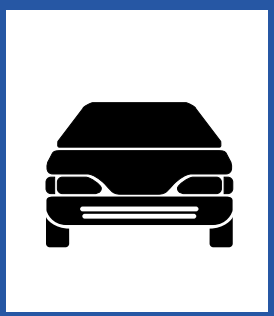
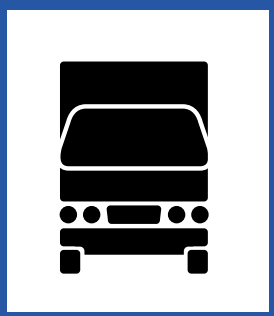
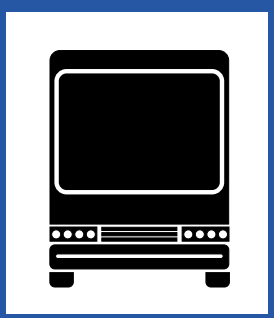
For Automobiles

Koyo®

SPRAG TYPE ONE-WAY CLUTCHES







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KOYO SEIKO CO.,LTD.

CAT.NO.286E

For Automobiles

SPRAG TYPE ONE-WAY CLUTCHES

SPRAG TYPE ONE-WAY CLUTCHES for Automobiles
With the recent improvements of automobiles in performance and comfort, demand for higher performance and functions in automatic transmissions has increased.

KOYO has been producing highly-reliable sprag type one-way clutches for automatic transmission with superior torque transmission performance by employing the latest analysis techniques and machining technologies.

Inner and outer rings for one-way clutches are specially fabricated to comply with customer's specific requirements and ensure maximum performance.
This brochure covers dimensions of KOYO sprag type one-way clutches and technical information required for their selection and installation.

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SPRAG TYPE ONE-WAY CLUTCHES

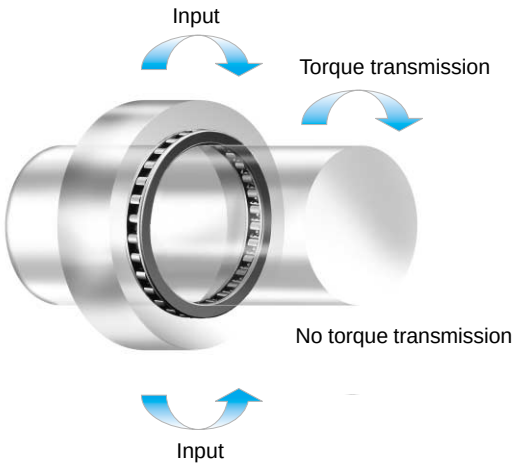
CONTENTS

1. Functions and Structure of One-way Clutches

1.1 Functions

The one-way clutch is a functional component located between cylindrical inner and outer rings for transmitting or suspending torque, which transmits torque in one rotational direction while stopping torque transmission in the opposite direction.

● Rotational direction of the outer ring determines transmission and non-transmission of torque.



● The inner ring easily overruns in the torque suspension direction.

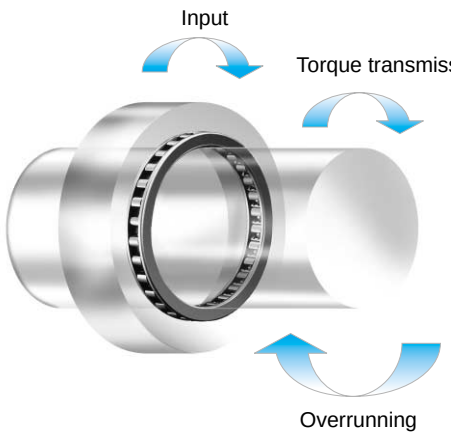


Fig. 1.1 Typical Applications of One-way Clutches

1.2 Structure

In the KOYO sprag type one-way clutches, KW and KX Series are selected according to desired application. The respective features are detailed below.

● KW Series

The KW Series controls sprag position with the inner and outer cages.

The two cages enhance engagement between the sprags and ensure stable torque transmission.

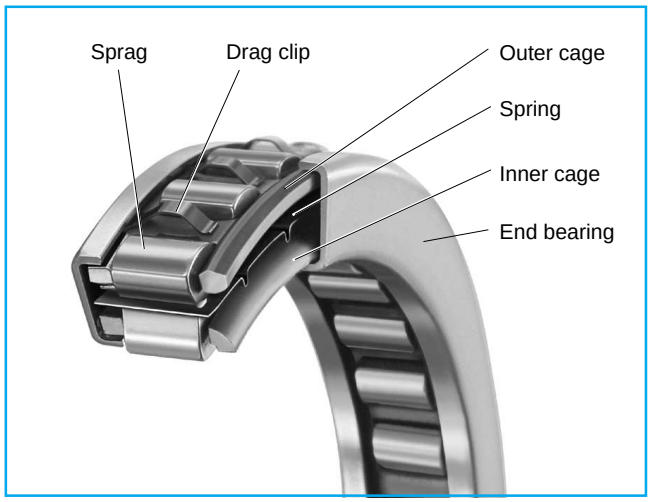


Fig. 1.2 Structure of KW Series One-way Clutch

● KX Series

KX Series controls sprag position with a uniquely shaped spring. A single cage contributes to reduction in weight and inertia torque.

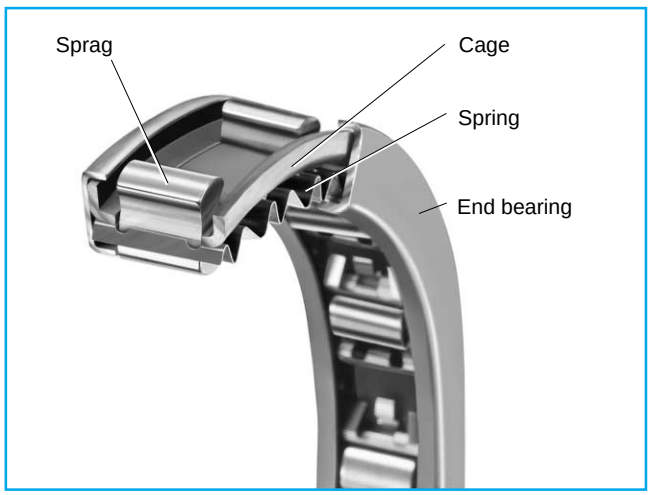


Fig. 1.3 Structure of KX Series One-way Clutch

1.3 Nomenclature

Sprag

Mates between inner and outer rings to transmit torque.
High-carbon chromium steel is drawn and heat-treated to obtain 60 HRC or more hardness.

Cage

Arranges sprags equally on the circumference for uniform torque transmission.
The cage is made of heat-treated carbon steel plate.

Spring

Maintaines constant sprag with the inner and outer rings to ensure engagement of sprangs.
The spring is made of stainless steel sheet or special alloy steel plate and is precision-stamped.

End bearing

Keeps the inner and outer rings on centered to maintain a constant spase, if the radial load on the one-way clutch is only small when overrunning.
The end bearing is generally made of bronze or similar materials, although other materials are available in accordance with the load, rotational speed, and lubrication requirements.

Drag clip

Several pieces are provided on the outer diameter surface of the cage.
The drag clip secures the cage against the outer ring by a spring action in order to synchronize movement of the cage with the outer ring for positive and prompt engagement of the sprags.
The clip is made of stainless steel plate.

T bar

In the one-way clutch without end bearings, T bars stamped on the cage provide the same spring action and function as that of the drag clips.

Fig. 1.4 Cage with T Bar

1.4 Designation

(Example)

KW 057 13 00

Serial number	00, 01, 02, · · ·	: Distinguishes the same bore diameter numbers and width numbers
Width number	13	: Width 13 to 13.999 mm
Bore diameter number	057	: Bore diameter 57 to 57.999 mm

For details of inner ring raceway diameter dimensions and mounting width, refer to the dimension table.

Series code	KW	: KW Series
	KX	: KX Series

1.5 Principle of Torque Transmission

The sprags are arranged equally on the circumference between the inner and outer rings by the cage and are constantly in contact with the inner and outer rings by spring force.

Since the sprags are larger than the space between the inner and outer rings, they are arranged at an angle to the raceway surfaces of the inner and outer rings.

The sprag surfaces in contact with the inner and outer surfaces are shaped such that the sprag height appears to increase when the sprags rotate around their centers (Fig. 1.5).

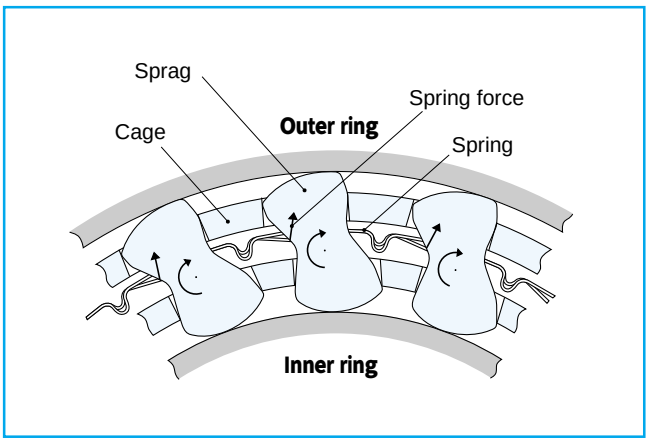


Fig. 1.5 Sprag Shape and Arrangement

When the outer ring rotates clockwise as shown in Fig. 1.6, friction between the outer ring and the sprag contact surface causes the sprags to incline clockwise and engage with the inner and outer rings to transmit torque.

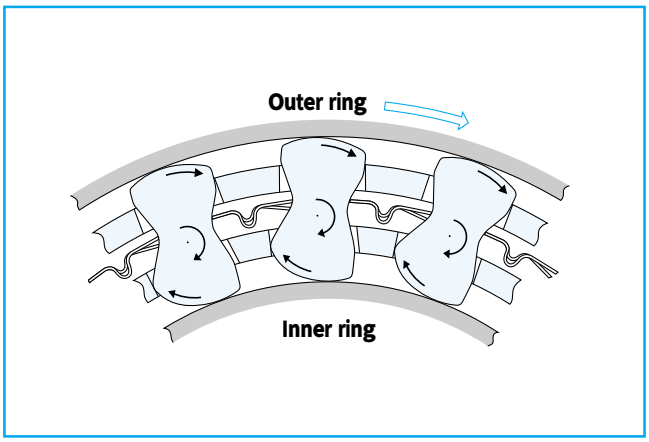


Fig. 1.6 Sprag Position in Torque Transmission

When the outer ring rotates counterclockwise as shown in Fig. 1.7, the sprags incline counterclockwise to disengage with the inner and outer rings, thus freewheeling the outer ring.

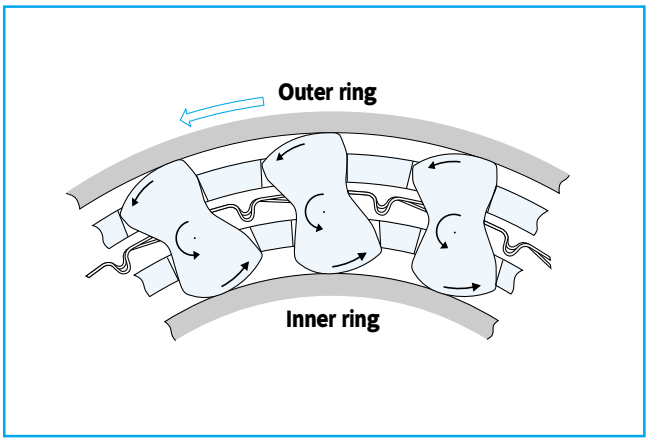


Fig. 1.7 Sprag Position in Freewheeling

1.6 Strut Angle

The positional relationship of the sprag engaging with the inner and outer rings is shown in Fig. 1.8.

The angles α and β are called the strut angles on the inner and outer ring respectively.

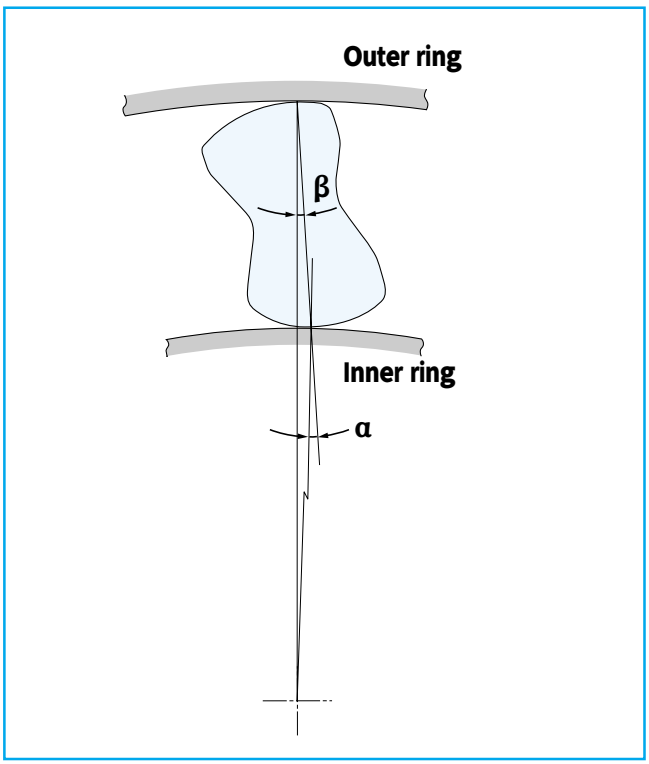


Fig. 1.8 Strut Angle

The sprag type one-way clutch is designed to transmit torque by friction between the contacting surfaces of the sprag with the inner ring and the outer ring.

If tanα with tanβ exceed the friction coefficient μ of the respective contacting surfaces, the sprags slip and fail to engage hence transmitting no torque.

When tanα and tanβ are excessively small, the load on the contacting surfaces becomes large, thus decreasing torque transmission capability.

Since α is always greater than β, tanα is smaller than μ for torque transmission.

KOYO sets optimum strut angles for maximum torque transmission without slip on the contacting surfaces.

2. Rated Torque and Drag Torque

2.1 Rated Torque

The rated torque of the sprag type one-way clutch is a function of the fatigue strength of the contacting surfaces on the sprag.

The rated torque is the limit in which the clutch functions without slip or harmful plastic deformation after repeated application of torque on the one-way clutch, and without flaking on the sprag or raceway surfaces due to fatigue after 10^6 repetitions of torque application.

Since the stress generated on the contacting surfaces is larger on the inner ring side than the outer ring side, the rated torque is calculated based on the stress on the inner ring side. The values are shown in the dimension table.

2.2 Required Rated Torque

The required rated torque of the sprag type one-way clutch to satisfy the required endurance performance is calculated as follows.

$$T \geqq \frac{T_C}{f_C} \quad \cdots\cdots\cdots (2.1)$$

where

T : Required rated torque, N·m

T_C : Actual maximum torque, N·m

f_C : Correction coefficient, N·m

When the required endurance performance of the clutch is 10^6, set f_C to 1.

For endurance performance other than 10^6, obtain the correction coefficient from Fig. 2.1 and calculate the required rated torque from expression 2.1.

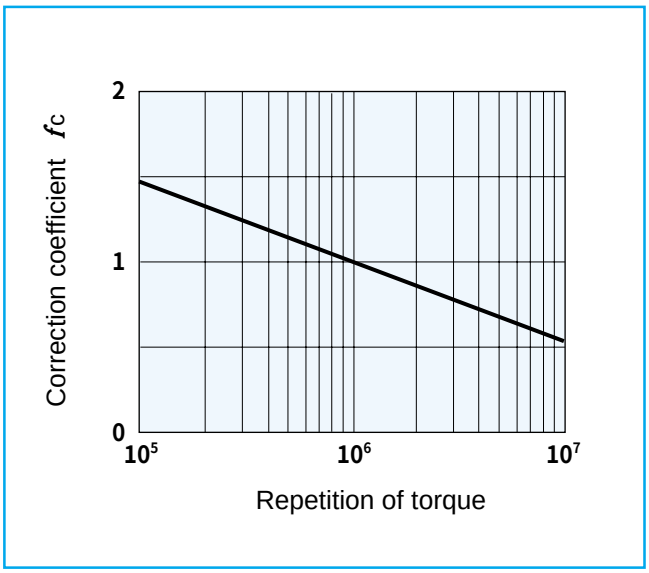


Fig. 2.1 Correction Coefficient of Rated Torque

Under operation with torsional vibration, the rated torque must be set sufficiently large to cover the actual maximum torque.

Temporary excessive torque 1.5 to 2 times the rated torque can be loaded. If excessive torque is anticipated frequently, however, the excessive torque shall be regarded as the actual maximum torque.

For detailed discussion about rated torque, consult with the KOYO representatives.

The rated torque is calculated based on the fact that the inner and outer rings employed for the one-way clutch have sufficient rigidity and that the raceway surfaces are machined to the specified dimensional precision. Therefore, the material, hardness, dimensional precision, sectional thickness, and lubrication of the raceway surfaces shall be properly selected; otherwise, the endurance performance of the one-way clutch may deteriorate.

2.3 Drag Torque

The sprag type one-way clutch slips between the sprag and the inner ring in freewheeling, generating frictional torque, known as drag torque.

Since the sprag comes into contact with the inner ring due to spring, the drag torque is determined by spring force.

Spring force is relatively small, and the sprag rotates at the same speed as the outer ring. When the outer ring rotates, centrifugal force acts on the sprag, and so the drag torque thus varies according to the rotational speed of the outer ring.

2.4 Types of Sprags

According to the sprag gravitational center location, the contacting force between the sprag and the inner ring changes under the influence of the centrifugal force caused by rotation on the sprag. (Fig. 2.2)

The respective sprags are engage and disengage types.

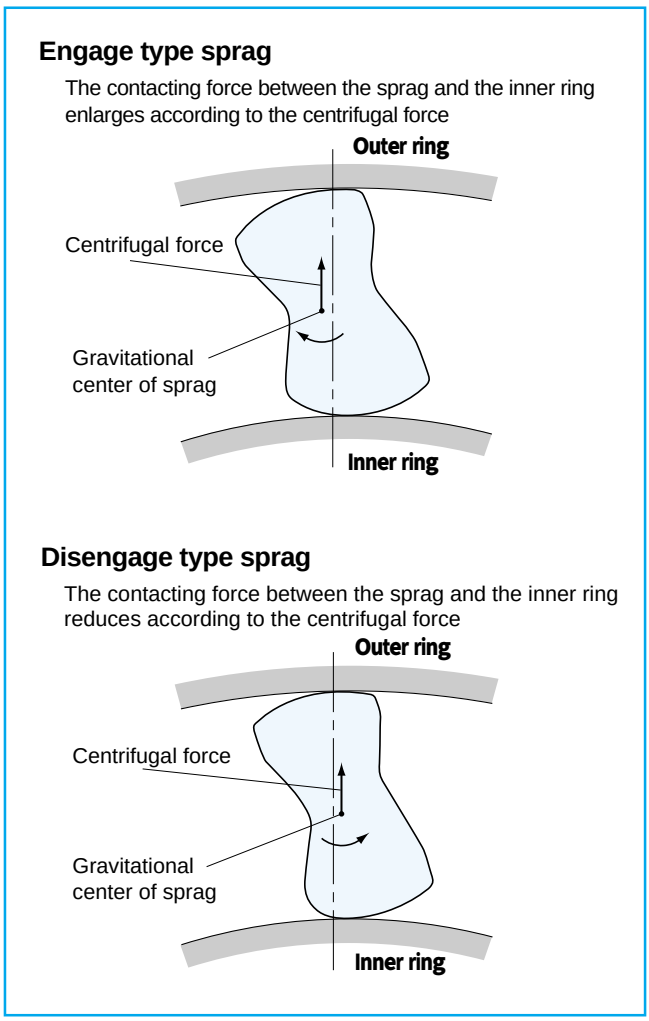


Fig. 2.2 Types of Sprag and the Effect of Centrifugal Force

The relationship between the rotational speed of the outer ring and the drag torque is shown in Fig. 2.3.

The rotational speed at which the drag torque becomes zero in the disengage type is called the disengage speed, above which the sprag does not come in contact with the inner ring.

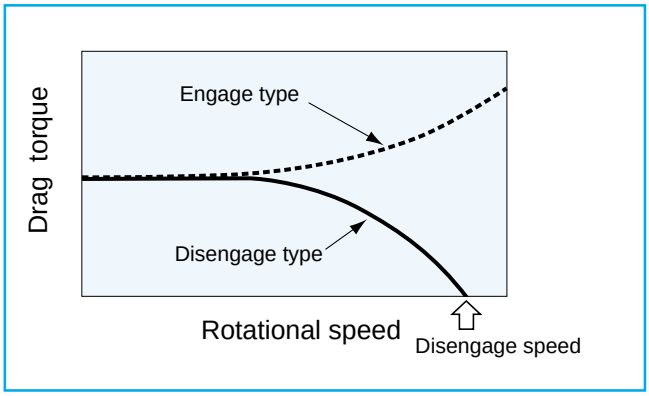


Fig. 2.3 Relationship between Outer-ring Rotation Speed and Drag Torque

2.5 Sprag Selection

It is important to select appropriate sprags for specific operating conditions in order to operate the for an extended period of time.

The sprag types are selected according to the static and rotational conditions of the inner and outer rings (Table 2.1).

Table 2.1 Selection of Sprag Type According to Static and Rotational Conditions

Rotational Conditions		Sprag Type	
Inner Ring	Outer Ring	Engage Type	Disengage Type
Static	Rotation	Usable	Suitable
Rotation	Rotation	Suitable	Unusable
Rotation	Static	Suitable	Suitable

Since the engage type increases drag torque with the increase in rotational speed of the outer ring, the sprag positively engages with the inner and outer rings when it changes to the engagement condition during the outer ring rotation.

Since the disengage type decreases drag torque with the increase in rotational speed of the outer ring, wear on the sprag and inner ring raceway surface is reduced. However the disengage type is not suitable for engagement in high-speed rotation.

When the static and rotational conditions are not covered by Table 2.1, consult KOYO representatives.

3. Mounting and Design of Inner and Outer Rings

3.1 Support of Radial Load

Since the sprag type one-way clutch cannot radial load, required the rolling bearing or plane bearing to support the radial load (Fig. 3.1).

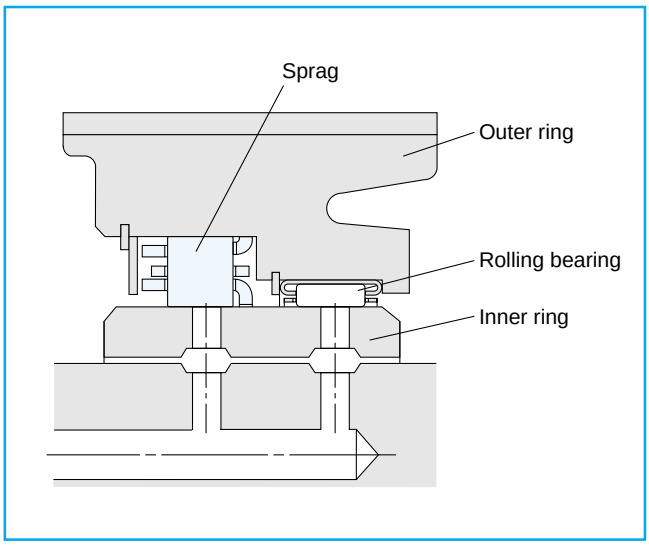


Fig. 3.1 Example of Radial Load Support Using Rolling Bearing

Relatively small radial loads such as dead load of the inner or outer ring alone can be supported by the sprag type one-way clutch with end bearing.

The radial load supported by the one-way clutch with end bearings varies according to the lubricant, rotational speed, and other conditions. Consult KOYO representatives.

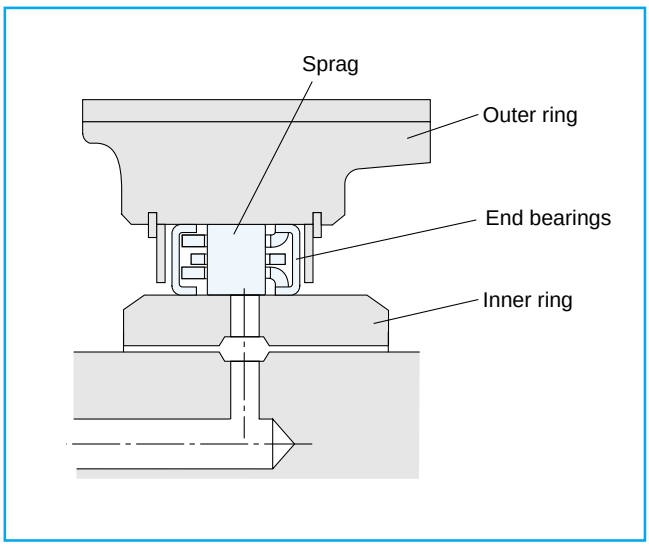


Fig. 3.2 One-way Clutch with End Bearings

3.2 Axial Mounting

Mounting width of the sprag type one-way clutch shall be set to Wf dimension or more as shown in the dimensional table.

Use the retaining plates similar to that shown in Fig. 3.3 to retain the one-way clutch in the axial direction and to hold the lubricant. Ensure a clearance between retaining plate and inner ring of 0.5 to 2mm.

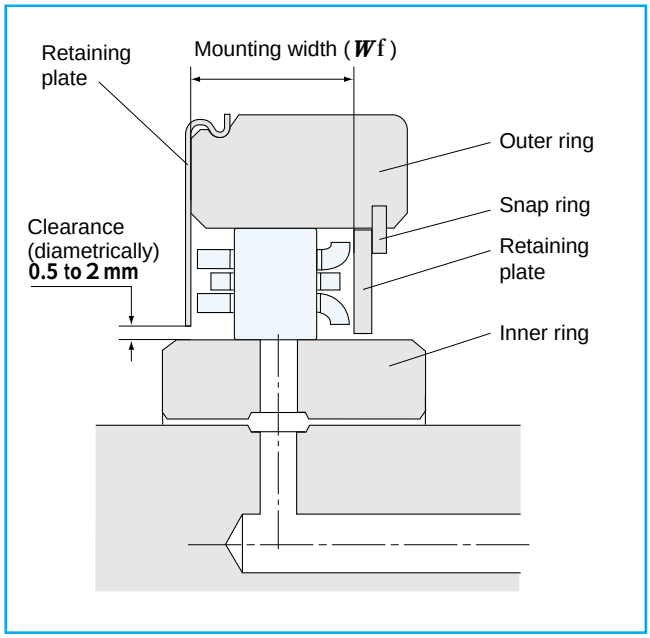


Fig. 3.3 Example of Axial Mounting

3.3 Materials and Hardness of Inner and Outer Rings

The materials of the inner and outer rings shall have sufficient endurance against load by sprag engagement and wear due to sliding during freewheel.

The materials shall also have impact strength and fatigue strength when the repetition frequency of the load torque is high.

According to these requirements, carburized and hardened or induction hardened alloy steel is suitable for the inner and outer rings of the sprag type one-way clutch.
Typical materials and heat treatment are shown in Table 3.1.

Table 3.1 Materials and Heat Treatment Example of Rings

	Carburized and hardened	Induction hardened
Surface hardness	60 HRC or more	
Core hardness	35 to 45 HRC	25 to 30 HRC
Hardening depth (500HV)	1.3 mm or more	1.5 mm or more
Materials	JIS SCr420, SCM415, or similar	JIS S45C, S55C or similar

For materials or if employing heat treatment other than the above, consult KOYO representatives.

3.4 Sectional Height of Inner and Outer Rings

Radial load is applied to the inner and outer rings of the sprag type one-way clutch by sprag engagement.

Since tensile stress occurs on the external diameter surface of the outer ring in the circumferential direction, the outer ring must have sufficient tensile strength.

Set the sectional height of the inner and outer rings as shown in Fig. 3.4.

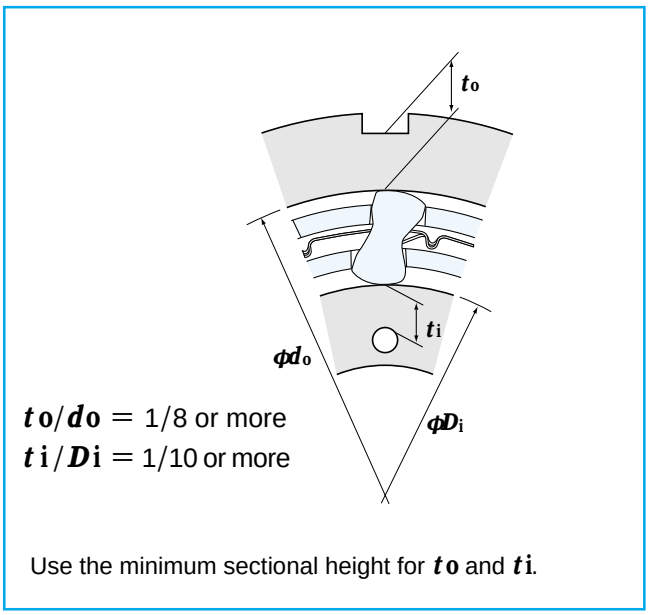


Fig. 3.4 Sectional Height of Rings

Any notches or oil holes in the rings may cause deformity under local stress, or excessive wear of the raceway surface, or cracking of the rings. For the strength of inner and outer rings with complicated contours, consult KOYO representatives.

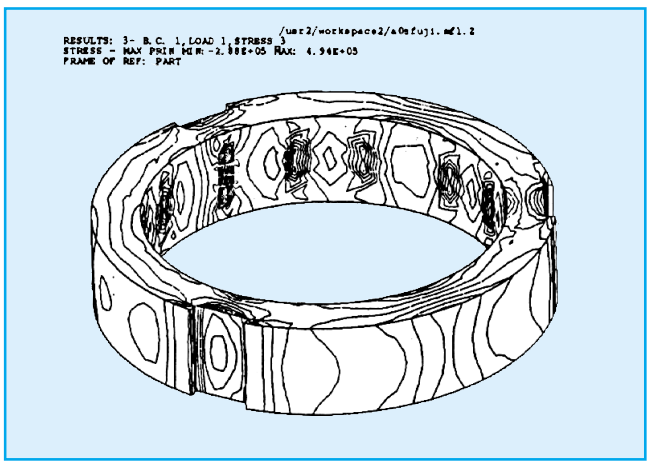


Fig. 3.5 FEM Analysis Sample of Outer Ring

3.5 Chamfering of Inner and Outer Rings

Chamfer of approx. 1 to 2 mm in length and 30 °in angle must be made at the ends of the raceway of the inner and outer rings to facilitate assembly of the one-way clutch (Fig. 3.6).

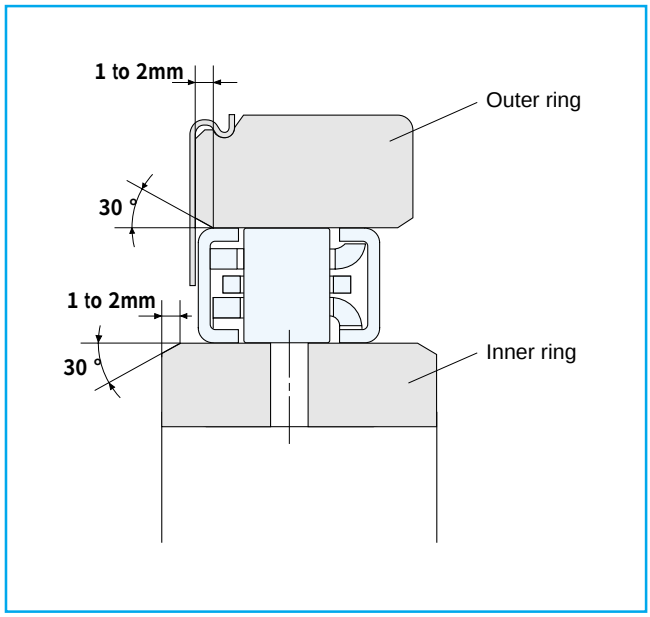


Fig. 3.6 Chamfering Dimensions for Inner and Outer Rings

3.6 Precision of Inner and Outer Rings

The inner and outer rings of the one-way clutch must be made to the precision as shown below to ensure the rated torque of the sprag type one-way clutch and to obtain required endurance performance.

- The nominal dimensions and tolerances of the inner and outer ring raceway diameters must be as shown on the dimension table.
- The precision of raceway surfaces other than the raceway diameter must be as shown on Tables 3.2 and 3.3.

Table 3.2 Precision of Inner and Outer Ring Raceway Surface

(Max. Unit: mm)

Roundness	0.013
Cylindricity	0.003/10
Raceway surface roughness	3.0 μm RZ

Table 3.3 Concentricity of Inner and Outer Ring Raceway Surface

(Max. Unit: mm)

Concentricity	ϕ 0.075

4. Lubrication

Appropriate lubricant and adequate supply are vital to ensure maximum performance of the sprag type one-way clutch.

4.1 Lubricant

Lubricant must be carefully selected since it determines friction coefficient of the sprag with the inner or outer ring and influences torque transmission performance.

In general, automatic transmission fluid is most suitable.

Do not use lubricants containing extreme-pressure additives, since they degrade the friction coefficient and affect the engagement performance of the sprag.

The sprag type one-way clutch is operable at 160℃ of instantaneous temperature and 120℃ of continuous temperature at the highest. If temperatures are anticipated to exceed these limits, the lubricant shall be cooled to maintain the one-way clutch temperature below the above.

Remove contaminants to keep the lubricant clean.

4.2 Lubrication Method

Keep the oil level above the center of the one-way clutch during oil bath lubrication to ensure that the one-way clutch is always immersed in the lubricant.

In forced lubrication, supply oil from the inner ring side to lessen wear on the inner ring raceway surface. In general, provide six oil intakes of approx. 2 mm in diameter at the center of the inner ring raceway (Fig. 4.1).

The oil supply shall be between 600 and 1 000 cm^3/min.

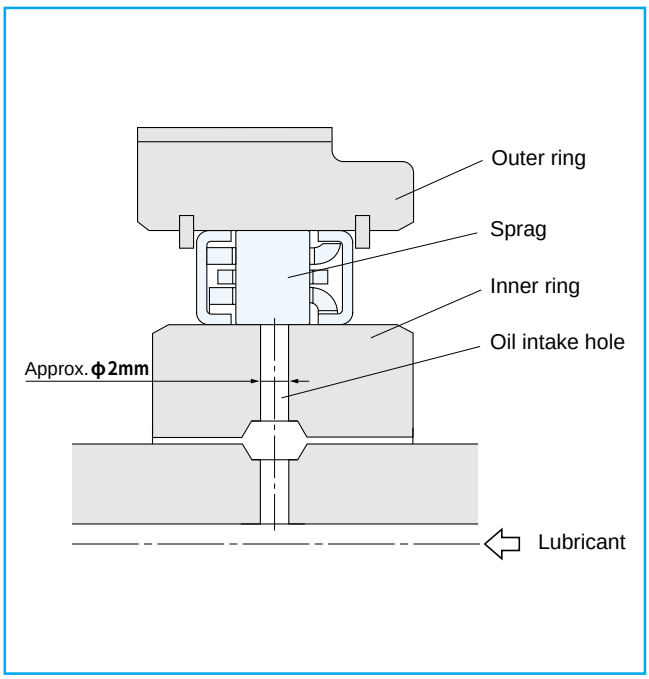


Fig. 4.1 Example of Oil Intake Hole for Forced Lubrication

If a continuous oil groove as shown in Fig. 4.1 cannot be provided due to the mechanical structure of the inner-ring-rotating clutch, an oil sump must be provided on the internal diameter surface of the inner ring as shown in Fig. 4.2 to ensure sufficient oil quantity.

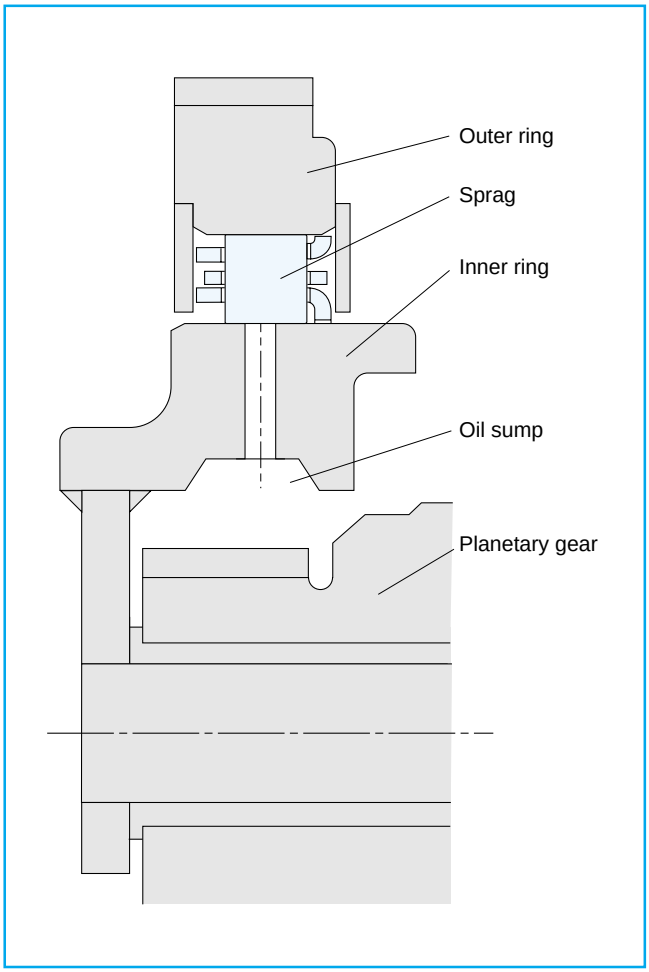


Fig. 4.2 Oil Sump Example in the Case of Inner Ring Rotation

5. Mounting

Since the sprag type one-way clutch is a high precision mechanism, ensure that it is free from dirt, rust, and damage.

Handle with care. Mishandling may deform the cage, or dislodge the sprags.

Mount the end bearings on each side before and after assembly of the one-way clutch.

After mounting in a transmission, check that engagement and drag directions are correct.

5.1 Mounting to Outer Ring

To mount the one-way clutch on the outer ring, a jig which pushes all the sprags against the inner surface of the cage will facilitate easy assembly.

Do not forcibly press the one-way clutch into place. Forced assembly may damage the sprag, cage, or drag clips.

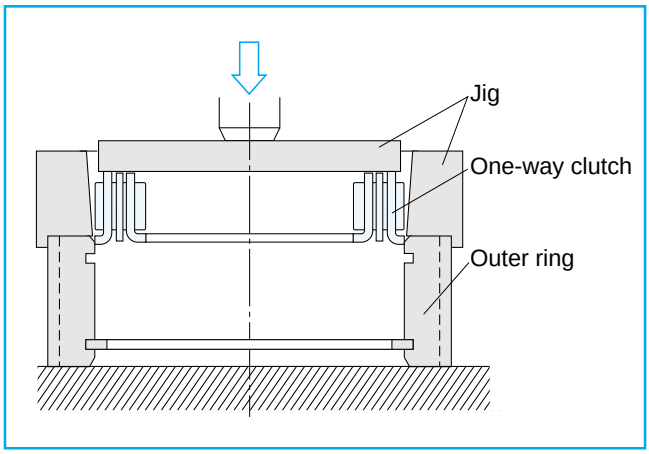


Fig. 5.1 Example of Mounting to Outer Ring

5.2 Mounting to Inner Ring

To mount the inner ring or shaft to the one-way clutch, rotate the inner ring or shaft in the freewheeling direction to facilitate easy assembly.

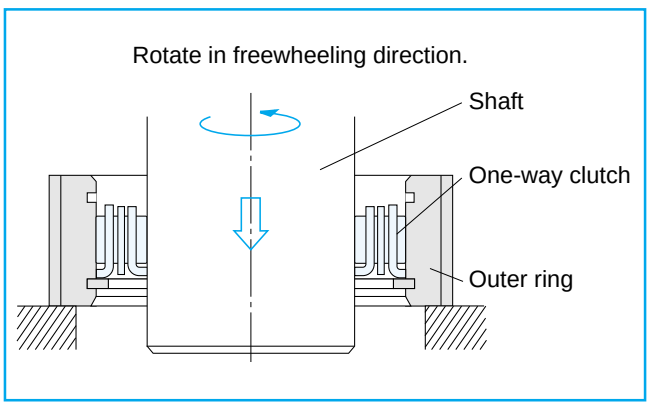


Fig. 5.2 Example of Mounting to Shaft

5.3 Simultaneous Mounting to Outer and Inner Rings

To mount the one-way clutch on the inner and outer rings at the same time, use a jig as shown in Fig. 5.3 and rotate the inner or outer ring in the freewheeling direction during assembly.

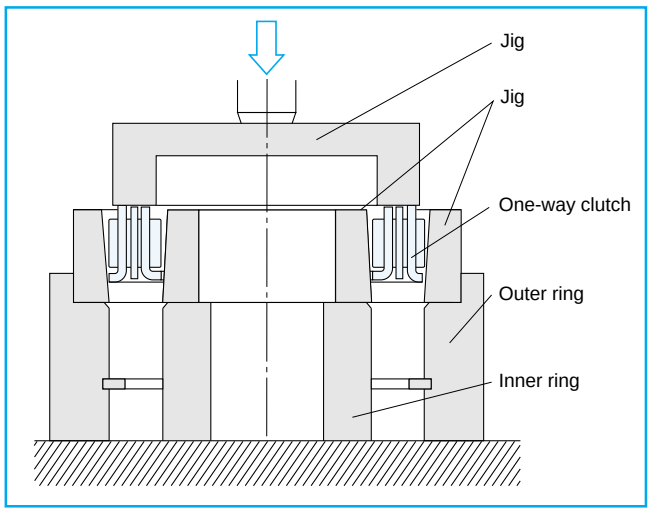


Fig. 5.3 Simultaneous Assembly on Inner and Outer Rings

6. Troubleshooting

Damages to the sprag type one-way clutch include flaking and wear of engagement surfaces. Failures inherent to the sprag type one-way clutch are described below.

6.1 Popping and Pop-out

Popping is a phenomenon in which sprags slip on the inner ring surface during engagement and hop toward the freewheeling side.

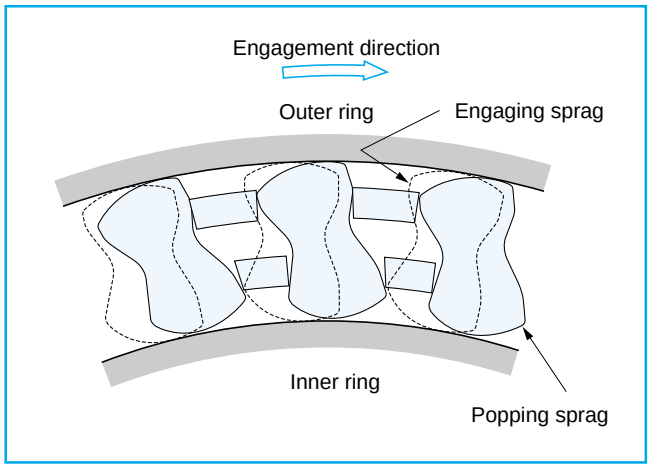


Fig. 6.1 Popping of One-way Clutch

Excessive popping may cause sprags to become stuck in the pockets of the cage, known as pop-out.

Fig. 6.2 One-way Clutch in Pop-out State

The causes of popping are described below.

- Inappropriate lubricant lowers the friction coefficient of engagement surfaces.
- The sprag engagement surface is worn by dirt or debris, and the strut angle becomes large.
- The inner and outer rings are mounted with excessive eccentricity.
- Load sharply fluctuates due to torsional or axial vibration. (Impact torque)

To prevent popping, use appropriate lubricant, and keep the lubricant clean using a filter.

If vibration is a possible cause, select a one-way clutch with higher rated torque.

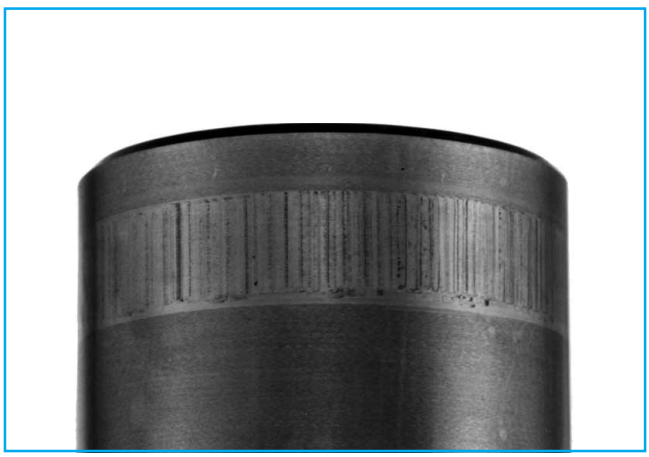


Fig. 6.3 Sliding Nicks on the Inner Ring Raceway Caused by Popping

6.2 Roll-over

Roll-over is a phenomenon in which sprags fall beyond the engagement position toward the opposite side due to excessively high torque. This subjects the raceway surfaces of the inner and outer rings to excessive force, causing deep brinelling.

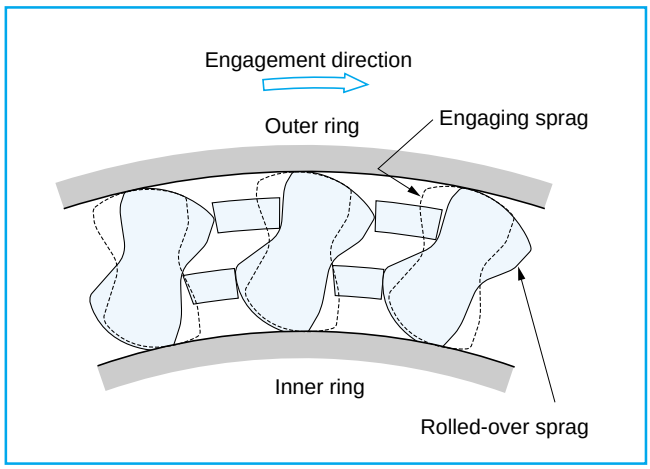


Fig. 6.4 Roll-over of One-way Clutch

The causes of roll-over are described below.

- The inner and outer rings deform because of insufficient rigidity, (or hardness) or because of excessively high torque.
- The strut angle becomes small because of inappropriate raceway diameter or worn inner ring raceway surface.

To prevent roll-over, increase the rigidity of the inner and outer rings, and enhance wear resistance of the raceway surface.

Use one-way clutches with higher rated torque.

Fig. 6.5 Brinelling on the Inner Ring Raceway Surface Caused by Roll-over

7. Performance Evaluation Test

KOYO conducts various evaluation tests to confirm the performance of sprag type one-way clutches upon request.
The evaluation tests include those listed below.

Table 7.1 shows operating conditions required for performance evaluation and selection of one-way clutches.
For reference to performance evaluation and selection, use Table 7.1.

● Roll-over test

Loading torque is gradually increased to determine the threshold torque at which roll-over occurs in sprags.

● Stroking test

Constant torque is repeatedly loaded to determine the durability of the one-way clutch.

● Freewheeling endurance test

The inner or outer ring is rotated in the freewheeling direction at constant speed to determine the wear resistance of sprags and raceway surfaces.

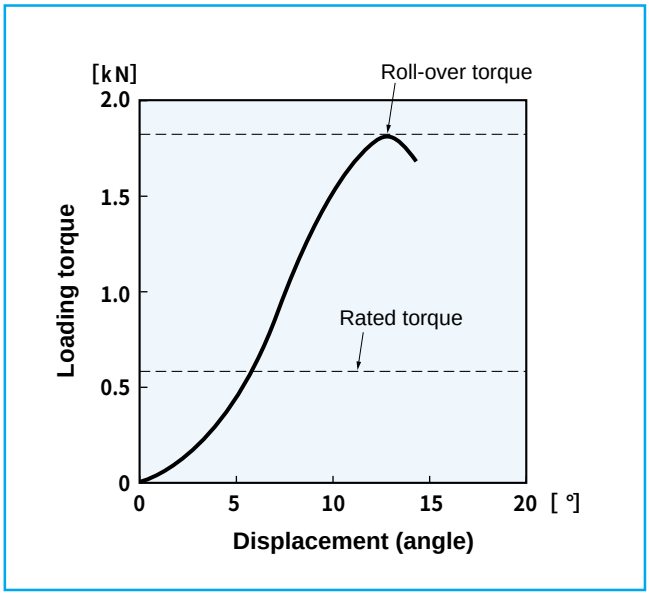


Fig. 7.1 Example of Roll-over Test Results

■ **Endurance Tester for Sprag Type One-way Clutches**

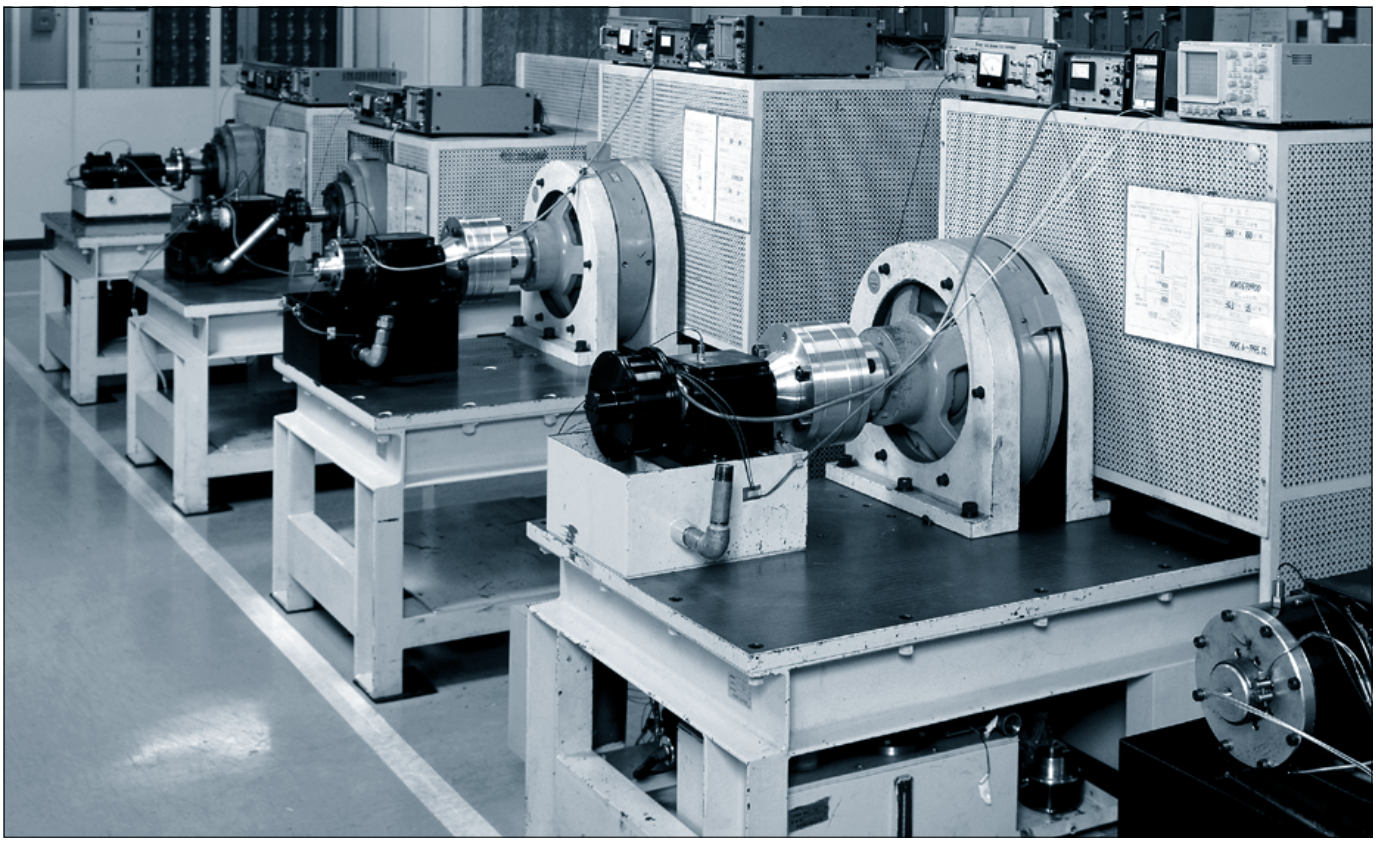


Table 7.1 Operating Conditions of Sprag Type One-way Clutches

1. Dimensions

■ Inner ring

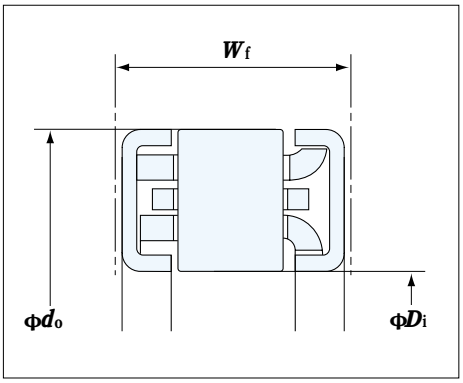
Raceway diameter (*Di*)		mm
Bore diameter		mm
Width		mm
Material		
Heat treatment		
Hardness	Surface	
	Core	
Hardening depth		mm
Mounting width (*Wf*)		mm

■ Outer ring

Raceway diameter (*do*)		mm
Outside diameter		mm
Width		mm
Material		
Heat treatment		
Hardness	Surface	
	Core	
Hardening depth		mm

2. Loading torque

Maximum torque	N•m
Required roll-over torque	N•m
Torque under normal operating conditions	N•m
Loading frequency	Hz



3. Running condition

Maximum free-wheeling speed	Outer ring	min^{-1}
	Inner ring	min^{-1}
Lubrication		
Lubricant		
Oil supply		cm^3/min
Ambient temperature		°C

4. Equipment

Name
Site

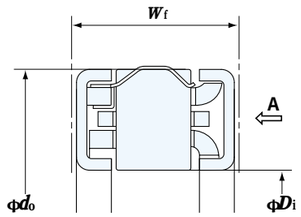
Operating Conditions of Transmission

Static and Rotational Condition		Speed (shift)					
		1	2	3	4	5	R
Freewheeling	Inner ring stops and outer ring rotates						
	Inner ring rotates and outer ring stops						
	Inner and outer rings rotate in the same direction						
	Inner and outer rings rotate in opposite directions						
Engagement	Rotation speed						

Fill in the rotation speed (min^{-1}) in the column appropriate for customer's static and rotational condition of one-way clutches at each speed.

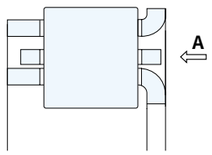
5. Other specifications

8. Dimension Table

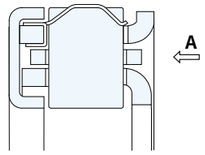


Type 1

With drag clip and end bearings

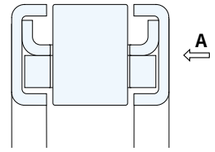


Type 2



Type 3

With drag clip and end bearings



Type 4

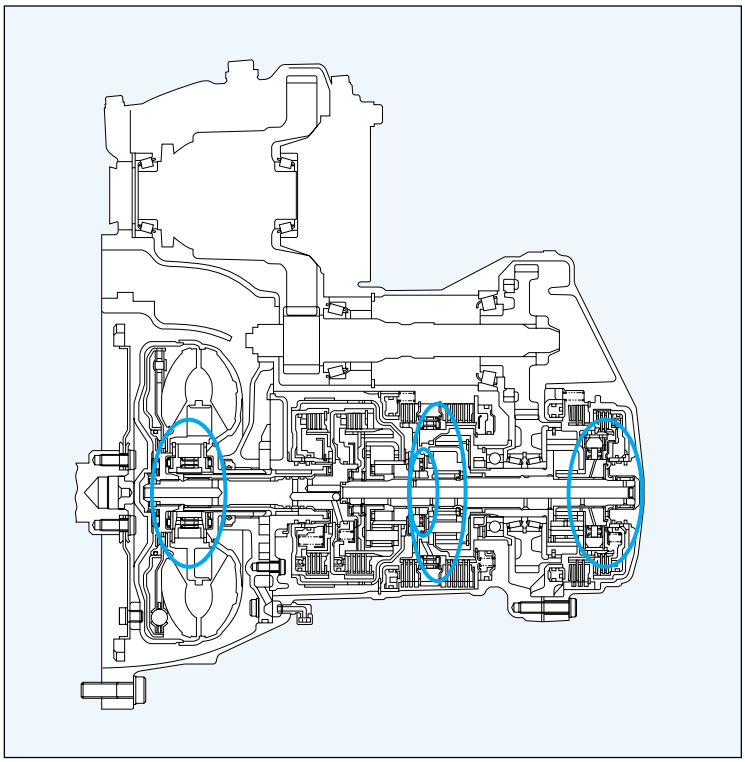
With end bearings

Mounting Dimensions (mm)					Designation		Type No.	Freewheeling Direction 1)	Sprag Type 2)	Rated Torque		Number of Sprags	Mass
Inner Ring Raceway Diameter D_i		Outer Ring Raceway Diameter d_o		Minimum Mounting Width W_f						(N·m)	{kgf·m}		(g)
34.475	$^{+0.008}_{-0.005}$	51.137	±0.013	13.0	KW0341200		2	L	D	133	13.6	12	60
37.318	$^{+0.008}_{-0.005}$	53.980	±0.013	13.5	KW0371100		1	R	E	123	12.6	12	70
				13.5	KW0371101		1	R	E	185	18.9	18	80
				15.5	KW0371400		2	R	D	221	22.5	18	75
40.485	$^{+0.008}_{-0.005}$	57.147	±0.013	11.5	KW0401100		2	R	D	202	20.6	19	60
41.275	$^{+0.008}_{-0.005}$	57.937	±0.013	13.5	KW0411300		2	R	D	212	21.6	14	70
				13.5	KW0411302		2	R	D	275	28.1	18	75
44.450	$^{+0.008}_{-0.005}$	61.112	±0.013	24.7	KW0442200		1	R	E	626	63.9	20	165
49.721	$^{+0.008}_{-0.005}$	66.383	±0.013	13.5	KW0491300		2	R	D	378	38.6	22	85
54.765	$^{+0.008}_{-0.005}$	71.427	±0.013	17.5	KW0541500		1	R	E	575	58.7	24	115
57.710	$^{+0.008}_{-0.005}$	74.427	±0.013	16.1	KW0571301		1	R	D	546	55.7	26	135
57.760	$^{+0.008}_{-0.005}$	74.427	±0.013	15.1	KW0571300		1	R	D	540	55.1	26	130
62.884	$^{+0.008}_{-0.005}$	79.603	±0.013	18.5	KW0621600		3	L	D	810	82.7	28	165
62.935	$^{+0.008}_{-0.005}$	79.600	±0.013	24.1	KW0622200		1	R	E	1130	115	28	220
68.600	$^{+0.008}_{-0.005}$	85.262	±0.013	13.5	KX0681100		4	R	E	478	48.8	24	105
				13.5	KW0681100		1	R	E	587	59.9	30	130
72.217	$^{+0.008}_{-0.005}$	88.882	±0.013	13.5	KW0721300		2	R	D	637	65.0	24	150
74.228	$^{+0.008}_{-0.005}$	90.890	±0.015	18.5	KW0741800		2	R	D	1220	124	30	170
79.118	$^{+0.008}_{-0.005}$	95.777	±0.015	16.1	KW0791500		2	R	D	1210	123	34	160
83.147	$^{+0.008}_{-0.005}$	102.147	±0.015	15.5	KW0831300		3	R	D	918	93.7	32	130
90.500	±0.013	107.162	±0.015	14.6	KX0901200		4	R	E	460	46.9	15	120
				14.6	KX0901202		4	R	E	920	93.9	30	140
94.562	±0.013	111.224	±0.015	14.8	KX0941200		4	R	E	1040	106	30	145
103.500	±0.013	122.500	±0.015	15.8	KW1031303		1	R	D	550	56.1	15	205
				15.8	KW1031300		1	R	D	740	75.5	20	220
				15.8	KW1031301		1	R	D	1100	112	30	230
118.983	±0.013	135.645	±0.015	13.7	KX1191101		4	R	E	760	77.6	19	150
109.500	±0.013	128.500	±0.015	15.7	KW1091300		1	R	D	1240	127	32	240
131.983	±0.013	148.645	±0.015	13.9	KX1321100		4	R	E	1780	182	42	200
				14.9	KX1321200		4	R	E	1070	109	21	170
140.990	±0.013	157.652	±0.015	13.7	KX1411102		4	R	E	1050	107	24	175

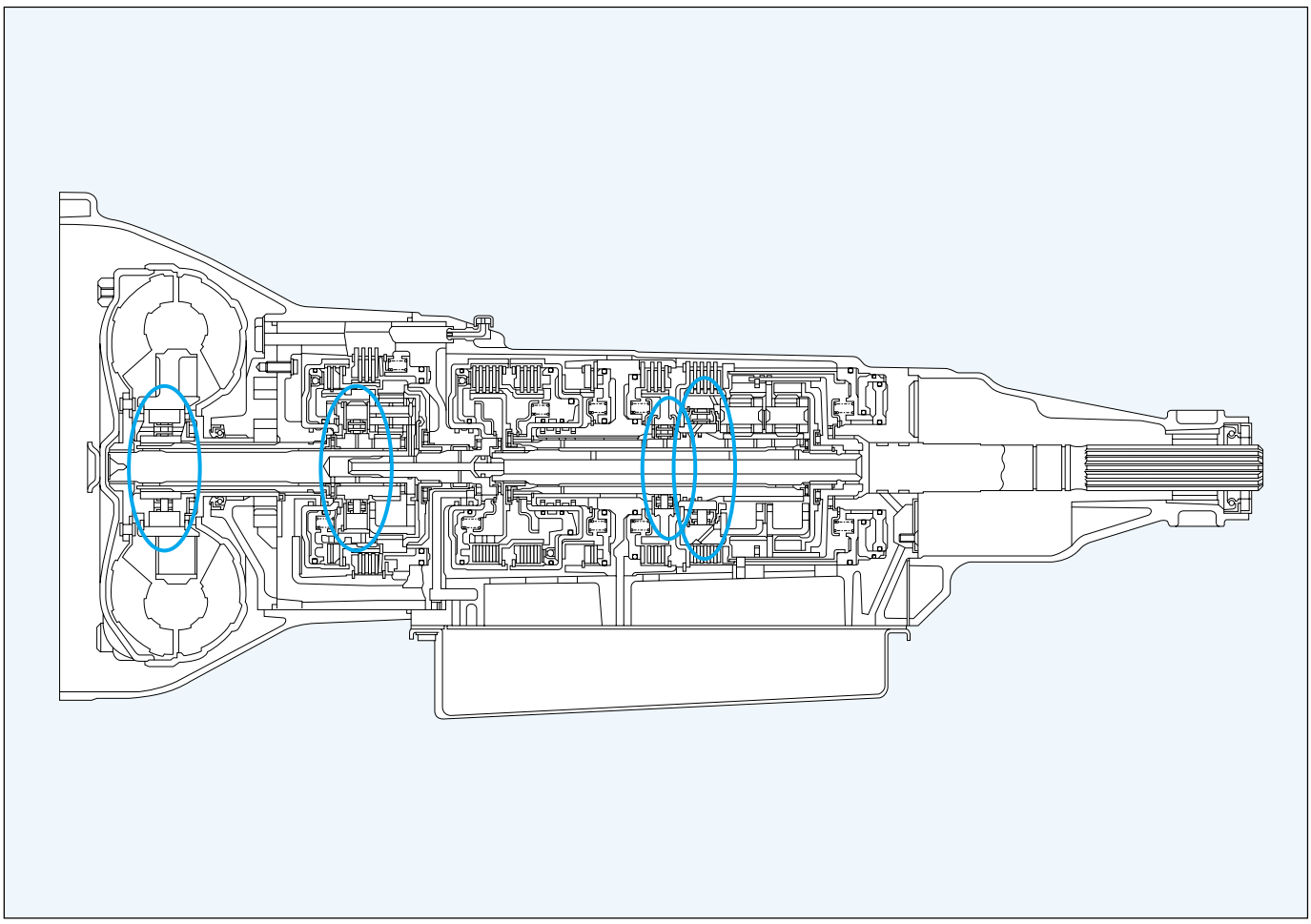
Notes: 1) The freewheeling direction is the rotational direction of the outer ring viewed from A in the example figures while the inner ring is stationary. R: right, L: left
2) E stands for the engage type, while D stands for the disengage type.

9. Application Example

■ Transmission for Front Drive Automobiles



■ Transmission for Rear Drive Automobiles



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