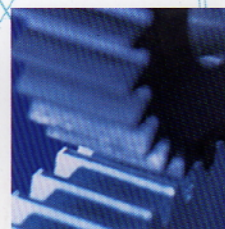
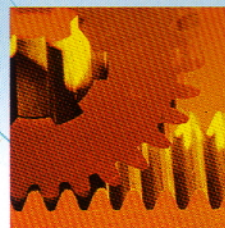




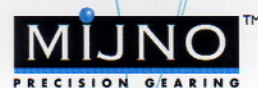
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## Racks and Pinions



TECHNICAL  
GUIDE

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## Racks and Pinions

In this catalog, MIJNO<sup>TM</sup> presents our precision Rack and Pinion (R & P) product lines. We have standard products suitable for either measuring applications or for translating loads. R&P sets for measurement applications have relatively small, but very accurate gear teeth. For translating (linear movement of) loads, we offer a variety of tooth sizes and precision levels.

The precision and overall quality of our R&P products is the result of over 75 years experience in the design and manufacture of gear products, particularly in R&P sets.

Precision, reliability, and long life are standard with MIJNO. These attributes make us a preferred supplier to high-tech manufacturing industries.

Our service begins with our Engineering expertise in suggesting combinations of tooth sizes, hardness, and accuracy level that provide the capability to meet customer expectations.

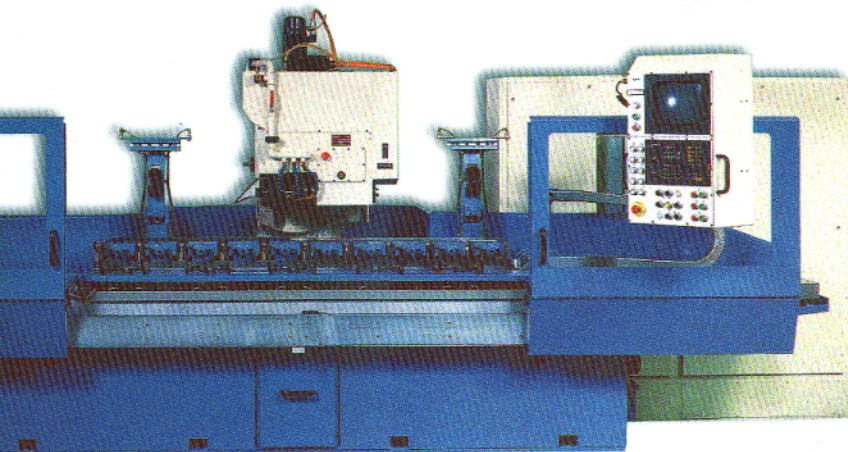
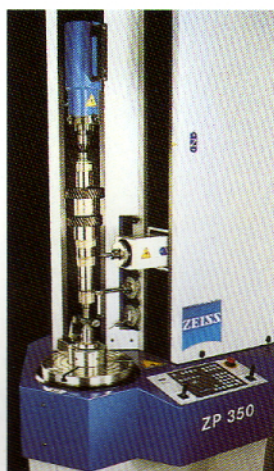
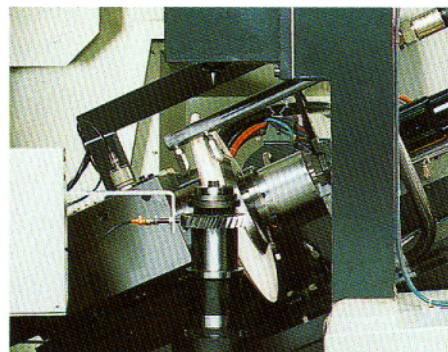
Quiet running is a standard attribute resulting from our tooth designs, material selection, and manufacturing capabilities.

The standard R & P sets in this catalog provide you with pre-engineered, high-quality choices that are available with short delivery times at economical prices.

The standard R & P program also provides the benefit of interchangeability when your machines are expanded, modified or otherwise upgraded. The R & P sets are produced to DIN (Deutschland Industry Norm) standards. For example, tooth profile and meshing is in accordance with DIN 867 and ISO 53.

MIJNO is a flexible manufacturer with design, engineering and manufacturing capability to also assist customers requiring unique R & P sets. We can support you with economical tailored solutions, no matter how complicated.

Our engineers relish each opportunity to provide you with optimized R & P solutions. Every day, they are prepared to apply their experience and expertise using the most modern software and hardware tools for their research and development.







# 7 Quality Advantages

## 1 PRECISION

MIJNO™ R & P combinations are **particularly quiet** and smooth running due to precision cutting techniques that accurately control the size and distance (pitch) of the gear teeth. These attributes are achieved with new computer controlled cutting machines and precision cutting tools. We guarantee the accuracy of the rack's tooth pitch line to its respective mounting surface. Concentricity of the mating pinions is also assured.

## 2 RACK SEGMENT CONTINUITY

Some machines require rack segments to be joined end-to-end. Tooth height and pitch between segments is critical for accuracy in the customer's machine. The accuracy of our rack machining provides for continuity of pinion movement between segments.

## 3 QUIET OPERATION

MIJNO R & P sets are **particularly quiet** due to several design and manufacturing features:

- "Tip relief" and "topping" modifications at the very top of the tooth profiles.
- Precision cutting of the basic tooth profile on both the racks and pinions.
- Close tolerances of the R & P pitch lines with respect to their locating surfaces.
- Precision spacing and size control of rack teeth for accurate pitch throughout the length of the rack.
- "Crowning" of the pinion teeth to accommodate any lack of parallelism between R & P teeth due to mounting misalignment or deflection during operation.

## 4 INTERCHANGEABILITY

Our rack segments are interchangeable due to very tight tolerances on the absolute distance and parallelism between the rack mounting surface and the tooth pitch line. Accuracy from lot-to-lot is consistent. Whether you order standard sizes or built-to-order sizes, MIJNO guarantees for subsequent orders, interchangeable R & P components with short delivery time.

## 5 LONG LIFE AND HIGH TOOTH STRENGTH

MIJNO guarantees the tooth strength and long wear life of its R & P products. We use alloy steels chosen for their intrinsic strength and suitability for selected hardening processes. The steels are certified and purchased from reliable suppliers.

## 6 CUSTOMIZATION

MIJNO can provide custom features due to complete control of the manufacture of the racks and pinions. We do all of the grinding and tooth cutting of the racks. We do all of the turning, tooth cutting and grinding of the pinions. Customized gear tooth profiles are available. We also provide custom-mounting holes drilled and/or tapped in rack. Furthermore, we have control of the heat treatment of the steel through a sister company.

## 7 FAVORABLE COMMERCIAL ASPECTS

Because of our lean manufacturing philosophy and our process controls, we are able to offer high quality racks and pinions at economical prices and short delivery time.



## How to order your Racks

T L 100 A 3 / 250

### SERIES

T : Rack for translation of loads  
P : Rack for translation & measurement  
M : Rack with metric preferred number pitch

### PROFILE

L : Low profile  
H : High profile  
S : Square profile

### MIJNO™ SIZE

See tables pages 7 & 9

### LENGTH (mm)

### ATTACHMENT (p.12)

3 : Rack is attached from underneath  
4 : Rack is attached from its side

### MOUNTING HOLES (p.12)

A : Threaded holes  
B : Straight holes  
C : Without holes  
D : Other

## How to order your Pinions

T LP 100 8

### SERIES

T : Pinion for translation of loads  
P : Pinion for precision measurement  
M : Pinion with metric preferred number pitch

### STYLES

LP : Long style Pinion  
SP : Short style Pinion

### TOOTH MODIFICATIONS (p.13)

8 : Crowning  
9 : Tip relief  
10 : Undercutting  
11 : Without modification

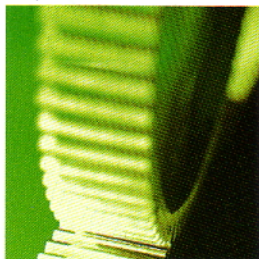
### MIJNO™ SIZE

See tables page 11



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# Table of Contents



## Series T - Racks for Translation of Loads

Standard racks to ISO 7 precision (approx. AGMA 10)

Precision suitable for quiet, high speed translation

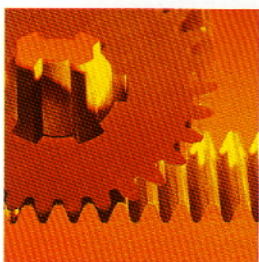
## Series P - Racks for Precision Measurement and Translation of Loads

Standard racks to ISO 6 precision (approx. AGMA 11)

Suitable for measuring or positioning applications that require high accuracy, higher strength, and smoothest high speed translation, together with quietness

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PAGE 6



## Series M - Racks with Metric Preferred Number Pitch

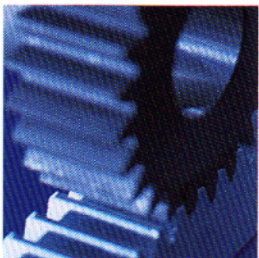
Standard racks to ISO 6 precision (approx. AGMA 11)

This group has non-integer module (tooth sizes) that provide preferred-number circular pitch distances.

In other words, for each revolution of the pinion, the system translates a preferred-number distance in mm

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PAGE 8



## Pinions for Series T, P, and M Racks

Standard pinions to ISO 5, 6 and 7 precision

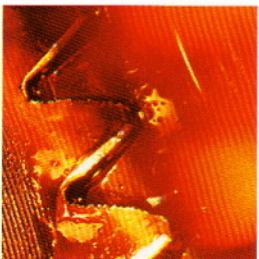
(approx. AGMA 12, 11, & 10)

Pinions with module pitch (Series T and P)

Pinions with metric preferred-number pitch (Series M)

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PAGE 10



## Technical Information

Mounting

Tooth characteristics

Formulas / Equations

Lubrication

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PAGE 12



## Series T / Series P

### Series T - Racks for Translation of Loads

Standard racks to ISO 7 (approx. AGMA 10) precision.

Precision level is suitable for quiet, high speed translation.

Racks are fabricated of steel types 1045 or 1049, according to EN 10083.

Tensile strength is **690 Mpa (N/mm<sup>2</sup>) = 100,000 psi.**

Teeth of these racks can be induction hardened to 50 to 55 HRC.

### Series P - Racks for Precision Measurement and Translation of Loads

Standard racks to ISO 6 precision (approx. AGMA 11).

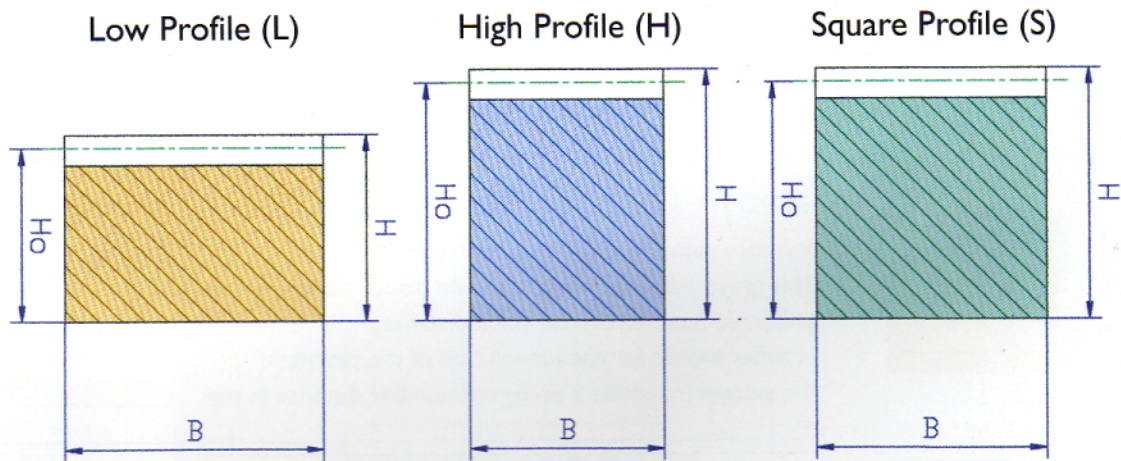
Precision level is suitable for measuring or positioning applications requiring high accuracy and quietness.

This group of rack products is fabricated from selected alloy steels for tooth strength and durability.

Tensile strength is **1100 Mpa (N/mm<sup>2</sup>) = 159,000 psi.**

Racks have precision ground sides and bottom for accuracy and smoothness.

These racks can be nitrided.



**Tolerance on Ho :** Series T.....0 / -0.06 mm per meter

Series P.....0 / -0.02 mm per meter

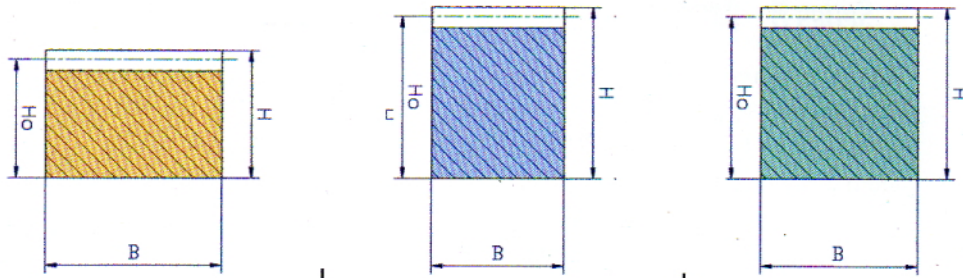
#### MIJNO™ RACK - GENERAL SIZE CAPABILITIES

In addition to the standard racks on these pages, MIJNO can supply built-to-order rack within the following range :

- Tooth module from 0.5 through 20
- Standard pressure angle of 20 degrees
- Length up to 2.1 meters maximum





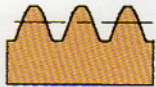
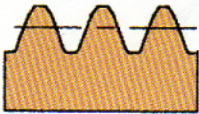
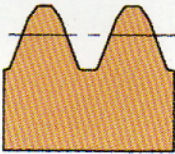
## Series T / Series P



|             |            | Low Profile (L) |        |         |             | High Profile (H) |        |         |             | Square Profile (S) |        |         |             |
|-------------|------------|-----------------|--------|---------|-------------|------------------|--------|---------|-------------|--------------------|--------|---------|-------------|
| Module (mm) | Pitch (mm) | B (mm)          | H (mm) | Ho (mm) | MIJNO™ Size | B (mm)           | H (mm) | Ho (mm) | MIJNO™ Size | B (mm)             | H (mm) | Ho (mm) | MIJNO™ Size |
| 1           | 3.1415     | 15              | 10     | 9       | 100         | 10               | 15     | 14      | 100         | 15                 | 15     | 14      | 100         |
| 1.5         | 4.7124     | 15              | 10     | 8.5     | 150         | 10               | 15     | 13.5    | 150         | 15                 | 15     | 13.5    | 150         |
| 2           | 6.2832     | 20              | 15     | 13      | 200         | 15               | 20     | 18      | 200         | 20                 | 20     | 18      | 200         |
| 2.5         | 7.8540     | 25              | 20     | 17.5    | 250         | 20               | 25     | 22.5    | 250         | 25                 | 25     | 22.5    | 250         |
| 3           | 9.4248     | 30              | 20     | 17      | 300         | 20               | 30     | 27      | 300         | 30                 | 30     | 27      | 300         |
| 4           | 12.5664    | 40              | 25     | 21      | 400         | 25               | 40     | 36      | 400         | 30                 | 30     | 26      | 401         |
| 4           | 12.5664    |                 |        |         |             |                  |        |         |             | 40                 | 40     | 36      | 402         |
| 5           | 15.7079    | 50              | 30     | 25      | 500         | 30               | 50     | 45      | 500         | 40                 | 40     | 35      | 501         |
| 5           | 15.7079    |                 |        |         |             |                  |        |         |             | 50                 | 50     | 45      | 502         |
| 6           | 18.8495    | 60              | 40     | 34      | 600         | 40               | 60     | 54      | 600         | 60                 | 60     | 54      | 600         |

See "How to order our Racks" page 4.

Standard lengths : 250 mm, 500 mm, 750 mm, 1000 mm. Please contact us for other lengths.

| $m = 0.5$  | $m = 1$  | $m = 1.5$  |
|--|--|--|
| $P_c = 1.570$<br> | $P_c = 3.141$<br> | $P_c = 4.712$<br> |
| $m = 2$  |  | $m = 3$  |
| $P_c = 6.283$<br> |  | $P_c = 9.426$<br>  |

Selected tooth sizes are shown above. See Figure 11 for additional information.



## Series M

### Series M - Racks with Metric Preferred Number Pitch

These racks have preferred-number circular pitch. In other words, the distance between rack teeth is a preferred number in mm. For each revolution of the pinion, the rack translates a distance that is convenient to calculate. See the selection table.

Standard racks to ISO 6 precision (approx. AGMA II).

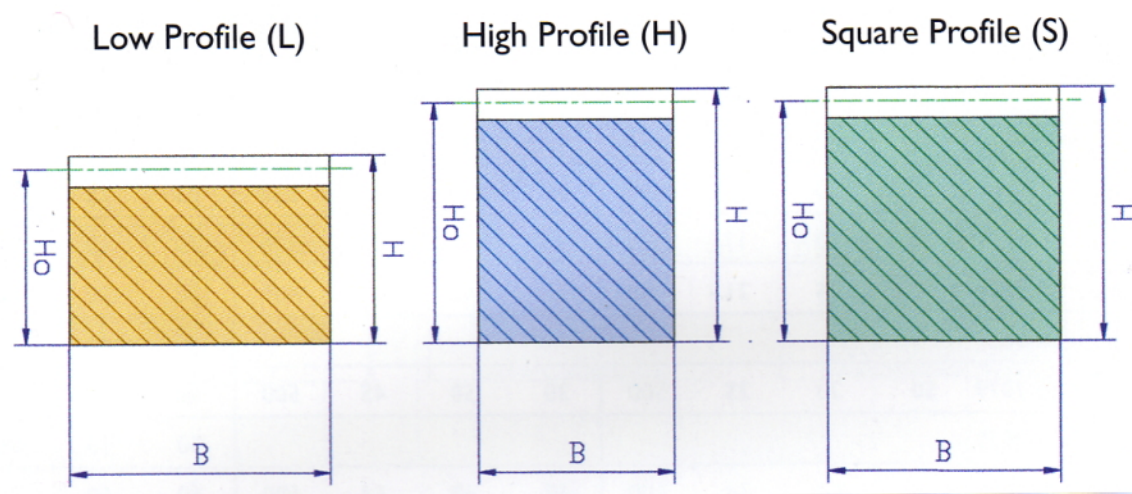
Precision level is suitable for measuring or positioning applications requiring high accuracy and quietness.

This group of rack products is fabricated from selected alloy steels for tooth strength and durability.

Tensile strength is **1100 Mpa (N/mm<sup>2</sup>) = 159,000 psi.**

Racks have precision ground sides and bottom for accuracy and smoothness.

These racks can be nitrided.



**Tolerance on Ho.....0 / -0.02 mm per meter**

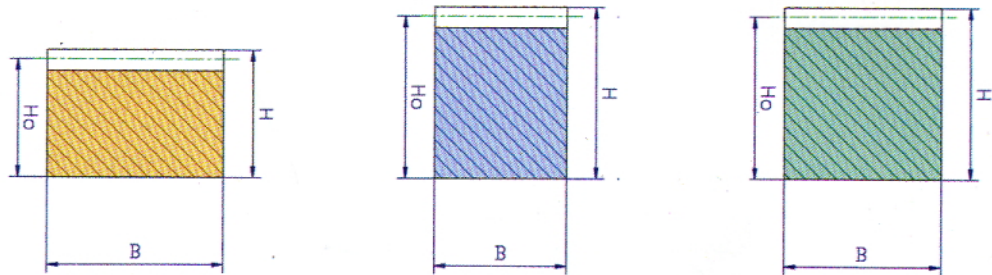
#### MIJNO™ RACK - GENERAL SIZE CAPABILITIES

In addition to the standard racks on these pages, MIJNO can supply built-to-order rack within the following range :

- Pitch distances from 2 through 50 mm
- Standard pressure angle of 20 degrees
- Length up to 2.1 meters maximum



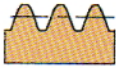
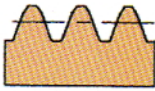
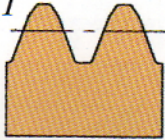
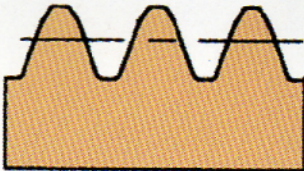
## Series M



|                |               | Low Profile (L) |           |            |                | High Profile (H) |           |            |                | Square Profile (S) |           |            |                |
|----------------|---------------|-----------------|-----------|------------|----------------|------------------|-----------|------------|----------------|--------------------|-----------|------------|----------------|
| Module<br>(mm) | Pitch<br>(mm) | B<br>(mm)       | H<br>(mm) | Ho<br>(mm) | MIJNO™<br>Size | B<br>(mm)        | H<br>(mm) | Ho<br>(mm) | MIJNO™<br>Size | B<br>(mm)          | H<br>(mm) | Ho<br>(mm) | MIJNO™<br>Size |
| 1.5915         | 5             | 15              | 10        | 8.41       | 500            | 10               | 15        | 13.41      | 500            | 15                 | 15        | 13.41      | 500            |
| 1.9894         | 6.25          | 20              | 15        | 13.01      | 625            | 15               | 20        | 18.01      | 625            | 20                 | 20        | 18.01      | 625            |
| 3.1831         | 10            | 30              | 20        | 16.82      | 1000           | 20               | 30        | 26.82      | 1000           | 30                 | 30        | 26.82      | 1000           |
| 3.9789         | 12.5          | 40              | 25        | 21.02      | 1250           | 25               | 40        | 36.02      | 1250           | 40                 | 40        | 36.02      | 1250           |

See "How to order our Racks" page 4.

Standard lengths : 250 mm, 500 mm, 750 mm, 1000 mm. Please contact us for other lengths.

| $P_c = 5$   | $P_c = 6.25$  | $P_c = 10$  |
|---|---|---|
| $m = 1.5915$  | $m = 1.9894$  | $m = 3.1831$  |
|  |  |  |
| $P_c = 12.5$  |   |   |
| $m = 3.9789$  |   |   |
|  |   |   |

Selected tooth sizes are shown above. See figure 11 for additional information.



## Pinions

Our standard is to cut the pinions with a tooth modification called "crowning".

See Figure 8 for an explanation of this desirable feature.

Pinions are fabricated from the same class of steels as the racks.

These steels are chosen for strength, stability and machinability :

### Series T Pinions

Standard pinions to ISO 7 (approx. AGMA 10) precision.

Precision level is suitable for quiet, high speed translation.

Pinions are fabricated of steel types 1045 or 1049, according to EN 10083.

Tensile strength is **690 Mpa (N/mm<sup>2</sup>) = 100,000 psi.**

Series T pinions are precision cut, but not ground.

### Series P and M Pinions

Standard pinions to ISO 6 precision (approx. AGMA 11).

Precision level is suitable for measuring or positioning applications requiring high accuracy and quietness.

This group of pinion products is fabricated from selected alloy steels for tooth strength and durability.

Tensile strength is **1100 Mpa (N/mm<sup>2</sup>) = 159,000 psi.**

These pinions have precision ground teeth for accuracy and smoothness.

### Pinion Options

The series P and M pinion steels can be nitrided to harden the surface to a controlled depth.

The nitriding improves tooth strength and resistance to wear.

We can also manufacture pinions to ISO 5 precision (approx. AGMA 12).

Pinions with smaller or larger numbers of teeth are possible (dimension B may require adjustment).

#### MIJNO™ - PINION SIZE CAPABILITIES

In addition to the standard pinions on these pages, MIJNO can supply built-to-order pinions within the following range :

- Tooth module (m) from 0.15 through 16
- Standard pressure angle of 20 degrees
- Diameters from 6 through 1250 mm
- No. of teeth (Z) = [ Do / m ]



# Pinions

Long style Pinion

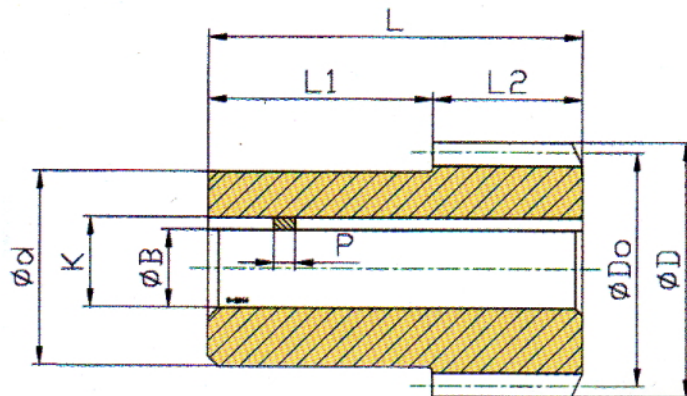


Figure 1

Short style Pinion

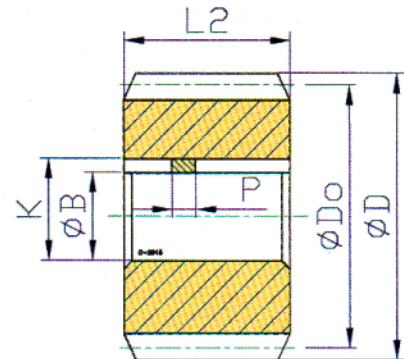


Figure 2

NOTES : These two styles of pinions are available with module or metric pitch.  
See "How to order our Pinions" page 4.

## Pinions with Module Pitch (pitch = $\pi \times$ module)

Corresponding to Series T or P

| Module (mm) | Z (No.teeth) | D (mm) | Do (mm) | d (mm) | B (mm) | K (mm) | P (mm) | L (mm) | L1 (mm) | L2 (mm) | MIJNO™ Size |
|-------------|--------------|--------|---------|--------|--------|--------|--------|--------|---------|---------|-------------|
| 1           | 26           | 27.8   | 26      | 23     | 12 G7  | 13.8   | 4      | 24     | 8       | 15      | 100         |
| 1.5         | 26           | 41.7   | 39      | 34     | 16 G7  | 18.3   | 5      | 25     | 14      | 15      | 150         |
| 2           | 26           | 55.6   | 52      | 45     | 16 G7  | 18.3   | 5      | 30     | 9       | 20      | 200         |
| 2.5         | 22           | 59.5   | 55      | 47     | 22 G7  | 24.8   | 6      | 40     | 12      | 25      | 250         |
| 3           | 22           | 71.4   | 66      | 55     | 22 G7  | 24.8   | 6      | 45     | 12      | 30      | 300         |
| 4           | 22           | 95.2   | 88      | 75     | 32 G7  | 35.3   | 10     | 55     | 19      | 40      | 400         |
| 5           | 22           | 119    | 110     | 85     | 32 G7  | 35.3   | 10     | 80     | 9       | 50      | 500         |
| 6           | 22           | 142.8  | 132     | 100    | 40 G7  | 43.3   | 12     | 80     | 23      | 60      | 600         |

## Pinions with Metric Preferred Number Pitch (module = pitch / $\pi$ )

Corresponding to Series M

| Pitch (mm) | Z (No.teeth) | D (mm) | Do (mm) | d (mm) | B (mm) | K (mm) | P (mm) | L (mm) | L1 (mm) | L2 (mm) | MIJNO™ Size |
|------------|--------------|--------|---------|--------|--------|--------|--------|--------|---------|---------|-------------|
| 5          | 25           | 42.6   | 39.79   | 34     | 16 G7  | 18.3   | 5      | 29     | 14      | 15      | 500         |
| 6.25       | 24           | 51.3   | 47.75   | 41     | 16 G7  | 18.3   | 5      | 29     | 9       | 20      | 625         |
| 10         | 25           | 85.3   | 79.57   | 55     | 22 G7  | 24.8   | 6      | 37     | 12      | 30      | 1000        |
| 12.5       | 24           | 102.6  | 95.49   | 75     | 32 G7  | 35.3   | 10     | 59     | 19      | 40      | 1250        |



## Technical information

### Mounting

Two basic methods of attachment to your machine are suggested :

■ **Method A** attaches the rack from underneath. See Figure 3. This method is favored because the rack is rigidly fastened and supported. The support prevents deflection and movement of the pitch line that can be caused by inherent gear separating forces that occur during operation. The attachment is accomplished with screws into threaded holes in the rack. Attachment from the bottom is preferred. If the attachment holes must be in the top (gear tooth) side, the attachment holes must be centered in the root of the rack teeth. The face width of the rack must also be increased to compensate for tooth strength lost because of the holes in the root of the teeth.

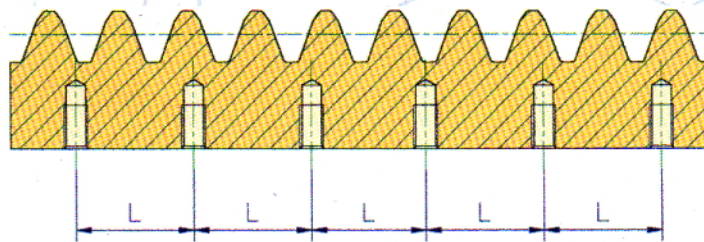


Figure 3

■ **Method B** attaches the rack from its side (attachment screws are parallel with the gear teeth). The screw heads can be exposed (straight holes) or sunk (counter-bored holes). See Figure 4.

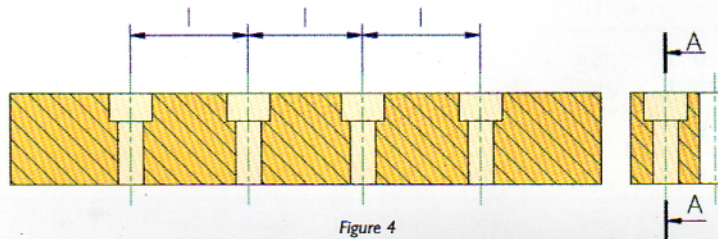


Figure 4

### Assembly continuity

MIJNO provides rack in relatively long lengths. A continuous length of rack is preferred for continuity of movement throughout the length of the rack. However, some installations require the joining of separate lengths of racks. To maintain continuity of movement, the rack should be identical with respect to height of the pitch line. To achieve proper tooth spacing, a joining gauge should be used with proper clamping during the assembly process.

See Figure 5 : there is a small gap between rack sections B and C.

Rack piece A is a joining gauge. Joining gauges can be purchased from MIJNO.

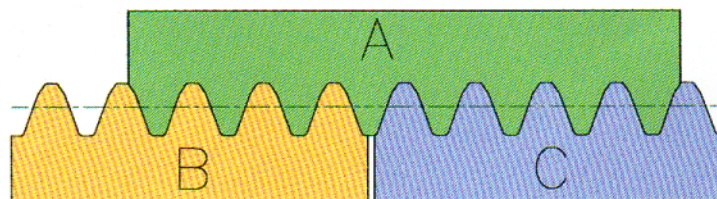


Figure 5



# Tooth modifications

## Racks

We chamfer the rack teeth at the corners of the tooth profile. This is the semi-topping feature.

Figure 6 shows an exaggeration of semi-topping. Figure 7 is a standard unmodified rack tooth.

We can also supply racks and pinions with helical teeth.

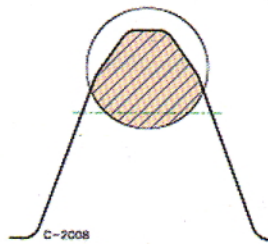


Figure 6

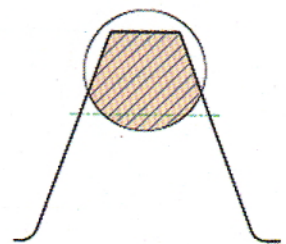


Figure 7

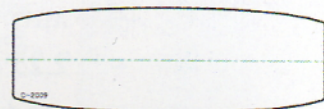


Figure 8

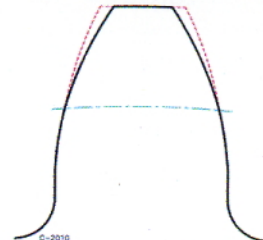


Figure 9

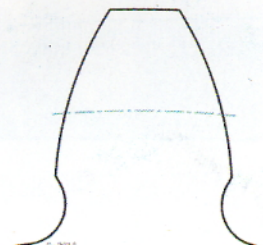


Figure 10

## Pinions

The first modification available is the semi-topping. See Figure 6.

The second important modification is called "crowning". See Figure 8, which represents looking down at the top of a pinion tooth. Note that the tooth is thickest at its center and there is a slight thinning of the tooth at its ends. Crowning also enables quiet running and smooth transmission of power.

The third modification is called "tip relief", which is an arbitrary modification of the tooth profile whereby a small amount of material is removed near the tip of the gear tooth. See Figure 9.

The last modification seen on pinions is "undercutting". It is the omission of profile at the base of the pinion teeth due to tool cutting action when generating pinions with low numbers of teeth. Undercut may also be deliberately introduced to facilitate finishing operations. See Figure 10.



## Useful Formulas / Equations

### STRENGTH OF THE RACKS

Choose a tooth size or module ( $m$ ) of sufficient strength to translate the required force ( $F$ ).  
The following equation is useful for an initial estimate of the minimum module :

$$m > 2.34 \sqrt{\frac{F}{6R_{pe}}}$$

$m$  is tooth module size in mm.

$R_{pe}$  is the yield strength of the material in  $N/mm^2$  (370 for Series T and 700 for Series P and M).

$F$  is the translating force in Newtons.

As stated, the equation is useful for an initial estimate. Other parameters should be considered in selecting a tooth module. Please do not hesitate to contact our Engineering Department for assistance in sizing.

### SELECTED USEFUL FORMULAS

$$\begin{aligned} P_c &= \pi m \\ h &= 2.25 m \\ m &= \text{module} \\ P_c &= \text{Pitch} \end{aligned}$$

$V$  = Linear translation speed (m/s)

$N$  = Speed of the pinion (rpm)

$D_o$  = Pitch diameter of the pinion in mm

$H_o$  = Distance between base of rack and pitchline of rack.  
( $H_o$  is also illustrated on pages 7 & 9).

$$V = (D_o) \times (\pi) \times (N) / 60,000$$

$T$  = Pinion torque in Nm

$$T = (F \times D_o) / 2,000$$

$P$  = Power in KW

$$P = (T \times N) / 9,550$$

$a$  = Distance from pinion center to base of the rack (mm)

$$a = H_o + D_o / 2$$

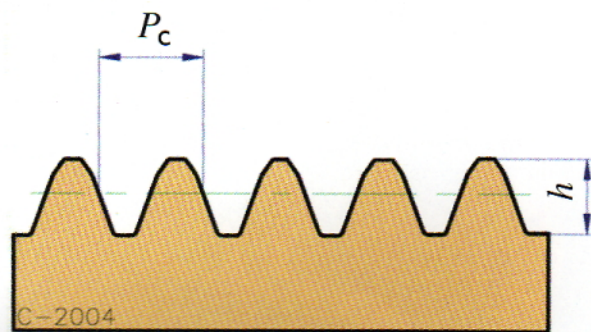


Figure 11

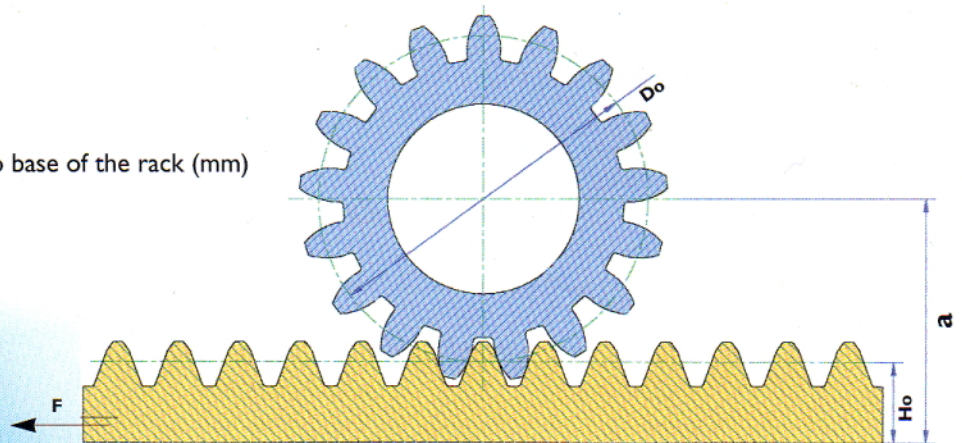


Figure 12



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## Lubrication

Whether used for translating loads or measuring position, a precision rack and pinion set has low backlash. This means that there is very little space in the gear mesh and any foreign matter that gets into the mesh can cause havoc. More over, in most applications, rack is not enclosed in a housing, which means it is vulnerable to contamination. Therefore, it is fundamental that the rack be mounted in such a way as to prevent particles from getting in the mesh. The best way to accomplish this is to mount the rack such that the teeth are in a vertical orientation, or mount in such a way that the teeth have their tops pointing down.

### Lubricants

It is generally impractical to operate rack and pinion in an oil bath. Rather, grease lubricants with adhering properties should be considered. Kluber Lubrication ([www.klueber.com](http://www.klueber.com)) has some excellent technical material regarding lubrication. Dry, solid lubricants may be useful for rack if the solids don't foul the mesh.

Too much lubrication has disadvantages. Many applications have a low tolerance for lubrication dripping or flying off the rack. Consequently, machine designers

are challenged to prevent rack lubrication from getting to unwanted places. It is not recommended to operate steel rack unlubricated. At the minimum, a light film of oil is needed to reduce heat and friction and thereby prevent surface damage and wear of the gear teeth. Lubrication is also important for quiet running.

Tooth size of rack is chosen to meet two conditions : (a) resistance to bending or breaking the teeth, and (b) surface durability of the mesh, or resistance to surface contact stresses. One possible design strategy is to deliberately use larger tooth sizes, or wider than necessary rack teeth, in order to reduce surface contact stress and, therefore, the criticality of lubrication.

It is also possible to arrange "sealing covers" over the rack. The concept is to keep contaminants out of the mesh and keep lubrication in. Covers are subject to friction and wear and may have to be changed periodically as a routine maintenance item. If there is an automatic lubricating system, lubricant that collects in the bottom of the sealed cavity may have to be periodically cleaned out.

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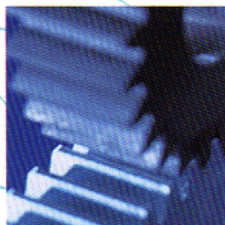
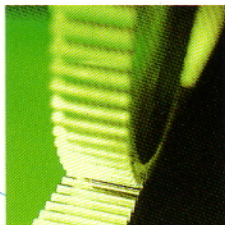
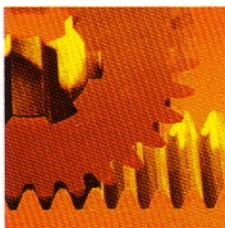
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