Link Ball®

THK General Catalog

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Features of the Link Ball

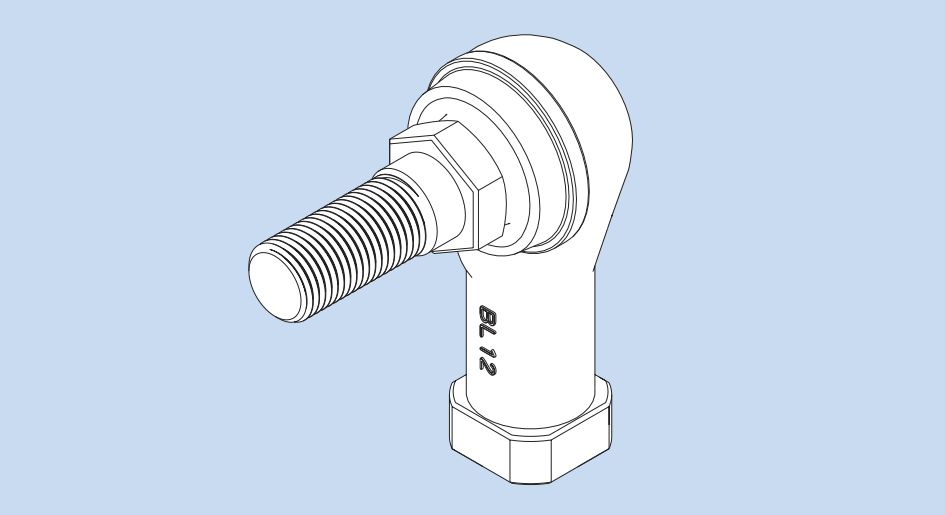


Fig.1 Structure of Link Ball Model BL

Structure and Features

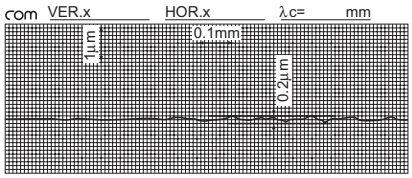
With the Link Ball, a highly accurate bearing steel ball used in the spherical area is first encased in the holder by die cast molding, and then is specially welded with the shank. This unique process enables the mirror surface of the steel ball to be transferred or duplicated on the spherical surface inside the holder to ensure full contact between the ball and the holder. As a result, smooth motion is achieved with a minimum clearance.

[Compact Design]
Model AL has an adequately firm and yet extremely compact shape because of a highly balanced design. Together with use of an A-1 alloy, a light-weight, compact design has been achieved. Thus, this model is optimal for use in an automobile height sensor or transmission control.

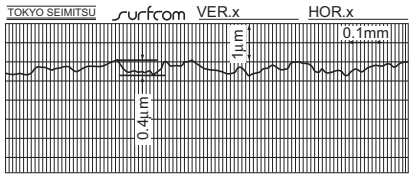
[Achieves Sphericity of 0.001 mm]
The spherical surface of the shank ball is transferred on the inner surface of the holder while maintaining the sphericity of the bearing steel ball. This allows smooth motion to be achieved with a minimum clearance and provides favorable operability and feel to the link motion.

Sphericity: 0.001 mm

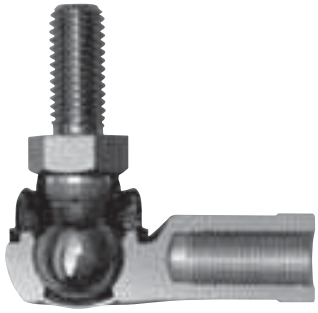
Sphericity of the spherical surface of the ball shank



Roughness of the spherical surface of the ball shank



Roughness of the spherical surface of the holder



Cut sample of the spherical area of model BL

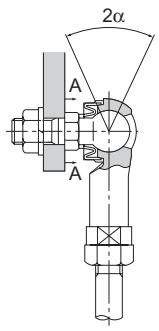
[Two Types of Holder Material]
Model AL uses the newly developed high strength aluminum alloy "A-1 Alloy" (see A-925), which is light and highly resistant to wear. Models BL, RBL and RBI use the proven, high strength zinc alloy (see A-926).

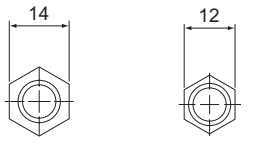
[High Lubricity]
Since models AL and BL and those models attached with boots contain grease, they have high lubricity and increased wear resistance.

[Large Hexagonal Bolt Seat]
The hexagonal bolt seat of the shank has the same dimensions as the seating surface for small hexagon head bolts in accordance with automotive specifications. This prevents the seating surface from sinking and ensures a stable link motion mechanism.

[Lightweight, High Strength]
Use of the A-1 Alloy enables the Link Ball to achieve mechanical strength approximately twice that of the commonly used aluminum die cast material ADC 12, or almost equal to the high strength zinc alloy, while maintaining aluminum alloys' advantages: lightweight and corrosion resistance.

[Equipped with a Boot for Protection against Muddy Water]
Use of a boot with high trackability in the ball shank prevents muddy water from entering the spherical area even in a muddy atmosphere. Accordingly, those types equipped with boots are used also in outdoor applications and automobile parts under the chassis. For details, see the muddy water test data (A-930 and A-931).





Model AL10
Model BL10

Model equivalent to similar product

A-A cross section

Jaw Span for Wrenching

Alloy

[High Strength Aluminum Alloy "A-1 Alloy"]

"A-1 Alloy," a newly developed high strength aluminum alloy, is an alloy with Aℓ-Zn-Si3 being the main components, is used in the holder of model AL.

● Features of the A-1 Alloy

- Achieves one of the highest strengths among the existing aluminum die cast alloys.
- Has yield strength approximately twice that of the commonly used aluminum die cast alloy (ADC 12).
- Has hardness equal to the high strength zinc alloy and achieves high wear resistance.
- Achieves specific gravity less than a half of the high strength zinc alloy to allow significant weight saving.
- Highly corrosion resistance and can be used as an automotive part related to wheel control.

● Mechanical Properties

Tensile strength	: 343 to 392 N/mm^2
Tensile yield strength (0.2%)	: 245 to 294 N/mm^2
Compressive strength	: 490 to 637 N/mm^2
Compressive yield strength (0.2%)	: 294 to 343 N/mm^2
Charpy impact	: 0.098 to 0.196 N-m/mm^2
Elongation	: 2 to 3 %
Hardness	: 140 to 160 HV

● Physical Properties

Specific gravity	: 3
Melting point	: 570℃
Specific heat	: 793 J/(kg・k)
Linear expansion rate	: 22×10^{-6}

● Wear Resistance

The result of our test has proven that the wear resistance of the A-1 alloy is equivalent to the high strength zinc alloy.

Rotation-and-rocking durability test between model AL10D (A-1 alloy) and model BL10D (high strength zinc alloy)

<Test conditions>

Item	Description	
Environment temperature	Normal temperature	
Applied load	±1.9kN (perpendicular to the axis) (note)	
Loading frequency	0.6Hz	
Kinematic angle	Rotation ±20°	Rocking ±20°
No. of cycles	40 times/min.	40 times/min.
Total No. of cycles	1,000,000 cycles	

Note) For the load direction, see A-927.

<Test result: change in clearance (mm)> Unit: mm

Model No.	AL10D (A-1 alloy)	BL10D (high strength zinc alloy)
Perpendicular to the axis	0.036	0.033
Axial direction	0.052	0.045

[High Strength Zinc Alloy]

The high strength zinc alloy used in the holders of models BL, RBL, RBI and TBS has been developed as a bearing alloy by mixing Aℓ, Cu, Mg, Be and Ti as well as zinc as the base component. It is excellent in mechanical properties, seizure resistance and wear resistance.

● Composition

Table1 Composition of the High Strength Zinc Alloy

Unit: %

Item	Description
Aℓ	3 to 4
Cu	3 to 4
Mg	0.03 to 0.06
Be	0.02 to 0.06
Ti	0.04 to 0.12
Zn	Remaining portion

● Mechanical Properties

Tensile strength : 275 to 314 N/mm^2
Tensile yield strength (0.2%) : 216 to 245 N/mm^2
Compressive strength : 539 to 686 N/mm^2
Compressive yield strength (0.2%) : 294 to 343 N/mm^2
Fatigue strength : 132 N/mm^2×10^7 (Schenk bending test)
Charpy impact : 0.098 to 0.49 N-m/mm^2
Elongation : 1 to 5%
Hardness : 120 to 145 HV

● Physical Properties

Specific gravity : 6.8
Melting point : 390℃
Specific heat : 460 J/(kg・k)
Linear expansion rate : 24×10^{-6}

● Wear Resistance

The wear resistance of the high strength zinc alloy is superior to that of class-3 brass and class-3 bronze, almost equal to that of class-2 phosphor bronze.

Amsler wear-tester
Test piece rotation speed : 185 min^{-1}
Load : 392 N
Lubricant : Dynamo oil

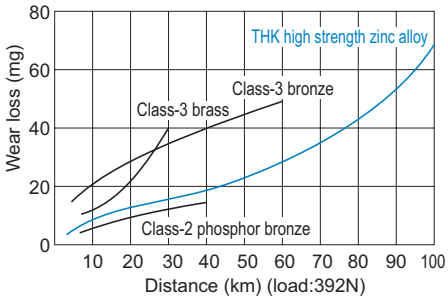


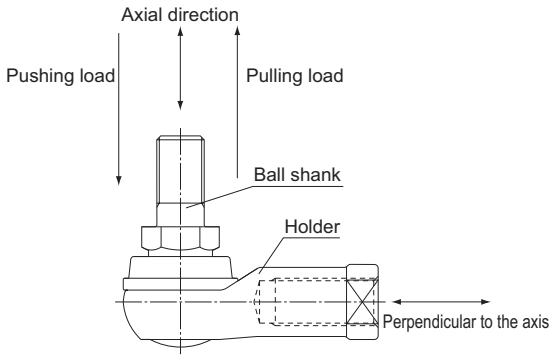
Fig.2 Wear Resistance of the High Strength Zinc Alloy

How Load Directions Are Called

Regardless of the shape, the direction of the load applied to the Link Ball is called "axial direction" if it is parallel to the axis of the ball shank, and "perpendicular-to-axis direction" if it is perpendicular to the axis.

Pushing Load and Pulling Load

Of the loads applied in the axial direction, the load in the direction of the ball shank being pressed toward the holder is called "pushing load" and the load in the direction of the ball shank being pulled from the holder is called "pulling load."



Performance Tests with the Link Ball

Tensile Strength Test with Model AL10D

[Test Method]
Place model AL10D on an Amsler universal testing machine as shown in Fig.3, then apply a load perpendicular to the axis to measure the tensile break load.

[Test Result]
All samples are broken in the shank, indicating that the holder has sufficient strength.

Sample No.	Breaking load (kN)	Broken point
1	18.82	A
2	18.72	A
3	18.6	A
4	18.78	A
5	18.45	A
6	18.95	A
7	18.65	A
8	18.91	A
9	18.55	A
10	18.5	A
$\overline{X}$	18.693	—
R	0.5	—

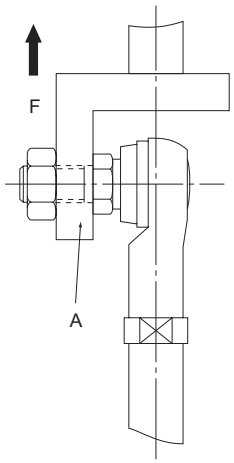


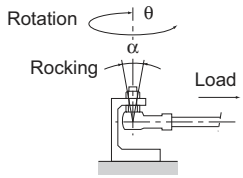
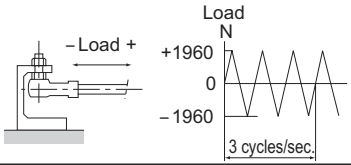
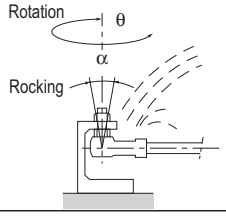
Fig.3

Durability Tests with Link Ball Model AL

[Purpose of the Tests]
The tests were conducted to identify the durability of Link Ball model AL while assuming that it is used for automobile suspensions.

[Tested Product]
Link Ball model AL10D

[Test Items, Test Conditions and Test Results]

Test item	Test conditions					
	Applied load	Rotation or rocking angle	Frequency	Total number of revolutions or time	Service environment	Load conditions, etc.
Rotation-and-rocking durability	1960N Load direction: Perpendicular to the axis (one direction)	Rotation angle: θ=±5° Rocking angle: θ=±10°	Rotation: 25 times/min. Rocking: 75 times/min.	500,000 cycles (rocking)	Normal temperature	
Fatigue durability test	±1960N Load direction: Perpendicular to the axis (both directions)	—	180 times/min.	1 million cycles (rocking)	Normal temperature	
Muddy-water rotation-and-rocking durability (identify sealability of the boot)	—	Rotation angle: θ=±12° Rocking angle: θ=±12°	Rotation: 25 times/min. Rocking: 75 times/min.	500,000 cycles (rocking)	Normal temperature	Discharge muddy water to the boot ● Discharge rate: 1 ℓ/min. ● Contaminates 10% of JIS Class-8 Kanto loamy layer powder 
Boot weathering test	—	—	—	96 hours	−30℃	Left standing
				96 hours	70℃	Left standing
		Rotation angle: θ=±10°	60 times/min.	144 hours	40℃	● Ozone concentration: 80pphm
Salt-water spray resistance test	—	—	—	200 hours	35℃	● Salt-water concentration: 5% ● Spray solution temperature: 33 to 37℃ ● Spray pressure: 0.098MPa ● Following spray test, apply pushing load to measure strength

[Comprehensive Evaluation]

The results of the durability tests indicate that Link Ball model AL has sufficient strength, wear resistance, corrosion resistance and boot sealability.

This is attributable to the superb characteristics of the newly developed alloy A-1 and the effect of THK's unique manufacturing process. Thus,THK Link Ball model AL provides a high level of performance as a lightweight component.

dammy

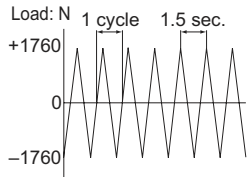
<table>
<tr><th></th><th>Test Result</th><th>Evaluation</th></tr>
<tr><td></td><td>
<table>
<tr><th rowspan="2">Sample No.</th><th colspan="2">Change in clearance (mm)</th></tr>
<tr><th>Perpendicular to the axis</th><th>Axial direction</th></tr>
<tr><td>(1)</td><td>0.038</td><td>0.02</td></tr>
<tr><td>(2)</td><td>0.04</td><td>0.03</td></tr>
<tr><td>(3)</td><td>0.042</td><td>0.04</td></tr>
<tr><td>(4)</td><td>0.038</td><td>0.03</td></tr>
</table>
</td><td>● Despite harsh test conditions where complex link motion was required under an axial load, no anomaly was observed in the samples after the test, and the abrasion loss was minimal and consistent among the samples. This indicates that the Link Ball has superb wear resistance and stable quality.</td></tr>
<tr><td></td><td>● Appearance
No anomaly was observed including fracture of the samples.
● Motion
The ball shank was capable of smoothly oscillating after the test, without any anomaly such as heavy and jerky motion.</td><td>● No anomaly in appearance or function was observed in the sample after the fatigue durability test involving 1 million cycles of rocking. This indicates that the product is sufficiently capable of continuously operating and has superb wear resistance.</td></tr>
<tr><td></td><td>● Motion
The ball shank was capable of smoothly oscillating after the test, without any anomaly such as heavy and jerky motion.
● Muddy water penetration
No muddy water penetration was observed in visual inspection with the boot removed.
● Boot status
No breakage of the boot or abnormal wear of the lip was observed.</td><td>● No anomaly in motion was observed in the sample, and no muddy water penetration into the boot or no grease deterioration was found after the test. This verifies that the boot has reliable sealability.</td></tr>
<tr><td></td><td>● Boot status
The boot showed no harmful ozone crack and maintained its pre-test status, including softness, after the test.</td><td>● No anomaly was observed in the sample after the test. The fact that no muddy water penetration into the boot or no grease deterioration was found in the sample after the above durability test verifies that the boot has reliable weatherability.</td></tr>
<tr><td></td><td>● Appearance
No erosion was observed in the holder, and no other anomaly including breakage was found either.
● Appearance
The ball shank was capable of smoothly oscillating after the test.</td><td>● No erosion-based deterioration of the sample was observed in function and performance.
This demonstrates that the A-1 alloy has superb corrosion resistance.</td></tr>
</table>

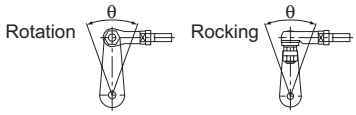
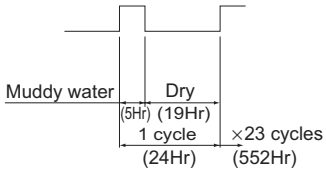
Durability Tests with Link Ball Model BL

[Purpose of the Tests]

The tests were conducted to identify the performance difference between THK Link Ball model BL and an equivalent product of a competitor. As a result, model BL has been used in joints for transmission control units of automobiles, trucks and buses and for steering mechanisms of agricultural tractors.

[Tested Product, Test Items, Test Conditions and Test Results]

<table>
<tr><th rowspan="2">Test item</th><th rowspan="2">Tested model No.</th><th colspan="6">Test conditions</th></tr>
<tr><th>Applied load</th><th>Rotation or rocking angle</th><th>Frequency</th><th>Total number of revolutions or time</th><th>Service environment</th><th>Load conditions, etc.</th></tr>
<tr><td>Rotation-and-rocking durability</td><td>Comparison of THK Link Ball model BL10D and competitor's product</td><td>±1760N (load direction: perpendicular to the axis)</td><td>Rotation angle: θ=±20° Rocking angle: α=±20°</td><td>40 times/min.</td><td rowspan="6">1,000,000 cycles</td><td>Normal temperature</td><td>The loading diagram is as follows.
 

The motion direction is as follows:
 
</td></tr>
<tr><td>Low-temperature rotation durability</td><td rowspan="3">THK Link Ball model BL10D only</td><td rowspan="3">±1225N (load direction: perpendicular to the axis)</td><td rowspan="2">Rotation angle: θ=±30°</td><td rowspan="3">60 times/min.</td><td>−30℃</td><td>Low-temperature retention time: 280 hours
Motion in the rotational direction</td></tr>
<tr><td>High temperature rotation durability</td><td>100℃</td><td>High temperature retention time: 280 hours
Motion in the rotational direction</td></tr>
<tr><td>Muddy-water rotation durability</td><td rowspan="2">Normal temperature</td><td rowspan="2">Motion: rotational direction and oscillation on a separate basis
Muddy water discharge pattern
Muddy water concentration: 5 Wt% of salt and dust each in 1 liter of water
Discharge direction: against the boot lip
Discharge pressure: 5 kg/cm³
 
</td></tr>
<tr><td>Muddy-water rocking durability</td><td>Comparison of THK Link Ball model BL10D and competitor's product</td><td>Rocking angle: α=±20°</td></tr>
</table>

[Comprehensive Evaluation]

As a result of comparing THK Link Ball model BL10D and a competitor's product in representative durability tests, it is demonstrated that model BL10D is superior in strength and wear resistance of the holder and sealability of the boot.

These features are achieved through THK's unique manufacturing process for the holder and the shank, the material used, the structure of upper and lower grease pockets on the spherical area and the development of a highly sealable boot.

	Test Result					Evaluation
		Sample No.	Change in clearance (μm)		Conditions of the holder, etc.	
			Perpendicular to the axis	Axial direction		
	THK model BL10D	(1)	26	42	The shank was capable of smoothly rotating after the 1-million cycle test, and capable of continuously operating.	● Even in complex link motion, THK model BL10D demonstrated higher durability and wear resistance of the holder than competitor's product.
		(2)	25	40		
	Competitor's product	(1)	Broke in the holder neck after 8,600 cycles		Wear and damage were observed in the holder's spherical area in approx. 150,000-cycle operation.	● The abrasion loss of the competitor's product immediately before the breakage of the holder was 6 times greater than THK model BL10D (perpendicular to the axis).
			154	60		
		(2)	Broke in the holder neck after 151,300 cycles			
			62	20		
	THK model BL10D	(1)	63	65	The boot did not show a crack or the like at low temperature	● This indicates that THK model BL10D is sufficiently capable of operating in outdoor applications in cold climates.
		(2)	56	59		
		(1)	79	84	The holder did not show abnormal wear and the boot did not show thermal deterioration at high temperature.	● This indicates that THK model BL10D is sufficiently capable of operating in hot areas of a truck engine.
		(2)	74	78		
		(1)	48	51	No muddy-water penetration that may cause wear was observed.	● This indicates that THK model BL10D is sufficiently capable of operating in environments subject to muddy water such as trucks, construction vehicles and agricultural machines since the sealing effect of the boot prevents penetration of muddy water.
		(2)	57	63		
		(1)	32	38		
		(2)	35	42		
	Competitor's product	(1)	240	105	Muddy water penetrated the boot, the spherical area showed chipping and the boot had cuts.	● The competitor's product cannot be used in environments subject to muddy water since chipping or the like may occur in such environments. In addition, wear of the spherical area reached 0.24 mm, 7.4 times greater than THK model BL10D.
		(2)	246	107		

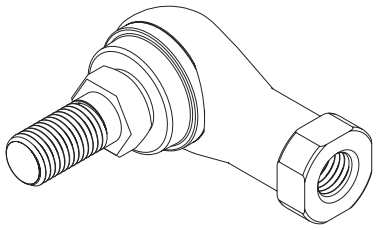
Types of the Link Ball

Types and Features

Model AL

Specification Table⇒B-834

The holder is connected in perpendicular to the shank, which comprises a male thread specially welded with a highly accurate steel ball. With a grease pocket formed on the top and bottom of the spherical area, this model achieves high lubricity and high wear resistance.
Use of the A-1 alloy in the holder significantly reduces the weight.



Model AL

"A-1 Alloy," a high strength aluminum alloy newly developed for the Link Ball, has yield strength approximately twice that of the commonly used aluminum die cast material ADC 12, and its strength and wear resistance are equivalent to the high strength zinc alloy.
With its specific gravity less than that of the high strength zinc alloy, model AL is optimal as an automotive part that requires lightweight, high strength, high corrosion resistance and high wear resistance.

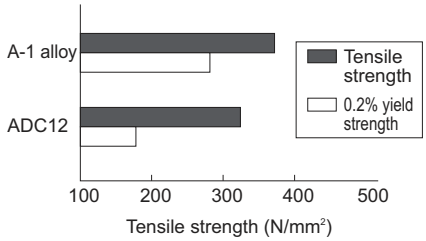
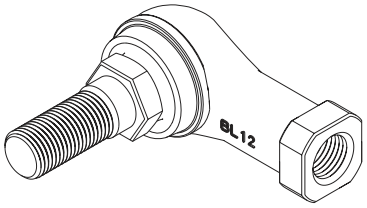


Fig.4 Tensile Strength and Yield Strength of THK A-1 Alloy and ADC 12

Model BL

Specification Table⇒B-836

A compact type of model RBL, this model's holder made of the high strength-zinc alloy is connected in perpendicular to the shank, which is incorporated with a ball.
With a grease pocket formed on the top and bottom of the spherical area, this model achieves high lubricity and high wear resistance.

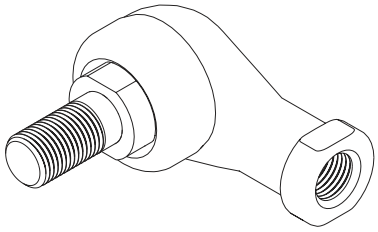


Model BL

Model RBL

Specification Table⇒B-838

The holder made of the high strength zinc alloy is connected in perpendicular to the shank, which is incorporated with a ball.
Since grease is contained in the boot, this model achieves high lubricity and high wear resistance.

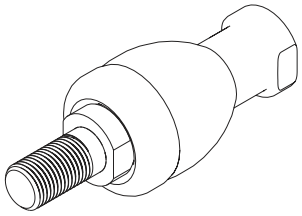


Model RBL

Model RBI

Specification Table⇒B-840

With this Link Ball model, the high strength zinc alloy is used in its holder and the mounting bolt and the holder are arranged on the same axis, allowing this model to receive both a compressive load and a pulling load.
Since grease is contained in the boot, this model achieves high lubricity and high wear resistance.

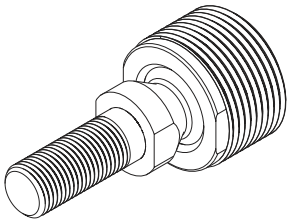


Model RBI

Model TBS

Specification Table⇒B-842

The rolled thread on the circumference of the outer ring allows this model to easily be mounted on the housing. Simply by tightening the screw, the user can achieve play-free, firm installation.
Since the coating area of sphere is large, the model is capable of receiving a large axial load.



Model TBS

Selecting a Link Ball

The selected bearing must meet both the permissible load obtained from equation (1) and the dynamic load capacity obtained from equation (2).

[Permissible Load P]

The yield-point strength indicated in the specification tables refers to the mechanical strength of the bearing. With models AL, BL and RBL, the yield point strength indicates the strength when a load is applied perpendicular to the ball shank axis. With model RBI, it indicates the strength when an axial load is applied to the holder in the shank axis direction.

Table1 Safety Factor (f_s)

Type of load	Lower limit of f_s
Constant load in a constant direction	2 to 3
Fluctuating load in a constant direction	3 to 5
Load in varying directions	5 to 8

According to the type of the load, select a bearing that satisfies the following equation from a mechanical strength's viewpoint.

$$P \leqq \frac{P_k}{f_s} \quad \cdots\cdots\cdots\cdots(1)$$

P : Permissible Load (N)
P_k : Yield-point strength (N)
f_s : Safety factor (see Table1)

[Dynamic Load Capacity C_d]

The dynamic load capacity (C_d) refers to the upper limit of load that the spherical area of the Link Ball can receive without showing seizure while the Link Ball is rotating or oscillating. The dynamic load capacity is obtained from the following approximation formula using the static load capacity (C_s) (note) indicated in the dimensional table.

$$C_d = \frac{C_s}{\sqrt[3]{n}} \quad \cdots\cdots\cdots\cdots(2)$$

C_d : Dynamic load capacity (N)
C_s : Static load capacity (N)
n : Rotation speed per minute (min^{-1})

Note) Static load capacity (C_s) refers to the value obtained by multiplying the projected area on the spherical section by the permissible surface pressure, and is used to obtain the dynamic load capacity.

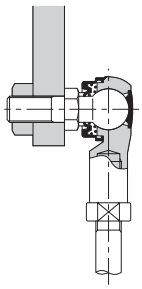
Permissible Tilt Angles

The permissible tilting angles of Link Ball models are indicated in the corresponding specification tables.

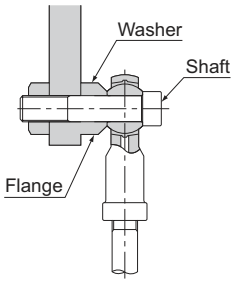
Note) If the permissible tilt angle is exceeded, it may cause serious damage to the holder or the boot. Be sure to use the Link Ball within its permissible tilt angle.

Example of Installation

[Comparison of THK Link Ball and the Conventional Rod End]



THK model BL

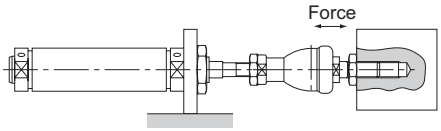


Conventional Rod End model PHS

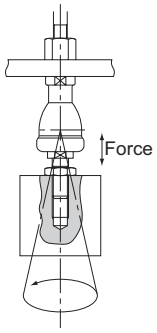
- Sine it has a shaft, model BL can easily be installed (especially useful for rod assembly).
- Because of the improved shape of the boot lip, the spherical area is protected from muddy water even in a muddy atmosphere.
- Since it contains grease, it can be used without further lubrication. (with the boot attached)
- Unlike the conventional type, which has a clearance between the shaft and the inner circumference of the inner ring and cannot be fixed completely, model BL has minimum distortion and high rigidity since the shank is integrated with the ball.

[Examples of Installing Model RBI]

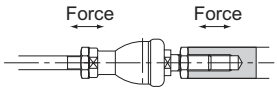
Joint for cylinder end metal fitting



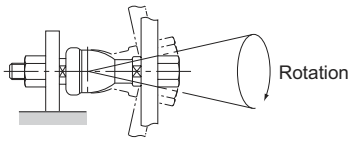
Suspending a light object



Connecting a rod in the axial direction



Rotation support



[Temperature Range]
The temperature range of the Link Ball series is basically between -20℃ and 80℃. If the service temperature exceeds this range, contact THK(see examples of testing the product at temperature other than the above temperature range on A-930 to A-933)

[Handling]
Dropping or hitting the Link Ball may damage it. Giving an impact to it could also cause functional damage to it even if the product looks intact.

[Lubrication]
(1) All Link Ball models except model TBS contain lithium soap-based grease in their boots and can be used without further greasing. For model TBS and those models without boot, apply grease to the spherical section as necessary.
(2) Do not mix lubricants of different physical properties.

[Precautions on Use]
(1) Do not use the product in the manner that the permissible tilting angle is exceeded since doing so may damage the product.
(2) When using the product in locations exposed to vibrations or an impact load or in a special environment such as a clean room, vacuum and low/high temperature, contact THK in advance.
(3) Entrance of foreign material such as dust between the holder and the inner ring may cause damage or functional loss. Prevent foreign material, such as dust and cutting chips, from entering the product.
(4) Models AL, BL and RBL are designed for use under a load in the direction perpendicular to the axis, while models RBI and TBS are designed for use under an axial load. Take this into account when selecting a model.

[Storage]
When storing the Link Ball, avoid high temperature, low temperature and high humidity.