



# Racks

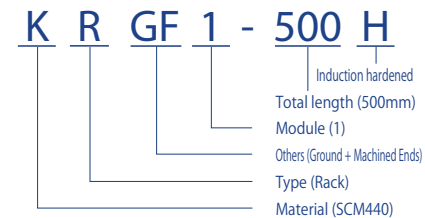


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## Catalog Number of KHK Stock Gears

The Catalog Number for KHK stock gears is based on the simple formula listed below. Please order KHK gears by specifying their Catalog Numbers.

(Example) Racks



### Material

- S S45C
- K SCM440
- SU SUS304
- BS Free Cutting brass C3604
- P MC901
- D DURACON

### Type

- R Racks
- RH Helical Racks
- RO Round Racks

### Other Information

- F Racks with Machined Ends
- D Racks with Bolt Holes
- K Racks with Drill Holes
- G Ground Racks
- H Induction hardened tooth surface

### Feature Icons

- RoHS Compliant Product
- Re-machinable Product
- Finished Product
- Heat Treated Product
- Ground Gear
- Stainless Product
- Resin Product
- Copper Alloy Product
- Injection Molded Product
- Black Oxide coat-ed Product

- Spur Gears
- Helical Gears
- Internal Gears
- Racks
- CP Racks & Pinions
- Miter Gears
- Bevel Gears
- Screw Gears
- Worm Gear Pair
- Worm Gearboxes
- Bevel Gearboxes
- Other Products

## Characteristics



KHK stock racks are made for high precision linear motion applications. We offer a large selection of racks ranging from module 0.5 to 10 and lengths from 100 to 2000 mm. The following table lists the main features.

Catalog No. <small>Note 1</small>	Module	Total Length (mm)	Material	Heat Treatment	Tooth Surface Finish	Precision <small>KHK R 001 Note 3</small>	Features
MRGF · MRGFD	1.5 ~ 3	500	SCM415	Tooth area Carburized	Ground	1	Has the highest strength and precision in the KHK standard rack series. Bolt holes can be remanaged as carburizing is applied only within the tooth area. J Series products are also available.
KRGF-H KRFD-H	1.5 ~ 3	500,1000	SCM440	Thermal refined, induction hardened	Ground	1	Heat treated ground gears with high precision and strength has excellent cost-performance ratio. J Series products are also available.
KRG · KRGF · KRGD	1 ~ 3	100,500, 1000	SCM440	Thermal refined	Ground	1	High strength and abrasion-resistant for precision linear motion.
SRG · SRGF · SRGFD · SRGFK	0.5 ~ 6	100,300, 500,1000	S45C	Gear teeth induction hardened <small>Note 2</small>	Ground	3	Reasonably priced ground racks with abrasion-resistant characteristics. J Series products are also available.
KRF-H KRFD-H	1.5 ~ 5	1000	SCM440	Thermal refining and teeth induction hardened	Ground	5	This is a strong rack made of Chromoly steel, treated by carburizing. Has high-strength, high wear resistance, and enables downsizing of SR racks. J Series products are also available.
SRF-H SRFD-H	1.5 ~ 4	1000	S45C	Gear teeth induction hardened	Cut	4	Stable Hardened racks with high strength, long life span are reasonably priced. J Series products are also available.
KRF · KRFD	1.5 ~ 5	1000	SCM440	Thermal refined	Cut	4	Increased strength with SCM440 material which is thermal refined.
SRAF · SRAFD · SRAFK	1.5 ~ 4	1000	S45C	—	Cut	4	This gear rack has the same tooth height and face width sizes, more compact and reasonably priced in comparison to SRF Racks
SR · SRF · SRFD · SRFK	0.5 ~ 10	100,300,500, 1000,1500,2000	S45C	Straightened & annealed	Cut	4	Low cost, large selections of modules and number of teeth. J Series products are also available.
SUR · SURF · SURFD	1 ~ 4	500,1000	SUS304	Solution treated	Cut	5	Suitable for food machinery due to SUS304 material's rust-resistant quality.
DRF · DRFD · DRFK	1 ~ 3	500, 1000	Polyacetal	—	Hobbed	5	Plastic racks with little dimensional change, absorb lesser water than MC Nylon racks. J Series products are also available.
PR · PRF	1 ~ 3	500,1000	MC901	—	Cut	5	Made form MC nylon, can be used without lubrication.
BSR	0.5 ~ 1	300	C3604	—	Cut	4	Small pitch racks made of free-cutting brass, excellent workability and high rust resistance.
DR	0.8 ~ 2	2000	Duracon (M25-44)	—	Injection Molded	8	Used in applications due to its flexibility, where metal racks do not have this attribute. Pinions and accessories are also available.
SRO · SROS	1 ~ 6	500,1000	S45C	Straightened & annealed	Cut	4	Convenient in applications where the rack has the reciprocal motion. S Type is easy to install.
SURO	1 ~ 3	500,1000	SUS303	—	Cut	5	Same dimensions as SRO racks, except in stainless steel. Use where rust-resistance is required.
KRHG · KRHGF	1 ~ 3	100,500, 1000	SCM440	Thermal refined	Ground	1	Excellent products with high precision and strength, and low noise and abrasion characteristics.
SRH · SRHF · SRHFD	2 ~ 3	100,500, 1000	S45C	Straightened & annealed	Cut	5	Effective in reducing noise and vibration due to larger contact ratio of helical gears.

(NOTE 1) The catalog numbers in the above table with (F) suffix have both ends machined so that they can be butted against each other to make any desired length. The items with (D) have mounting screw holes for easier assembly.

(NOTE 2) Products with module less than 0.8 are thermal refined, without their gear teeth being induction hardened.

(NOTE 3) Precision grade standard of racks are set by KHK. Please see "Precision of Racks" in Selection Hints section for details.

- For safe handling and to prevent damage such as deformation, KHK stock racks have round chamfering at the corners of the top land of the gear tooth. This rounded chamfered shape is patented by KHK. Because it is effective for reducing noise, all of KHK products, except for BSR and PR racks, have this chamfering treatment.
- Black colored products are KHK stock gears that have an applied black oxide coating for rust resistance; this 'blackness' is a product characteristic of KHK stock gears.

## Selection Hints



Please select the most suitable products by carefully considering the characteristics of items and contents of the product tables. It is also important to read all applicable notes before the final selection.

### 1. Caution in selecting the mating Gears

- With the exception of helical racks, KHK stock racks can mate with any spur gears of the same module. Products with different tooth width can also be mated as a pinion.
- There are limited choices for of mating gears for KRHG · KRHGF Ground Helical Racks and Helical Racks. There are limited choices for of mating gears for KRHG(F) Ground Helical Racks and SH Helical Racks. Be sure to check the helix hand (right or left) when selecting.

### ■ Mating Gear Selection Chart (○ Allowable × Not allowable)

Catalog No. & Helix Hand	KRHG KRHGF		SRH · SRHF SRHFD	
	RH	LH	RH	LH
KHG	LH	○ × × × ×	○ × × × ×	○ × × × ×
	RH	× ○ × × ×	× ○ × × ×	× ○ × × ×
SH	LH	× × × ○ ×	× × × ○ ×	× × × ○ ×
	RH	× × × × ○	× × × × ○	× × × × ○



### 2. Caution in Selecting Gears Based on Gear Strength

Allowable bending strength and surface durability values shown in product tables were computed by assuming a certain application environment. They should be used as reference only. We recommend that each user computes his own values by applying the actual usage conditions. The table below contains the assumptions established for various products in order to compute gear strengths.

### ■ Calculation assumptions for Bending Strength of Gears

Item	Catalog No.	MRGF MRGFD	KRGF-H KRGD-H	KRG · KRHG KRGF · KRHGF KRGD · KRF	SRG SRGF SRGFD · SRGFK SRF-H · SRFD-H	SRAF · SR · SRF SRFD · SRFK SRO · SROS	SUR SURF SURFD SURO	BSR	DRF DRFD DRFK	PR PRF	DR
Formula <small>NOTE 1</small>	Formula of spur and helical gears on bending strength (JGMA401-01)								The Lewis formula		
No. of teeth of mating gear	30								(30)		
Rotation	100rpm								(100rpm)		
Durability	Over 10 <sup>7</sup> cycles								Allowable Bending Stress (kgf/mm <sup>2</sup> )		
Impact from motor	Uniform load								1.0 (40°C with No Lubrica- tion)	1.15 (40°C with No Lubrica- tion)	m 0.8 4.0 m 1.0 3.5 m 1.5 1.8 <small>NOTE 4</small> m 2.0 1.2 (Grease lubri- cation40°C)
Impact from load	Uniform load										
Direction of load	Bidirectional										
Allowable bending stress at root $\sigma_{lim}$ (kgf/mm <sup>2</sup> ) <small>NOTE 2</small>	47	32	32	20 (24.5) <small>NOTE 3</small>	20	10.5	4				
Safety factor $S_F$	1.2										

### ■ Calculation assumptions for Surface Durability (Except where it is common with Bending Strength)

Item	Formula <small>NOTE 1</small>	Formula of spur and helical gears on surface durability (JGMA402-01)
Kinematic viscosity of lubricant	100cSt (50°C)	
Gear support	Supported on one end.	
Allowable Hertz stress $\sigma_{Hlim}$ (kgf/mm <sup>2</sup> )	166	112
Safety factor $S_H$	79	90 (62.5)
	52.5	41.3
	1.15	

(NOTE 1) JGMA (Japanese Manufacturers' Association), "MC Nylon Technical Data" of Nippon Polyenco Limited and "Duracon Gear" of Polyplastic Co. The units for rotational speed (rpm) and the load (kgf/mm<sup>2</sup>) were matched to the units needed in the equation.

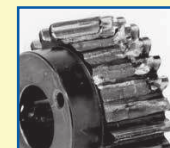
(NOTE 2) The allowable bending stress at root  $\sigma_{lim}$  is calculated from JGMA401-01, and set to 2/3 of the value in the consideration of the use of planetary-, idler-, or other gear systems, loaded in both directions.

(NOTE 3) For SRG, or SRGF Ground Racks, with a module less than 0.8, the rack teeth are not induction hardened. Allowable bending stress and allowable hertz stress are referred to the value shown in the parentheses.

(NOTE 4) The values for DR m 1.5 racks were assumed by KHK. Usage conditions for SDDR (DR Rack Pinion) are the same for the SSCP Pinion, shown on page 227.

### ■ Definition of bending strength by JGMA 401-01 (1974)

The allowable bending strength of a gear is defined as the allowable tangential force at the pitch circle based on the mutually allowable root stress of two meshing gears under load.



Example of the failure due to insufficient bending strength.

### ■ Definition of surface durability by JGMA 402-01 (1975)

The surface durability of a gear is defined as the allowable tangential force at the pitch circle, which permits the force to be transmitted safely without incurring surface failure.



Example of the defacement due to insufficient surface durability.

### 3. Selecting Racks By Precision

The precision standards of KHK stock racks are established by us. The table below indicates the tolerance ranges of our racks.

#### ① Pitch Errors of Racks (KHK R 001)

Our precision grades for pitch errors are established by referring to JIS Standards. The precision grades are set from 1 to 8, in accordance with the tolerance of a single pitch error (S.P.E.), adjacent tooth-to-tooth error (T.T.E.), and the total composite error (T.C.E.) for each module and length.

#### ■ Precision Grades of Racks (KHK R 001) Unit : μm

Grade	Pitch Error	Rack Length (nominal)											
		over m0.4 up to 1		over m1 up to 1.6		over m1.6 up to 2.5		over m2.5 up to 4		over m4 up to 6		over m6 up to 10	
		1000 or less	1500 up to 2000	1000 or less	1500 up to 2000	1000 or less	1500 up to 2000	1000 or less	1500 up to 2000	1000 or less	1500 up to 2000	1000 or less	1500 up to 2000
1	SPE	10	—	10	12	11	12	11	13	13	14	14	16
	TTE	10	—	11	13	12	14	13	15	14	16	16	18
2	SPE	28	—	29	33	30	35	32	37	35	40	40	45
	TTE	14	—	14	17	15	17	16	18	18	20	20	23
3	SPE	16	—	16	19	17	19	18	21	20	24	24	27
	TTE	39	—	41	48	43	49	46	53	50	57	58	64
4	SPE	20	—	20	24	21	25	23	26	25	29	29	32
	TTE	22	—	24	28	25	29	27	31	30	34	34	40
5	SPE	56	—	57	67	60	70	64	74	71	80	81	91
	TTE	28	—	29	33	30	35	32	37	35	40	40	45
6	SPE	33	—	34	42	38	43	40	46	44	50	51	57
	TTE	79	—	81	95	85	99	91	105	100	115	115	130
7	SPE	39	—	41	48	43	49	46	53	50	57	58	64
	TTE	49	—	51	59	53	62	57	69	66	75	76	85
8	SPE	110	—	115	135	120	140	130	145	140	160	160	180
	TTE	206	206	212	212	219	219	—	—	—	—	—	—
9	SPE	330	330	339	339	350	350	—	—	—	—	—	—
	TTE	—	—	—	—	—	—	—	—	—	—	—	—

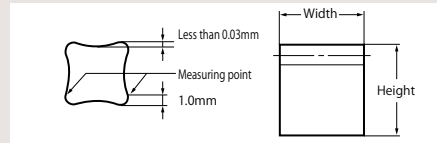
(NOTE) Since the pitch accuracy of racks may vary due to humidity, the precision grades are evaluated at the bottom surface of the product, at the temperature of 20°C. The dimensions of the KHK PR Plastic Racks may vary widely due to humidity. Therefore, the total composite error is assumed to be excluded from this accuracy standard. Please refer separate technical reference book to "Design of Plastic Gears" (Page 107) for change in dimensions.

#### ■ Pitch inspection and a sample report using Karl Zeiss UMC-550 Coordinate Measuring Machine. (KHK R 001 Grade 1)



### ② Precision of Rack Blanks

#### ■ Tolerance on Face Width and Height

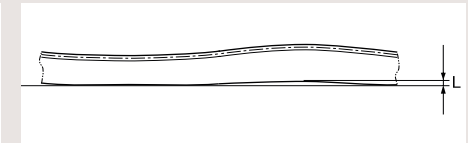


Unit: mm

Precision grade (KHK R 001)	Grade 1	Grades 3 to 4 (Excludes thermal refined racks)	Grades 5 (Includes thermal refined racks)	Grade 8
Below 6	—	0 -0.09	—	± 0.25
6 up to 10	0 -0.05	0 -0.09	0 -0.22	± 0.30
10 up to 18	0 -0.05	0 -0.11	0 -0.27	± 0.35
18 up to 30	0 -0.05	0 -0.13	0 -0.33	± 0.40
30 up to 50	0 -0.05	0 -0.16	0 -0.39	—
50 up to 90	0 -0.05	0 -0.19	0 -0.46	—

(CAUTION) The width and height tolerances of KHK R 001 grades 3 to 5 products are measured at 1mm inside from each corner. Dimensional tolerance for plastic racks is the value obtained when machining is performed, and the maximum tolerance value is +0.2 x Module (+0.40 for m2 products.), with consideration for aging.

#### ■ Maximum Curvature Values (Flatness Tolerance L)



Unit: mm

Precision grade (KHK R 001)	Grade 1	Grade 3	Grades 4 & 5
500	0.05	0.1	0.2
1000	0.05	0.2	0.3
1500	—	—	0.3
2000	—	—	0.4

(CAUTION) The straightness tolerances of round racks are 0.15/500 mm and 0.2/1000 mm.

#### ■ Tolerance on Overall Length Unit: mm

Type of product	Module	Allowable error
Type F racks with machined ends	0.5	(- 0.1) (- 0.3)
	0.8 (CP2.5)	(- 0.1) (- 0.5)
	1 up to 2.5	(- 0.2) (- 0.6)
	Over 2.5	(- 0.2) (- 0.8)
FRCP, DR flexible racks	Uniform	± 10
Other racks	Uniform	+ 3 - 2

(CAUTION) For Type-F racks with machined ends, the dimensional tolerance is a calculated value according to assumed usage conditions, without consideration of pitch errors and aged deterioration.

### ③ Backlash of Rack Tooth

#### ■ Backlash of Rack Tooth (Amount of Tooth Thinning) Unit: mm

Precision grade (KHK R 001)	Grade 1, 2	Grade 3	Grade 4		Grade 5		
			Excludes thermal refined racks	Includes thermal refined racks	Hardened racks	Stainless steel/Helical racks	Plastic racks
m0.5	—	0 ~ 0.07	0 ~ 0.08	—	—	—	—
m0.8, CP2.5	0 ~ 0.06	0 ~ 0.08	0 ~ 0.09	—	—	—	—
m1	0 ~ 0.06	0 ~ 0.10	0 ~ 0.11	—	—	0 ~ 0.13	0 ~ 0.20
m1.5, CP5	0 ~ 0.06	0 ~ 0.10	0.04 ~ 0.13	0.04 ~ 0.15	0.02 ~ 0.17	0.04 ~ 0.15	0 ~ 0.21
m2	0 ~ 0.06	0 ~ 0.10	0.05 ~ 0.14	0.05 ~ 0.16	0.03 ~ 0.18	0.05 ~ 0.16	0 ~ 0.22
m2.5	0 ~ 0.06	0 ~ 0.10	0.06 ~ 0.16	0.06 ~ 0.18	0.04 ~ 0.20	0.06 ~ 0.18	0 ~ 0.24
m3, CP10	0 ~ 0.06	0 ~ 0.10	0.07 ~ 0.18	0.07 ~ 0.20	0.05 ~ 0.22	0.07 ~ 0.20	0 ~ 0.27
m4	—	0 ~ 0.10	0.08 ~ 0.22	0.08 ~ 0.24	0.06 ~ 0.26	0.08 ~ 0.24	—
m5, CP15	—	0 ~ 0.10	0.09 ~ 0.24	0.09 ~ 0.26	0.07 ~ 0.28	0.09 ~ 0.26	—
m6, CP20	—	0 ~ 0.10	0.10 ~ 0.28	—	0.08 ~ 0.32	—	—
m8	—	—	0.13 ~ 0.32	—	—	—	—
m10	—	—	0.15 ~ 0.34	—	—	—	—

(NOTE) The values shown in the table are amount of tooth thinning. The theoretical backlash of assembled rack and pinion is given by:

$$\text{Rack \& pinion backlash} = \text{Amount of tooth thinning of the rack} + \text{Amount of tooth thinning of the pinion}$$

Amount of tooth thinning of the rack : See above table.

Amount of tooth thinning of the pinion : Take 1/2 of backlash given in the product table.

## Application Hints

In order to use KHK stock gears safely, carefully read the Application Hints before proceeding. If there are questions or if you require clarifications, please contact our technical department or your nearest distributor.

KHK CO., LTD.  
PHONE: 81-48-254-1744 FAX: 81-48-254-1765  
E-mail export@khkgears.co.jp

### 1. Caution on Performing Secondary Operations

- Secondary operations can be performed on all KHK stock racks except for the racks with their gear teeth induction hardened. To avoid problems of gear precision, do not reduce the face width. The precision of ground racks and racks with mounting holes may drop if you do not exercise extreme caution during installation or while modifying.
- Pitch lines of racks are controlled by using the bottom surface as the reference datum and over-pin measurements on tooth thickness. If you machine the bottom surfaces, the precision of the racks may be affected.
- When connecting two racks, the machining of the mating ends requires careful consideration. The meshing will be poor if the pitch straddling the connection has a positive tolerance. We recommend a minus tolerance on pitch of at the connection. The below is an indication of pitch tolerance for each module.

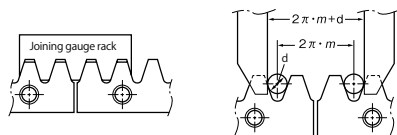
Unit : mm

Module	Pitch (p)	Tolerance
m0.5	1.57	-0.05 -0.15
m0.8	2.51	-0.05 -0.25
m1	3.14	
m1.5	4.71	-0.1 -0.3
m2	6.28	
m2.5	7.85	
m3	9.42	
m4	12.57	
m5	15.71	-0.1 -0.4
m6	18.85	
m8	25.13	
m10	31.42	

$p = \pi \cdot m$   
 $p$  : Reference pitch  
 $\pi$  : Pi  
 $m$  : Module

- To use dowel pins to secure racks, attach the racks to the base and drill both simultaneously.
- KHK stock racks made of S45C and SCM440 (except for ground racks) can be induction hardened. However, the precision of pitch is decreased.
- To be able to handle parts safely, all burrs and sharp corners should be removed after the secondary operations are done.
- If you are going to modify the gear by gripping the teeth, please exercise caution not to crush the teeth by applying too much pressure. Any scarring will cause noise during operation.

### An example of Rack Joining, we recommend the following method.

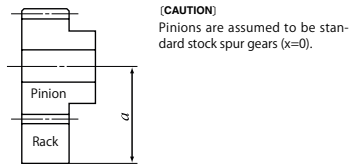


**(CAUTION)** Joining gauge racks for helical racks must have the opposite hand from the racks. Please use Module 1..10 100 racks as a joining gauge rack, or alternatively the rack of the same specifications on hand.

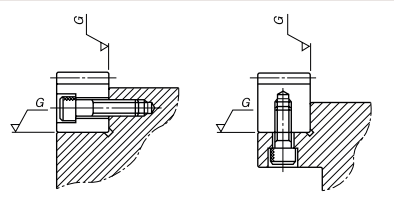
### 2. Points of Caution in Assembling

- KHK stock racks are designed to give the proper backlash when assembled using the mounting distance given by the formula below (mounting distance tolerance of H7 to H8 required). The backlash values are given in the table on Page 191. Make sure that the mounting distance stays constant for the length of the rack.

$$\text{Mounting distance } a = \text{Height of pitch line of rack} + \text{Pitch radius of pinion}$$



- KRG type of KHK stock ground racks have four surfaces ground parallel to within 10~15μm. To maintain true angle, they should be mounted on high precision bases as shown below. It is even possible to correct for the angular errors of racks by compensating the mounting base. With recent increases in the requirement for zero backlash linear drives, such accurate assembly as shown is becoming more important.

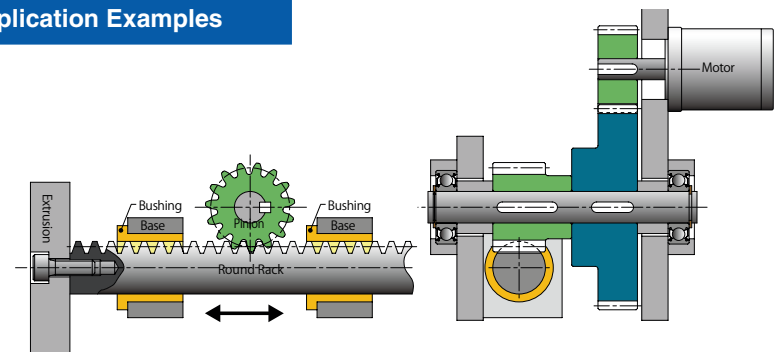


- If the racks are not secured properly to the base, they could shift during operation and cause unexpected problems. It is very important to insure firm mounting by the use of dowel pins or similar devices.
- Machined end type racks such as SRF and SRFD series have the pitch tolerance of -0.05 to -0.4mm at the end face. If you try to connect the racks without any space, the pitch at the connection will be too small and will cause problems. Please follow the following diagrams for assembly.

### How to mount racks on a mounting base (In case of SRF2-1000)

- Adjusting the pitches.**  
Mount the SRF2-1000 Rack on the mounting base and connect with the SR2-100 Rack, then, fix with bolts temporarily.  
  
SRF2-1000 Racks are designed so that they will have a clearance gap between 0.2mm and 0.6mm.
- Fixing the rack on the mountain base.**  
Hit the rack with a plastic hammer to combine closely with the mountain base, then, retighten the bolts. (If a metal hammer is being used, be sure not to deform the gear teeth and use a pressure equalizing plate to protect them.)
- Test and run the pinion on the rack to confirm the following:**  
(1) Makes no large vibrations or abnormal noise.  
(2) Has appropriate backlash.  
(3) Has no uneven teeth-contact occurred.
- Secure the fixing to the mountain base.**  
It is recommended to use knock pins to prevent slippage due to vibration etc. (1) Drill reamer bores simultaneously.  
  
(2) Hammer in the knock pins.  
  
\*After installing the knock pins, retighten them. Making a mark with a pen beforehand will be of help to find looseness if it occurs.\*

### Application Examples



Extrusion device with a round rack\* (It can also be a lifting/lowering device by setting up vertically.)



KRG Ground Rack and SSG Ground Spur Gear used as a work conveying device of the auto loader.



SRO Round Rack used as a work storage device (fluctuating table) of the auto loader.