	NA	30 Million Contacts					
Endurance	Slope (**m**)		NA	NA	-20	-30	-44	-72	NA	NA
Endurance	Intercept (**b**)	N	NA	NA	1600	2400	3520	5760	NA	NA
Universal & Universal Stainless	Max Dynamic Thrust (F_{max})	N	NA	NA	750	1125	1650	2700	4500	10500
Universal & Universal Stainless	Thrust at Max Life (F_{final})	N	NA	NA	750	1125	1650	2700	4500	10500
Universal & Universal Stainless	Max Life ($N_{max\ contacts}$)		NA	NA	5 Million Contacts				2 Million Contacts	
Versa	Max Dynamic Thrust (F_{max})	N	NA	NA	500	750	1100	NA	NA	NA
Versa	Thrust at Max Life (F_{final})	N	NA	NA	500	750	1100	NA	NA	NA
Versa	Max Life ($N_{max\ contacts}$)		NA	NA	2 Million Contacts				NA	

RPS Rack Life Calculations

STEP 1: GATHER APPLICATION DATA

Before you begin calculations, there are three key measurements that you will need from your application. Collect the data and record it in space provided below.

Measurements Required for Rack Calculations	Customer Data (record your values below)	*Sample Data*
Average Thrust Force (**F_{avg}**)	N	*2500 N*
Distance Per Cycle (**L**) (single direction move)	m	*1.3 m*
Average Speed (**V_{avg}**)	m/s	*2 m/s*

STEP 2: CALCULATE THE TOTAL NUMBER OF TOOTH CONTACTS

Perform the following calculations using the data collected from your application and the values from Table 8.

RACK TOOTH CONTACTS ($N_{contacts}$)

The total number of tooth contacts ($N_{contacts}$) that an RPS Rack can sustain before needing replacement is based on the average thrust force of your application. Use Table 5 to determine which equivalency or inequality statement below is true for the average thrust force (F_{avg}) of your application. Then complete the corresponding rack tooth contact formula and record your value below.

IF F_{avg} is:	THEN $N_{contacts}$:
$\leq F_{final}$	$= N_{max\ contacts}$
$> F_{final}$ AND $< F_{max}$	$= (F_{avg} - b) \div m = ($ ____ N − ____ N $) \div$ ____
$= F_{max}$	$= E_T$

Rack Life in Tooth Contacts

$N_{contacts} =$ ____ million contacts

Sample: *(Evaluating RPS20 size)* $N_{contacts} = (2500\ N - 3180) \div -56 = 12$ *million contacts*

STEP 3: CONVERT RACK TOOTH CONTACTS TO HOURS OF LIFE

Perform the following calculations using the data collected from your application and the values from Table 5.

RACK LIFE IN HOURS (N_{hours})

Use Table 5 along with the data you collected above to calculate the total number of service hours your rack can sustain before needing replacement.

$$N_{hours} = (N_{contacts} \div 3600) \bullet (L \div V_{avg}) \bullet 10^6$$

$N_{hours} = ($ ____ $\div 3600) \bullet ($ ____ m $\div$ ____ m/s$) \bullet 10^6$

Rack Life in Hours

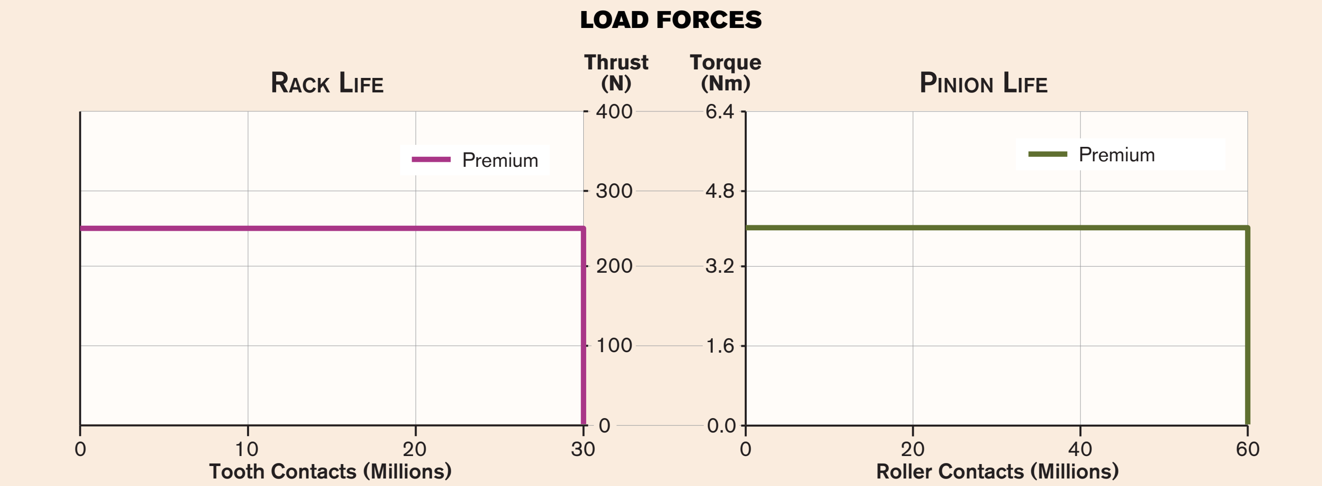
$N_{hours} =$ ____ hours

Sample: $N_{hours} = (12 \div 3600) \bullet (1.3\ m \div 2\ m/s) \bullet 10^6 = 2166$ *hours*

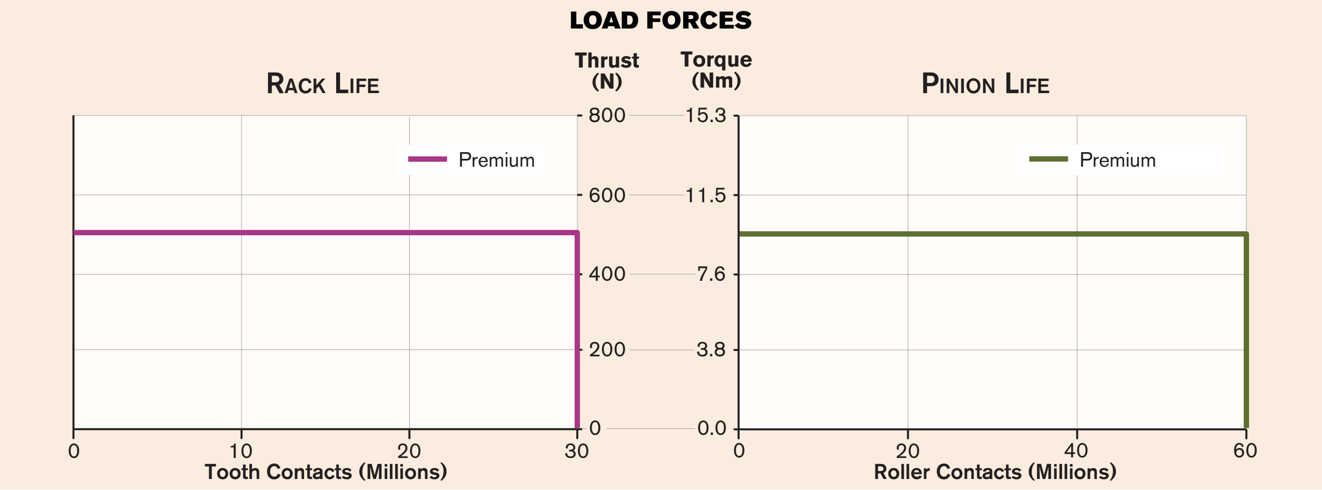
RPS System Life Graphs (RPS10, 12 & 16)

The RPS system life ratings are based on the force of the load. Refer to the following graphs to determine the pinion and rack life based on your application load forces. Graphs show the thrust along side the corresponding torque to more easily calculate your complete system life. Typically the pinion can be replaced numerous times before replacing the rack.

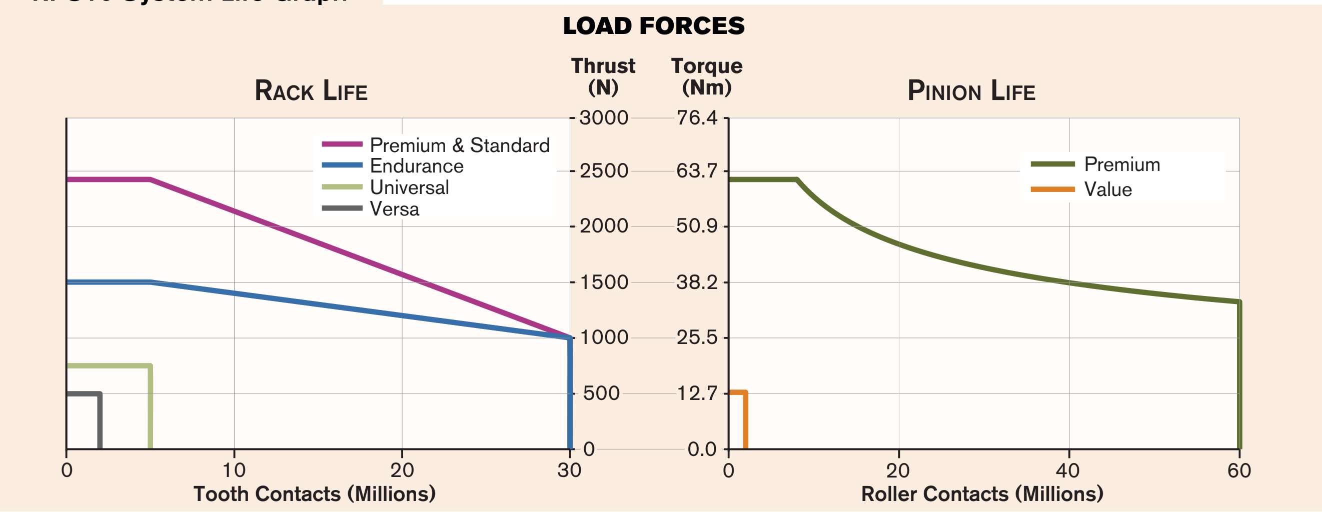
RPS10 System Life Graph



RPS12 System Life Graph

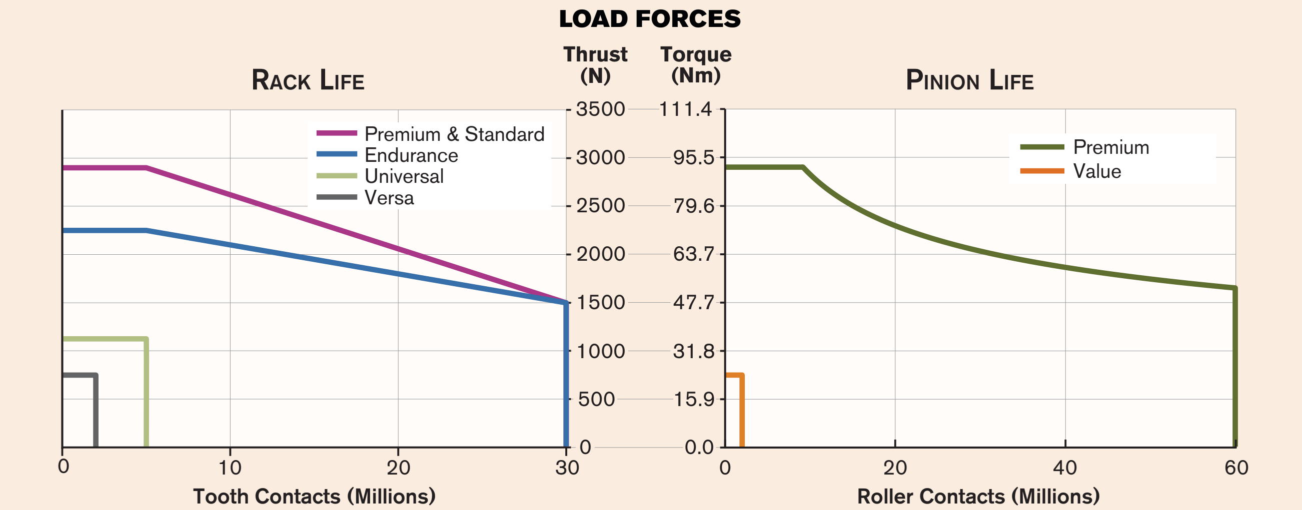


RPS16 System Life Graph

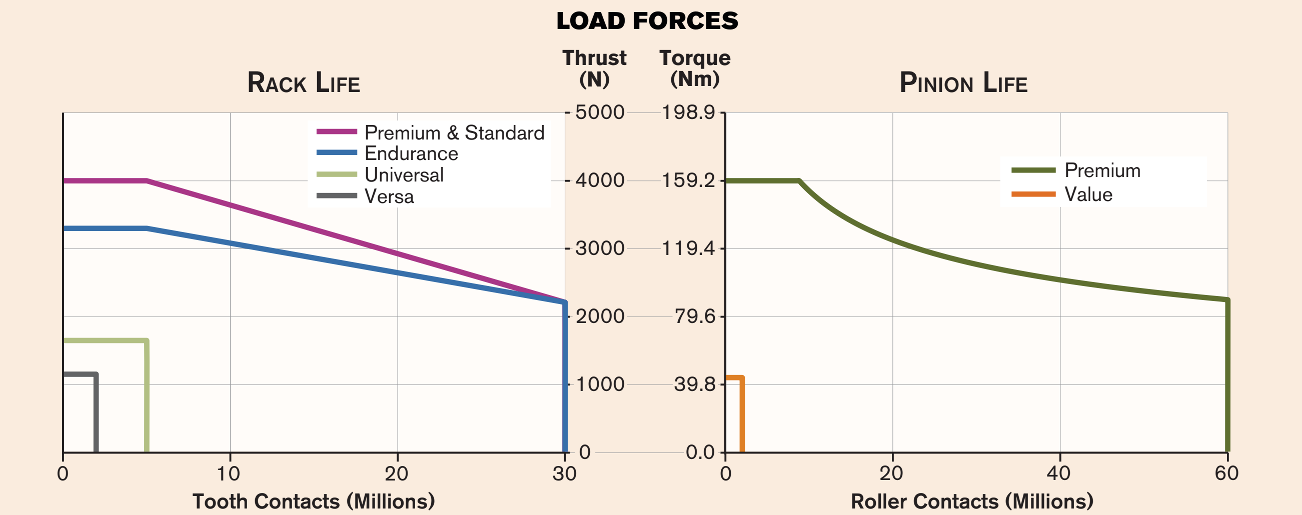


RPS System Life Graphs (RPS20, 25 & 32)

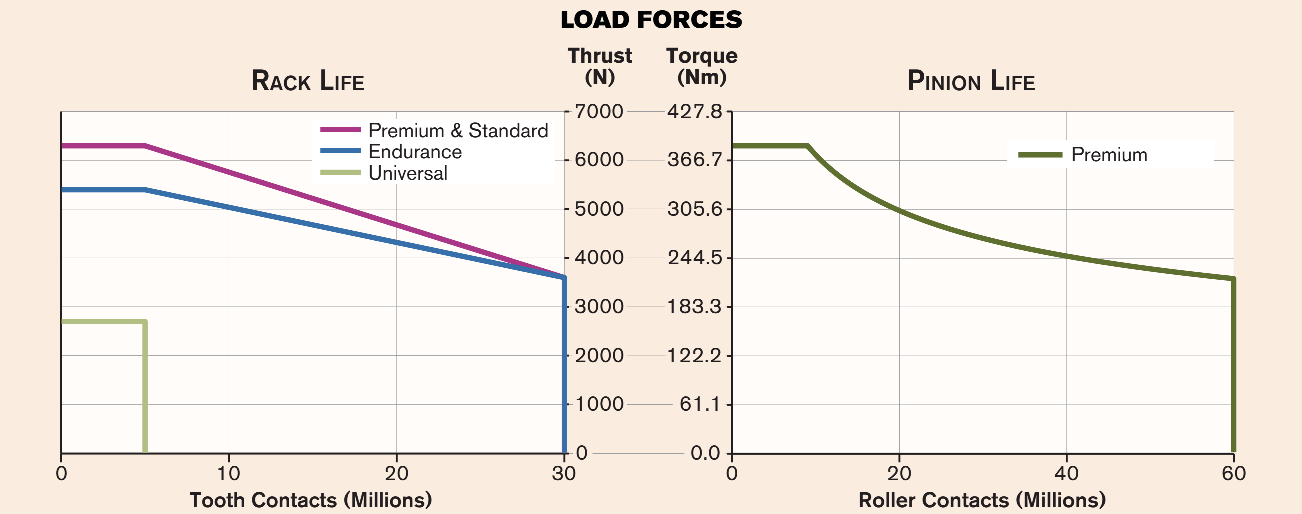
RPS20 System Life Graph



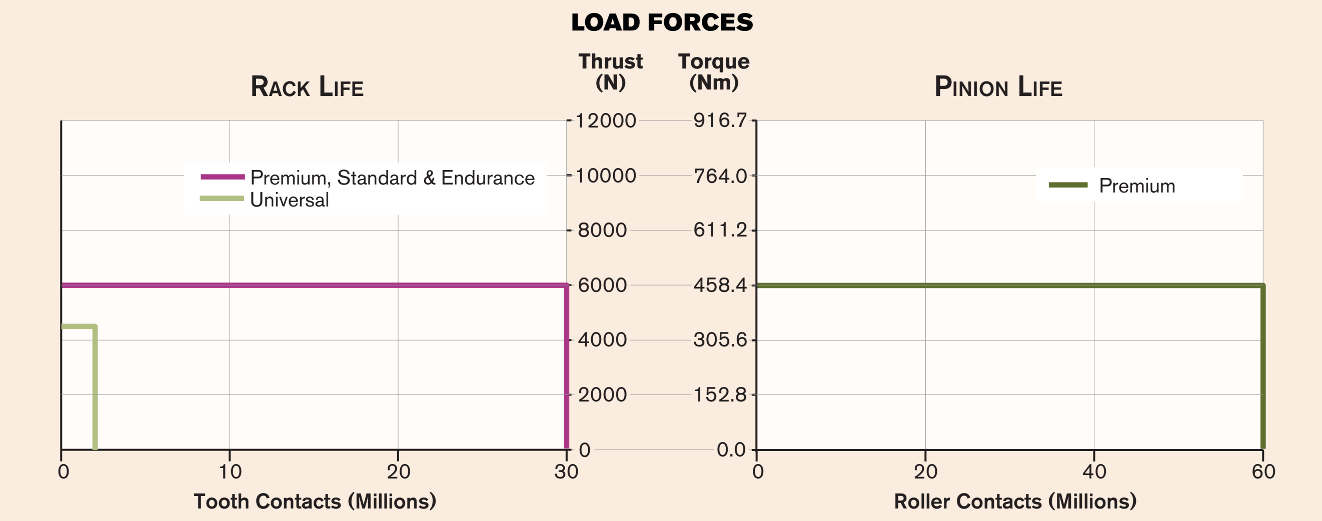
RPS25 System Life Graph



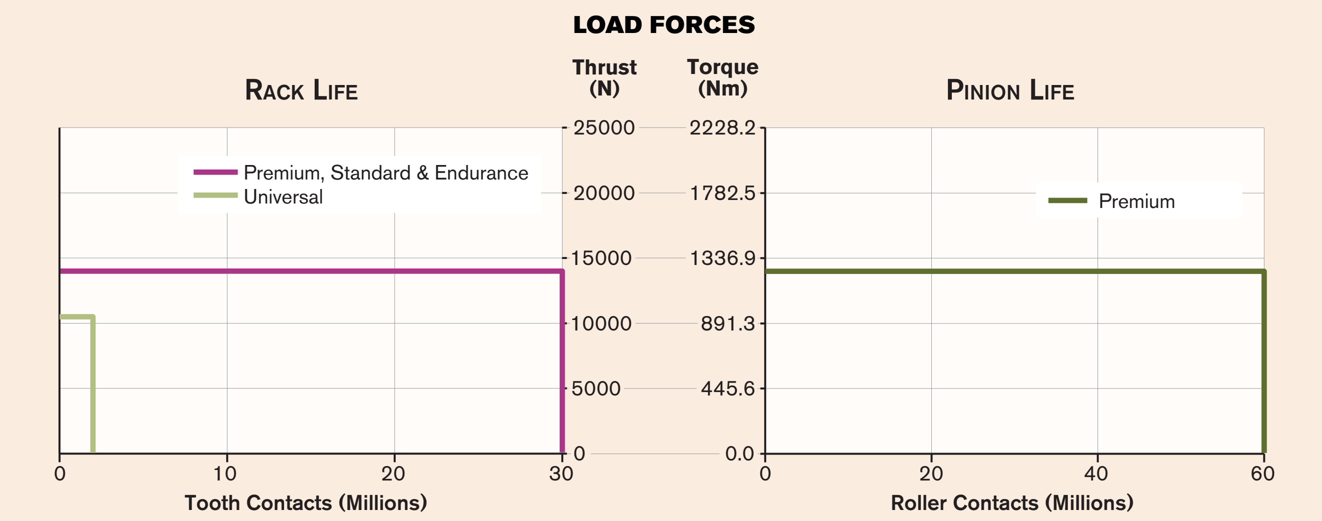
RPS32 System Life Graph



RPS40 System Life Graph



RPS4014 System Life Graph



Appendix: Definitions & Notes

ARCSECOND
ArcSecond is a unit of angular measurement equal to $^1/_{3600}$ of a degree.

BACKLASH
The innovative design of the RPS tooth allows for a zero-backlash drive system. Because zero backlash is impossible to measure, industry standard maintains that anything under 3.2 microns is considered zero.

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.

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).

LIFE RATING

Pinions: Pinion life is based on L10 of the bearing components. Just like any bearing, environmental conditions will affect life. The product rating is assuming a clean environment with normal manufacturing facility temperatures.

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.

Racks & Gears: 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.

Rack wear is relatively 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.

MASS VS. WEIGHT

Mass is the quantity of matter contained in an object, while weight is the force by which the object is pulled to the earth due to gravity. Therefore, in this literature, mass is shown in kilograms (kg) and weight is shown in kilograms force (kgf).

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.

SERIES DIFFERENTIATION

The RPS and RPG pinions, racks and gears have been 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. All current pinions, racks and gears are B-series. Series A pinions (discontinued) are interchangeable with C-series pinions (discontinued) and have a wider body with longer rollers than the B-series pinions. The current rack and gear products only use B-series pinions, and the previous 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.

SHOCK FACTOR

Shock Factor is a value given to represent the smoothness of operation. Accommodating for Shock Factor when calculating system requirements ensures more accurate product selection.

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