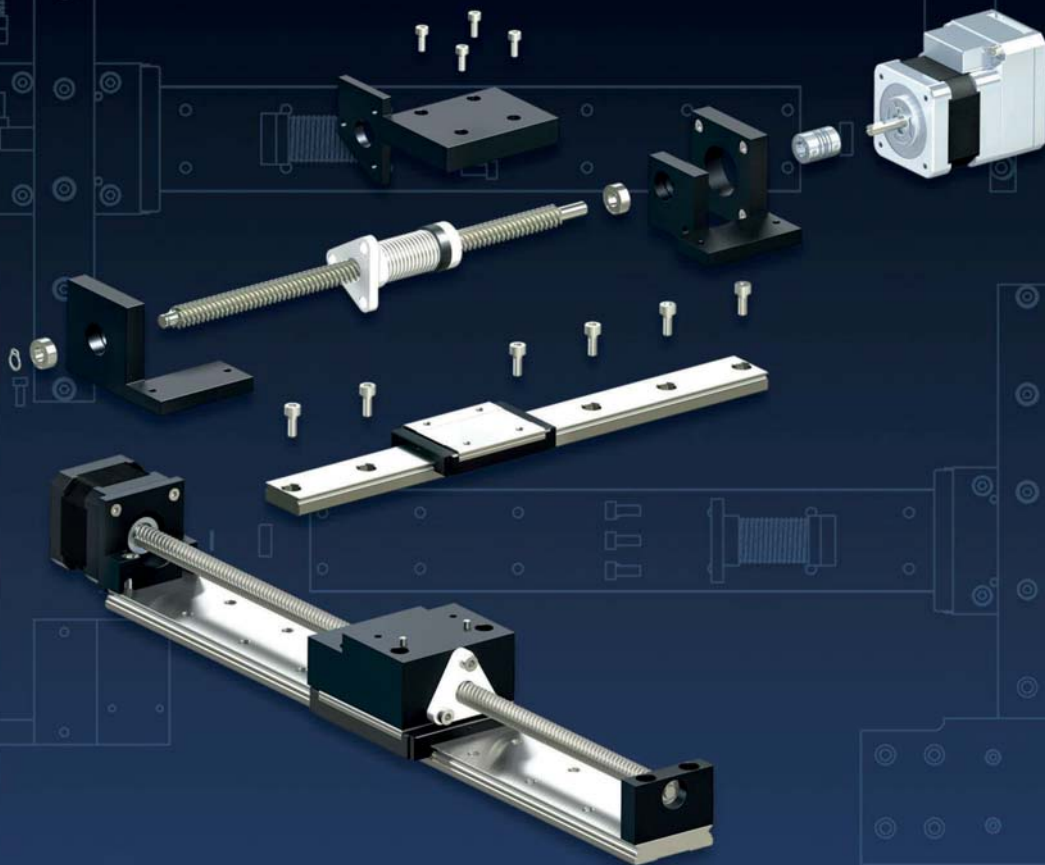










Reliance[®]

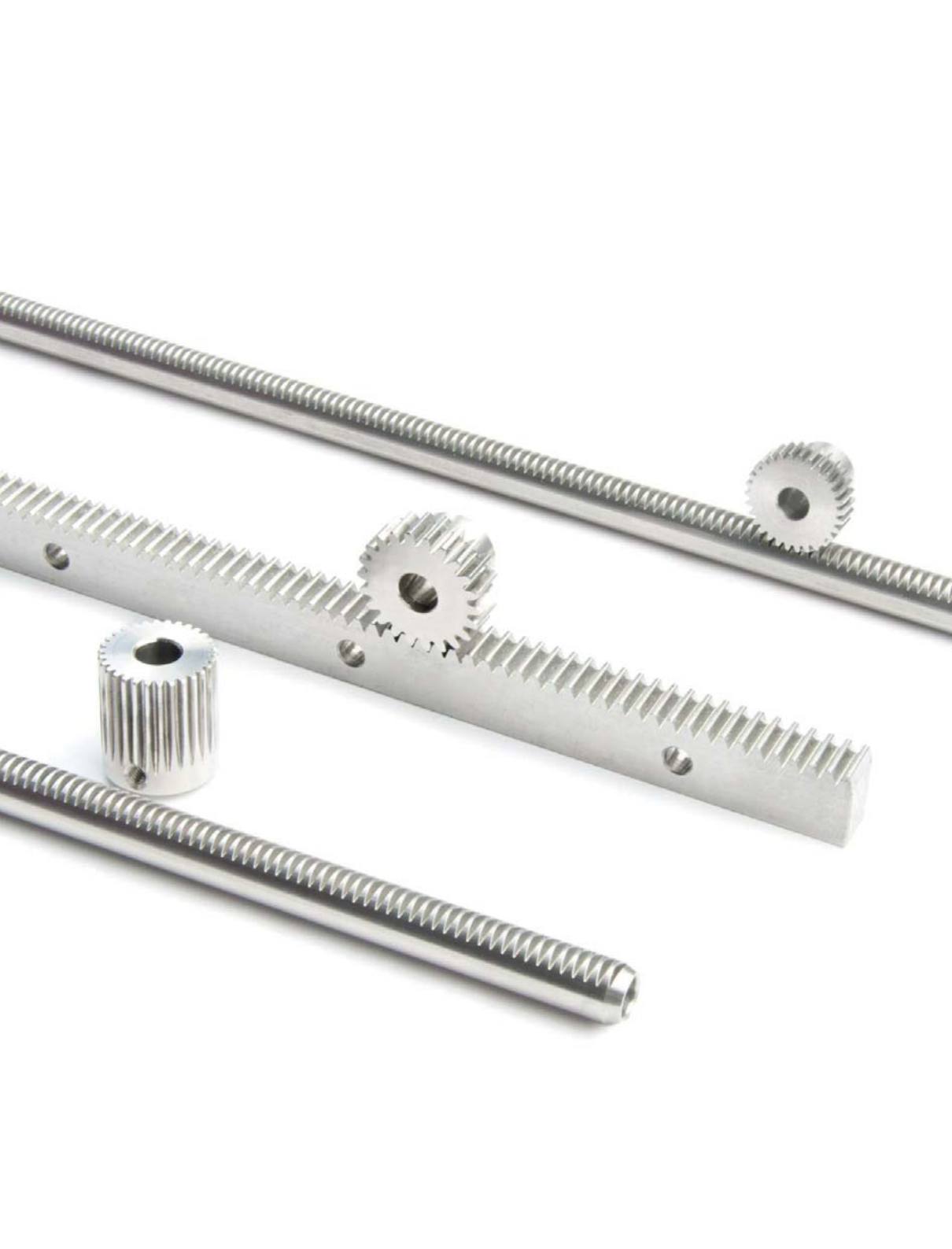
Precision Limited



Precise Motion Control Solutions

Round and Rectangular Racks and Pinions

	<i>Introduction to Reliance</i>	<i>i</i>
	<i>Systems Overview</i>	<i>1</i>
	Intelligent Motors and Motorised Actuators	2
	Planetary and Right Angle Gearboxes	3
	Brass, Ground and Precision Spur Gears	4
	Worms and Wheels, Bevels and Internal Gears	5
	Round and Rectangular Racks and Pinions	6
	Leadscrews and Leadscrew Assemblies	7
	Flexible Shaft Couplings, Clutches and Collars	8
	Linear Guides and Slides	9
	Belts and Pulleys	10
	Gear Clamps and Accessories	11
	Bearings and Spacers	12
	Machine Screws, Dowel Pins and Hardware	13
	<i>Technical Information</i>	<i>14</i>
	<i>Appendices and Index</i>	<i>15</i>



Section Contents

Racks and Pinions - Overview	Page 6-2
Precision Ground Rack - Hardened Rectangular	Page 6-3
Precision Ground Rack - Hardened Round	Page 6-4
Precision Ground Rack - Soft Round Solid	Page 6-5
Precision Ground Rack - Soft Round Tubular	Page 6-6
Precision Hobbed Rack - Soft Round.....	Page 6-7
Precision Hobbed Rack - Soft Rectangular	Page 6-8
Hobbed Brass Rack - Rectangular	Page 6-9
Plain Rack Pinions	Page 6-10
Hardened Rack Pinions	Page 6-10
Anti-backlash Rack Pinions	Page 6-11
Technical Information.....	Page T6-1



Accurate conversion from rotary to linear motion

A rack and pinion system gives the ability to transfer rotary to linear motion, with all the accuracy expected of a geared system.



The racks are manufactured from ground, hardened stainless steel or ground stainless steel and available with a choice of accuracies, pitches, and lengths, plus the facility to provide modifications such as flats, journals or custom ends. Hobbed stainless steel and brass racks are also available. The rack pinions are plain or anti-backlash, also with a choice of accuracies, pitches, bore sizes, alternative materials and coatings.

Ground racks can be used for both measurement and actuation. In general the smaller pitches (1 mm) suit measurement as the smaller pinion diameter gives higher linear resolutions. The larger pitches (2 mm and 2.5 mm) allow for a higher load capacity. For most applications the rack can be used for both the feedback and the actuation; however in very precise applications it is best to use a non-drive section of the rack for feedback, alternatively a separate rack can be used. Hobbed racks are more suited to light actuation applications where cost is a key consideration.

We offer three types of rack – rectangular racks, solid round racks and tubular racks. Rectangular racks are used when the application requires the rack to be stationary and the rack pinion provides the element of motion. Our rectangular racks are used with a motor, slide and carriage for example in the printing industry for the actuation of paper cutting knives in a printing press. Round racks are a more flexible alternative, with regard to mounting, used for example in XY stages. The tubular racks allow for the passage of fluids, fibre-optics, gasses etc, making them ideal for medical and scientific applications, such as laboratory automation pick and place mechanisms.

For a fully integrated solution the Racktuator™ (see [page 2-14](#)) is a combined rack and intelligent motor actuation system. Bringing together Reliance's racks and Cool Muscle servo system, the Racktuator™ provides a very high level of control and accuracy in a compact, space saving package.



Laboratory automation systems



Printing automation systems

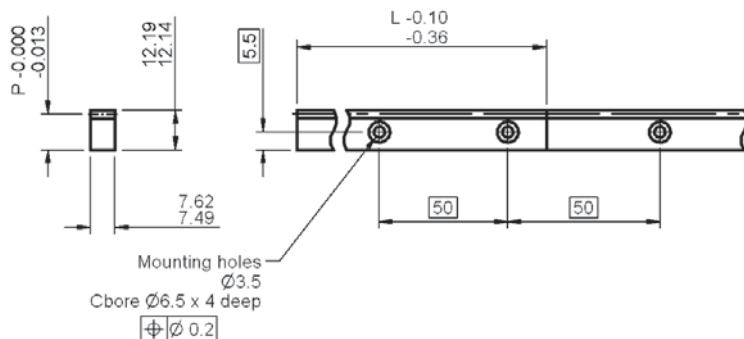
Precision Ground Rack Hardened Rectangular

1, 2 & 2.5mm
Circular Pitch



Associated Products
Rack pinions: page 6-10

All dimensions in mm
Material: Stainless steel grade 416
Treatment: Hardened to 35-45 HRC
Pressure angle 20°



Part number selection table

Part Number	Circular Pitch (mm)	Length L	Pitch Height P	Number of Holes
R9-1M-300	1	300	11.869	6
R9-2M-300	2		11.550	
R9-25M-300	2.5		11.391	



i Features and options

- Cumulative pitch error less than 0.008 mm per 300 mm
- Ground teeth, accuracy grade 4 as standard
- Alternative grades available - see [page T6-1](#)
- Unlimited axis lengths possible by setting individual racks together
- Shorter lengths available
- Alternative pitches, including module
- Small quantities of selected items available ex-stock, please visit our on-line store: www.reliance.co.uk/shop

? Technical support

- Installation information - see [page T6-4](#)
- Technical information - see [pages T6-1 to T6-6](#)
- PTFE based grease is recommended for lubrication
- For modified or fully bespoke racks, please contact us

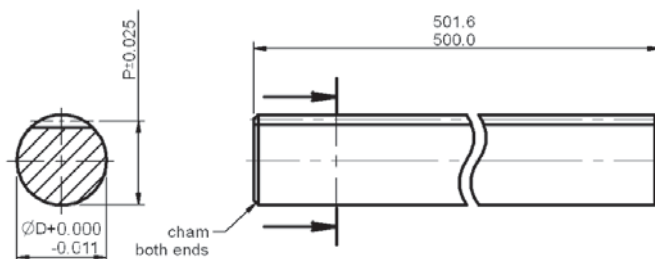


Ø12mm 2mm Circular Pitch

Precision Ground Rack Hardened Round

All dimensions in mm
General tolerances ± 0.13 mm
Material: Linear bearing shaft
stainless steel grade 440C
or X90CrMoV18
Treatment: Case hardened to
55 HRC min
Pressure angle 20°

Associated Products
Rack pinions: page 6-10



Part number selection table

Part Number	Circular Pitch (mm)	Outer Dia ØD	Pitch Height P	Rack Thrust (N)
RR12-1M-500	1	12	11.841	30*
RR12-2M-500	2		11.682	60*

* Rack thrust based on meshing with a 60 tooth hardened rack pinion, theoretically calculated.



i Features and options

- Cumulative pitch error less than 0.025 mm
- Ground teeth, accuracy grade 3 as standard
- Higher accuracy grades available
- Bearing surface and drive in one component
- Shorter lengths available
- Alternative pitches available
- Flats, journals and end modifications
- Small quantities of selected items available ex-stock, please visit our on-line store: www.reliance.co.uk/shop

? Technical support

- Installation information - see [page T6-4](#)
- Technical information - see [pages T6-1 to T6-6](#)
- PTFE based grease is recommended for lubrication
- Can be used with both open and closed linear bearings with either 4, 5 or 6 ball tracks (the bearing must be positioned so the balls do not run on the edges of the teeth - see [page T6-3](#)).
- For modified or fully bespoke racks, please contact us

Associated Products

Rack pinions - CP: page 6-10

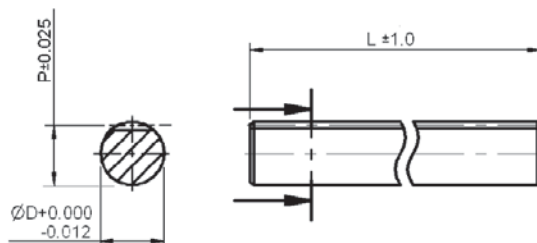
Rack pinions - Module: page 4-12

All dimensions in mm

General tolerances ± 0.13 mm

Material: Stainless steel grade 300

Pressure angle 20°



Part number selection table

Part Number	Pitch (mm)	Length L	Outer Dia ØD	Bore Dia Ød	Pitch Height P	Rack Thrust (N)
RRS06-1M-500	1 mm CP	500	6	-	5.682	20*
RRS10-050-500	0.5 module	500	10	-	9.500	40*

* Rack thrust based on meshing with a 50 tooth stainless steel pinion, 3 N if used with a 50 tooth PEEK polymer pinion.



i Features and options

- Cumulative pitch error less than 0.050 mm
- Ground teeth, accuracy grade 2 as standard
- High resistance to pitting corrosion
- Flats, journals and end modifications
- Ideal for medical and scientific applications
- Bearing surface and drive in one component
- Shorter lengths available
- Alternative pitches available
- Small quantities of selected items available ex-stock, please visit our on-line store: www.reliance.co.uk/shop

? Technical support

- Installation information - see [page T6-4](#)
- Technical information - see [pages T6-1 to T6-6](#)
- PTFE based grease is recommended for lubrication
- For modified or fully bespoke racks, please contact us

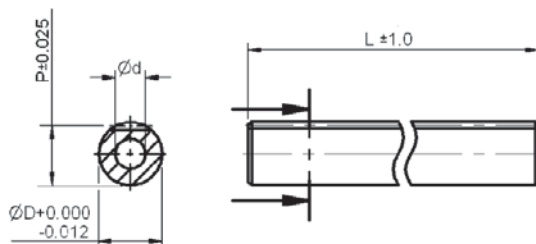


1mm Circular Pitch 0.3 Module

Precision Ground Rack Soft Round Tubular

All dimensions in mm
General tolerances ± 0.13 mm
Material: Stainless steel grade 316
Pressure angle 20°

Associated Products
Rack pinions - CP: page 6-10
Rack pinions - Module: page 4-12



Part number selection table

Part Number	Pitch (mm)	Length L	Outer Dia ØD	Bore Dia Ød	Pitch Height P	Rack Thrust (N)
RRT06-1M-500	1 mm CP	500	6	3.6	5.682	20*
RRT06-030-500	0.3 module				5.700	

* Rack thrust based on meshing with a 50 tooth stainless steel pinion, 3 N if used with a 50 tooth PEEK polymer pinion.



i Features and options

- Cumulative pitch error less than 0.050 mm
- Ground teeth, accuracy grade 2 as standard
- High resistance to pitting corrosion
- Hollow shaft allows for the passage of fluids, fibre-optics and gasses etc
- Ideal for medical and scientific applications
- Bearing surface and drive in one component
- Flats, journals and end modifications
- Shorter lengths available
- Alternative pitches available
- Small quantities of selected items available ex-stock, please visit our on-line store: www.reliance.co.uk/shop

? Technical support

- Installation information - see [page T6-4](#)
- Technical information - see [pages T6-1 to T6-6](#)
- PTFE based grease is recommended for lubrication
- For modified or fully bespoke racks, please contact us

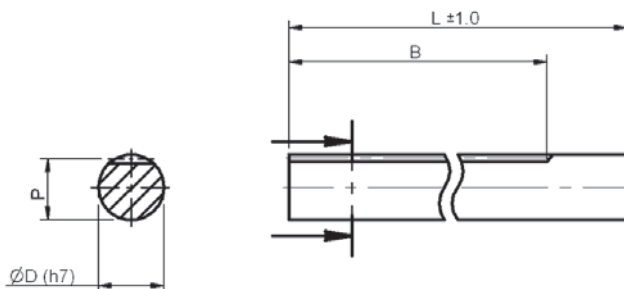
Precision Hobbed Rack Soft Round

0.5, 0.75, 0.8
& 1.0 Module



Associated Products
Rack pinions: page 4-12

All dimensions in mm
Material: Stainless steel grade 304
Pressure angle 20°



Part number selection table

Part Number	Module	Number of Teeth	Length L	Pitch Height P	Extent of Teeth B	Diameter D	Weight (g)
ORK50SU2-0815	0.5	95	202	7.5	149	8	78
ORK75SU2-0815	0.75	63	202	7.25	148	8	76
ORK80SU2-0815	0.8	59	202	7.2	148	8	76
ORK1SU3-1024	1.0	76	305	9.0	238	10	177



i Features and options

- Longer tooth lengths available, please contact us
- Small quantities of selected items available ex-stock, please visit our on-line store: www.reliance.co.uk/shop

? Technical support

- PTFE based grease is recommended for lubrication
- Installation information - see [page T6-4](#)
- Technical information - see [pages T6-1 to T6-6](#)
- For modified or fully bespoke racks, please contact us

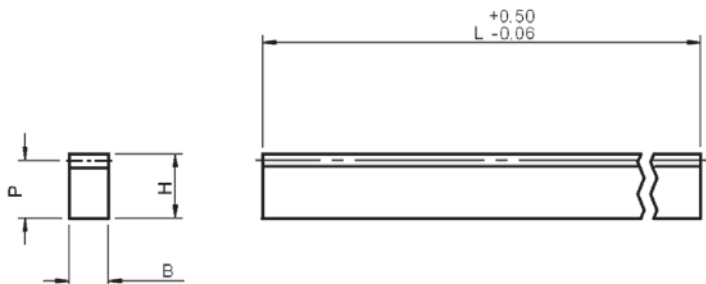


**0.5, 0.75, 0.8
& 1.0 Module**

Precision Hobbed Rack Soft Rectangular

All dimensions in mm
Material: Stainless steel grade 304
Pressure angle 20°

Associated Products
Rack pinions: page 4-12



Part number selection table

Part Number	Module	Number of Teeth	Length L	Pitch Height P	Face width B (h12)	Height H (h12)	Weight (g)
RK50SU2-0310	0.5	126	202~205	9.5	3	10	45
RK50SU2-0808				7.5	8	8	95
RK75SU2-0310	0.75	83	202~205	9.25	3	10	44
RK75SU2-0808				7.25	8	8	91
RK80SU5-0510	0.8	198	505~508	9.2	5	10	183
RK1SU5-0810	1.0	158	505~508	9	8	10	280



i Features and options

- Racks are manufactured from cold drawn stainless steel
- Small quantities of selected items available ex-stock, please visit our on-line store: www.reliance.co.uk/shop

? Technical support

- PTFE based grease is recommended for lubrication
- Installation information - see [page T6-4](#)
- Technical information - see [pages T6-1 to T6-6](#)
- For modified or fully bespoke racks, please contact us

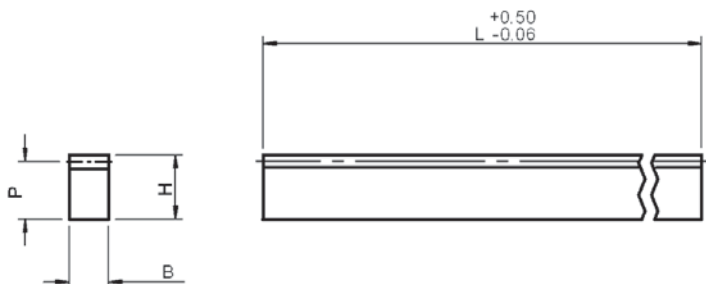
Hobbed Brass Rack Rectangular

0.3, 0.5, 0.75
& 0.8 Module



Associated Products
Rack pinions: page 4-12

All dimensions in mm
Material: Brass grade CuZn39Pb3
Pressure angle 20°



Part number selection table

Part Number	Module	Number of Teeth	Length L	Pitch Height P	Face width B (h11)	Height H (h11)	Weight (g)
RK30B2-0308	0.3	210	200	7.7	3	8	38
RK50B2-0808	0.5	125	200	7.5	8	8	98
RK75B2-0808	0.75	82	200	7.25	8	8	95
RK80B5-0510	0.8	198	505	9.2	5	10	191



i Features and options

- Brass racks, ideal for lightly loaded applications, an economic balance of accuracy and load capacity against cost
- Manufactured from cold drawn material
- Small quantities of selected items available ex-stock, please visit our on-line store: www.reliance.co.uk/shop

? Technical support

- Installation information - see [page T6-4](#)
- Technical information - see [pages T6-1 to T6-6](#)
- For modified or fully bespoke racks, please contact us

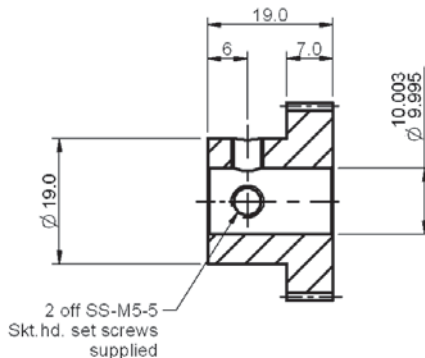
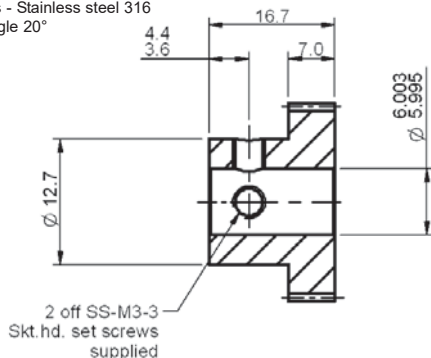


6 mm & 10 mm Bore

Plain and Hardened Rack Pinions

All dimensions in mm
General tolerances ± 0.13 mm
Material: Hardened pinions - 17-4 PH, 35-42HRC
Plain pinions - Stainless steel 316
Pressure angle 20°

Associated Products
Racks: page 6-3



Part number selection table

Example Part No:- SH25MS2B6F7A- 32					
Basic Part Number		Circular Pitch (mm)	Bore Size	Number of Teeth	
Plain	Hardened			Min	Max
SH1MS2B6F7A-	SH1MS8B6F7A-	1	6	43	111
SH2MS2B6F7A-	SH2MS8B6F7A-	2		23	54
SH25MS2B6F7A-	SH25MS8B6F7A-	2.5		19	43
SH1MS2B10F7A-	SH1MS8B10F7A-	1	10	63	104
SH2MS2B10F7A-	SH2MS8B10F7A-	2		33	51
SH25MS2B10F7A-	SH25MS8B10F7A-	2.5		27	40

Features and options

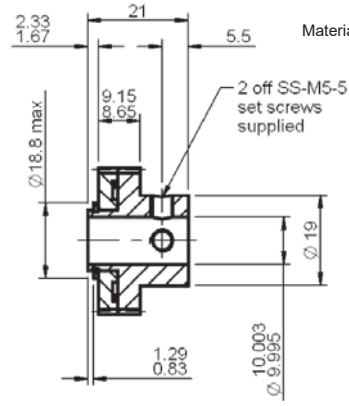
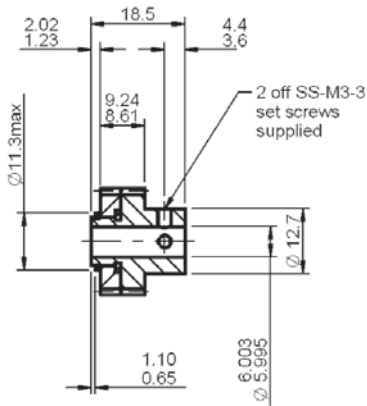
- Standard accuracy AQ10 - see [page T4-1](#)
- Hardened pinions provide longer pinion life, higher load capacity and higher thrust
- Higher accuracies available
- Alternative pitches available
- Alternative bore sizes, including imperial available
- Alternative materials available
- Special wear resistant coating available
- For modified or fully bespoke pinions, please contact us



Associated Products

Racks: page 6-3

All dimensions in mm
General tolerances ± 0.13 mm
Pressure angle 20°
Material: Stainless steel 316



Part number selection table

Example Part No:- <u>AH25MS2B6F89A- 20</u>				
Basic Part Number	Circular Pitch (mm)	Bore Size	Number of Teeth	
			Min	Max
AH1MS2B6F89A-	1	6	46	54
AH2MS2B6F89A-	2		24	26
AH25MS2B6F89A-	2.5		20	20
AH1MS2B10F89A-	1	10	87	104
AH2MS2B10F89A-	2		45	51
AH25MS2B10F89A-	2.5		37	40

i Features and options

- Standard accuracy AQ10 - see page T4-1
- Higher accuracies available
- Ideal for use with Reliance soft and hardened, round and rectangular racks
- Ideal for lightly loaded measurement applications
- Alternative pitches available
- Alternative bore sizes, including imperial available
- Alternative materials available
- Special wear resistant coating available
- For modified or fully bespoke pinions, please contact us

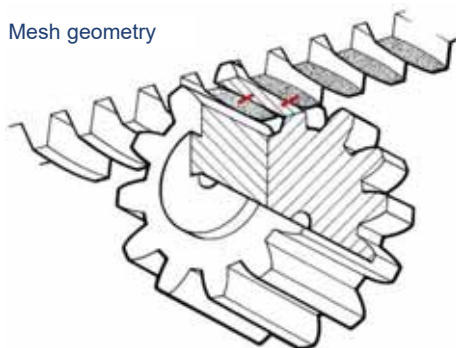


RACK MANUFACTURE

Reliance standard precision racks are produced by a thread grinding process, which generates teeth of helicoidal form. This provides two distinct advantages: very good pitch accuracy and sufficient tolerance of meshing conditions (within 0.25°) to make high precision alignment of the pinion unnecessary.

This feature will be appreciated from the diagram below. Slight misalignment of the straight-tooth pinion, in terms of deviation from a true right-angle between the axis and rack in either plane, results merely in a change of position of the contact points across the face.

Mesh geometry



Points of contact.
Standard pressure angle is 20°.
25° pressure angle available on request.

RACK STANDARDS AND TOLERANCES

Reliance precision racks are offered in four basic grades of accuracy through most of the range, please see the individual product pages for details. Grade 4b has been introduced to offer a lower cost grade 4 where a single rack is to be used in a non-butting application.

The tooth form is generally in accordance with BS 4582 part 1. fig 1. for metric racks.

Rack Grade	5	4	4b	3	2	1
Max pitch error between any two points per 300 mm of rack	0.005	0.008	0.008	0.015	0.025	0.050
Max end to end pitch error up to 300 mm of track*	±0.004	±0.004	±0.008	±0.008	±0.013	±0.025
Adjacent tooth error	0.0025	0.0025	0.0025	0.005	0.010	0.013
Pitch height variation	+0 -0.013	+0 -0.013	+0 -0.013	+0 -0.013	+0 -0.018	+0 -0.025

* Applies pro rata to length >300 mm

All dimensions in mm

ENGINEERING DATA

1. Linear Speed

Linear speeds of up to 10 m/s can be achieved with correctly installed rack and pinion systems. When specifying a system, care needs to be taken to ensure that the transducer count rates are not exceeded. With grease lubrication, care should be taken to ensure that the lubrication is not thrown off the pinion

2. Load Capacity

The following analysis is intended to give a guide to the load capacity of a rack system. To simplify the calculation a number of assumptions have to be made. In many applications this will give a conservative estimate of the gear capacity, therefore in critical applications an exact analysis must be completed. Please consult the relevant gear standards or Reliance Technical Sales.

The basic load capacity (F_b) of a rack and pinion is defined as the maximum linear force at which they can operate indefinitely.

F_b has two values: one calculated from tooth strength (F_{bs}) and one for tooth flank wear (F_{bw}). The useful or transmitted load capacity, F_t , is usually less than F_b due to transient or dynamic loads generated within the mechanism.

For tooth root strength $F_{ts} = F_{bs}/K_a$

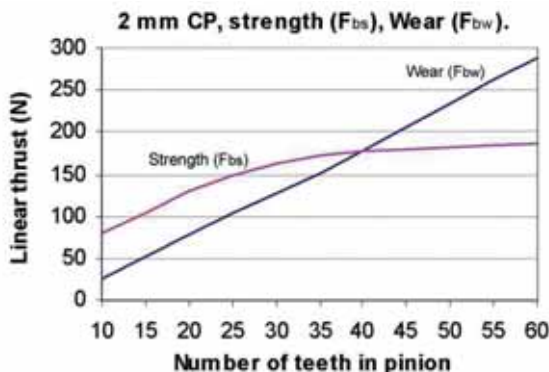
K_a & C_a = application factors

For tooth flank pitting (wear) $F_{tw} = F_{bw}/C_a$

Both calculations should be made and the lower value used.

The application factors K_a and C_a make allowance for any externally applied loads in excess of the nominal linear force F_b . These are most accurately determined by direct measurement. In determining application factors, consideration should be given to the fact that many prime movers develop momentary peak torques appreciably greater than those determined by the nominal ratings of either the prime mover or the driven equipment.

There are many possible sources of overload which should be considered, including system vibrations, acceleration torques, overspeeds, variations in system operation and changes in process load conditions. Impact loads due to reversing across backlash can be significant in servo systems. As a general guide application factors for a motor gear system range from 1.0 for uniform loads up to 1.75 where heavy shock loads are anticipated.





The previous graph has been calculated in accordance with AGMA 2001-B88 for a life of at least 10⁸ load cycles, and a rack hardness exceeding 50 HRc and pinion material 17-4PH. For alternative pitches and materials the graph values need to be modified as shown in the table below:

Pitch and Rack/Pinion Material Modification Factors				
Rack	Pinion	Pitch (mm)	Strength	Wear
Hardened Round Rack (hardness > 50 HRc)	17-4PH	1	0.50	0.50
	316	1	0.23	0.10
	PEEK polymer	1	0.04	0.01
Rectangular Rack (hardness 35-45 HRc)	17-4PH	1	0.38	0.28
		2	0.75	0.56
		2.5	0.94	0.70
	316	1	0.23	0.10
		2	0.47	0.20
		2.5	0.59	0.25
	PEEK polymer		1	0.04
				0.01
Tubular and Round Rack	17-4PH	1	0.23	0.10
	316	1	0.23	0.10
	PEEK polymer	1	0.04	0.01

Example:

A 40 tooth, 1 mm CP pinion material 316 meshing with rack of hardness < 50 HRc.

The application factors should be applied after the reduction for material and pitch.

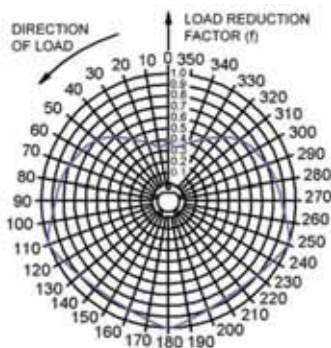
$$F_{bw} = 175 \times 0.10 = 17.5 \text{ N}$$

$$F_{bs} = 170 \times 0.23 = 39.1 \text{ N}$$

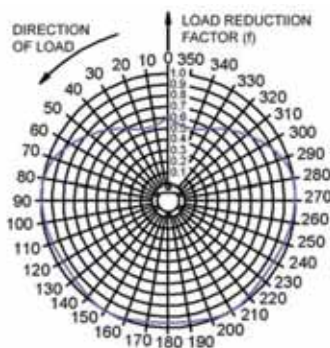
3. Bearing Capacity

When linear bearings are used with the hardened round bar racks the capacity of the support bearings needs to be considered. Where possible the bearings should be positioned with all the ball rows running on the rack shaft. However, it is important that the balls do not run on the edges of the teeth. If necessary the 5 and 6 row bearings can be used with 1 row above the teeth. In this scenario, the manufacturer's ratings apply with a modification for the direction of the load application. The factors given in the following charts should be substituted for the bearing manufacturer's load reduction.

Closed bearing 5 rows of balls



Closed bearing 6 rows of balls



4. Lubrication

Lubrication is not required when using PEEK polymer pinions. For other combinations unlubricated systems are not recommended. Measurement applications should use a very thin coat of light oil, in many machine tool applications stray cutting oil is sufficient. Grease lubrication is recommended for higher loads, but care should be taken to ensure the lubrication is not thrown off the pinion at speed.

INSTALLATION

The installation techniques differ according to the type of rack. All racks should be mounted with teeth pointing downwards wherever possible so that dust etc cannot settle in them.

1. Soft Round and Tubular Rack

Plastic moulded bearings are recommended for use with soft round and tubular racks, these can be found in the Bearings and Spacers section of the Reliance catalogue. Round racks are not recommended for multi-section use.

2. Hardened Round Rack

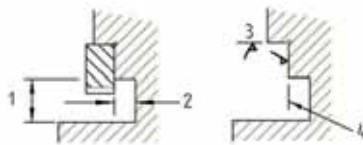
Bearings for the round bar rack should be fitted in accordance with the manufacturer's instructions. It is important that the balls do not run on the edge of the teeth. Round racks are not recommended for multi-section use.

3. Rectangular Rack

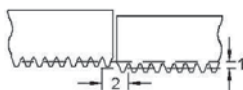
Reliance rectangular section rack is manufactured to enable butting to form infinite lengths. Socket head cap screws, plain washers and a thread locking adhesive are preferred for mounting. Dowels are not recommended. The pitch line of the rack in its constrained position must be straight to obtain maximum accuracy. To avoid distortion, racks should be screwed to a machined flat surface.

Machining requirements for rack location

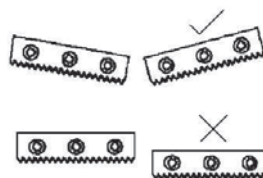
1. Pinion clearance
2. Clearance required if:
 - a) anti-backlash pinions are used
 - b) full face of rack is to be used
3. Abutment
4. Mounting face



To align racks, two adjustments need to be made, pitch line alignment and pitch adjustment. The pitch line straightness is not critical (see drawing below) but steps at the joints should be avoided as they can lead to excessive noise and wear.



1. Pitch line alignment
2. Pitch adjustment and error compensation

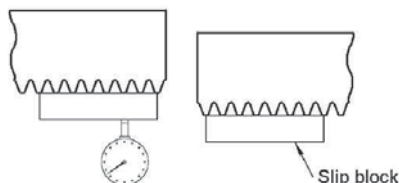


Pitch Line Alignment

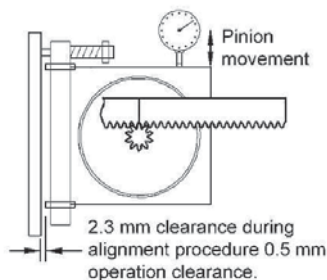
There are three methods of setting the pitch line at a joint. These are:

- i) Setting the base of the racks against an abutment perpendicular to the mounting face. The misalignment is then governed by the rack pitch line to base tolerance.
- ii) Using the tops of the rack teeth as a reference. These are parallel to the pitch line within 0.008 mm. Use a short straight edge (eg. slip block) as shown below.
- iii) The best measurement of the pitch line is with the pinion installed on a flexplate. A dial indicator fitted as shown gives a direct reading of the pitch line straightness.

Pitch line alignment using slip block



Dial indicator carried with flexplate



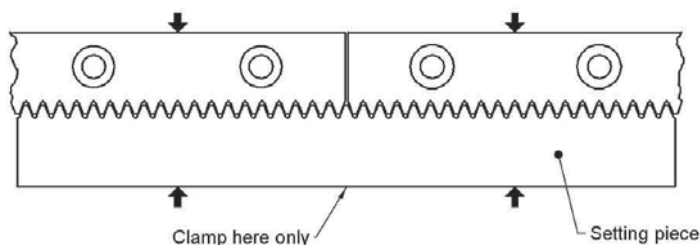
The flexplate spring loads the pinion into mesh on both flanks of the teeth, ensuring complete backlash elimination.

Pitch Adjustment and Error Correction

Pitch accuracy can be obtained by one of three methods depending upon accuracy required.

GRADE 1 (and for the initial setting of all grades)

For pitch accuracy across the joint of ± 0.020 mm the Rack Setting Piece is the simplest method.



GRADE 2, 3 or 4

After initial setting and with the measuring system functioning, length bars may be used as references. Checks made against these allow adjustment to be made within the system resolution.

GRADE 3, 4 or 5

After initial setting and with the measuring system functioning, comparison should be made with a laser measuring system. This allows pitch adjustment and machine error compensation within the system resolution over the full travel of the axis.

RACK APPLICATIONS

Reliance precision racks are manufactured in both round and rectangular sections, and can be used for both measurement and actuation. In general the smaller pitches (1mm) are ideal for measurement, as the smaller pinion diameter gives higher linear resolutions. The larger pitches (2 mm and 2.5 mm) allow a higher load capacity.

For most applications the rack can be used for both the feedback and the actuation. In very precise applications we recommend that an unused section of the actuation rack is used for feedback. Alternatively a separate rack can be used.

All Reliance racks are calibrated to measure correct at 20°C using a temperature compensated laser. Calibration graphs can be supplied if required.

RACK ACTUATOR

Information about the Rackuator™ is provided on [page T2-9](#).

<i>Introduction to Reliance</i>	<i>i</i>
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<i>Systems Overview</i>	<i>1</i>
-------------------------	----------



Intelligent Motors and Motorised Actuators	2
---	----------



Planetary and Right Angle Gearboxes	3
--	----------



Brass, Ground and Precision Spur Gears	4
---	----------



Worms and Wheels, Bevels and Internal Gears	5
--	----------



Round and Rectangular Racks and Pinions	6
--	----------



Leadscrews and Leadscrew Assemblies	7
--	----------



Flexible Shaft Couplings, Clutches and Collars	8
---	----------



Linear Guides and Slides	9
---------------------------------	----------



Belts and Pulleys	10
--------------------------	-----------



Gear Clamps and Accessories	11
------------------------------------	-----------



Bearings and Spacers	12
-----------------------------	-----------

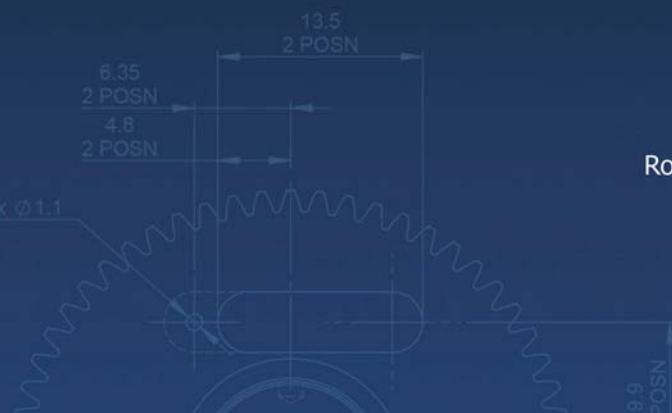


Machine Screws, Dowel Pins and Hardware	13
--	-----------

<i>Technical Information</i>	<i>14</i>
------------------------------	-----------

<i>Appendices and Index</i>	<i>15</i>
-----------------------------	-----------

Systems Overview	1
Intelligent Motors and Motorised Actuators	2
Planetary and Right Angle Gearboxes	3
Brass, Ground and Precision Spur Gears	4
Worms and Wheels, Bevels and Internal Gears	5
Round and Rectangular Racks and Pinions	6
Leadscrews and Leadscrew Assemblies	7
Flexible Shaft Couplings, Clutches and Collars	8
Linear Guides and Slides	9
Belts and Pulleys	10
Gear Clamps and Accessories	11
Bearings and Spacers	12
Machine Screws, Dowel Pins and Hardware	13
Technical Information	14



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