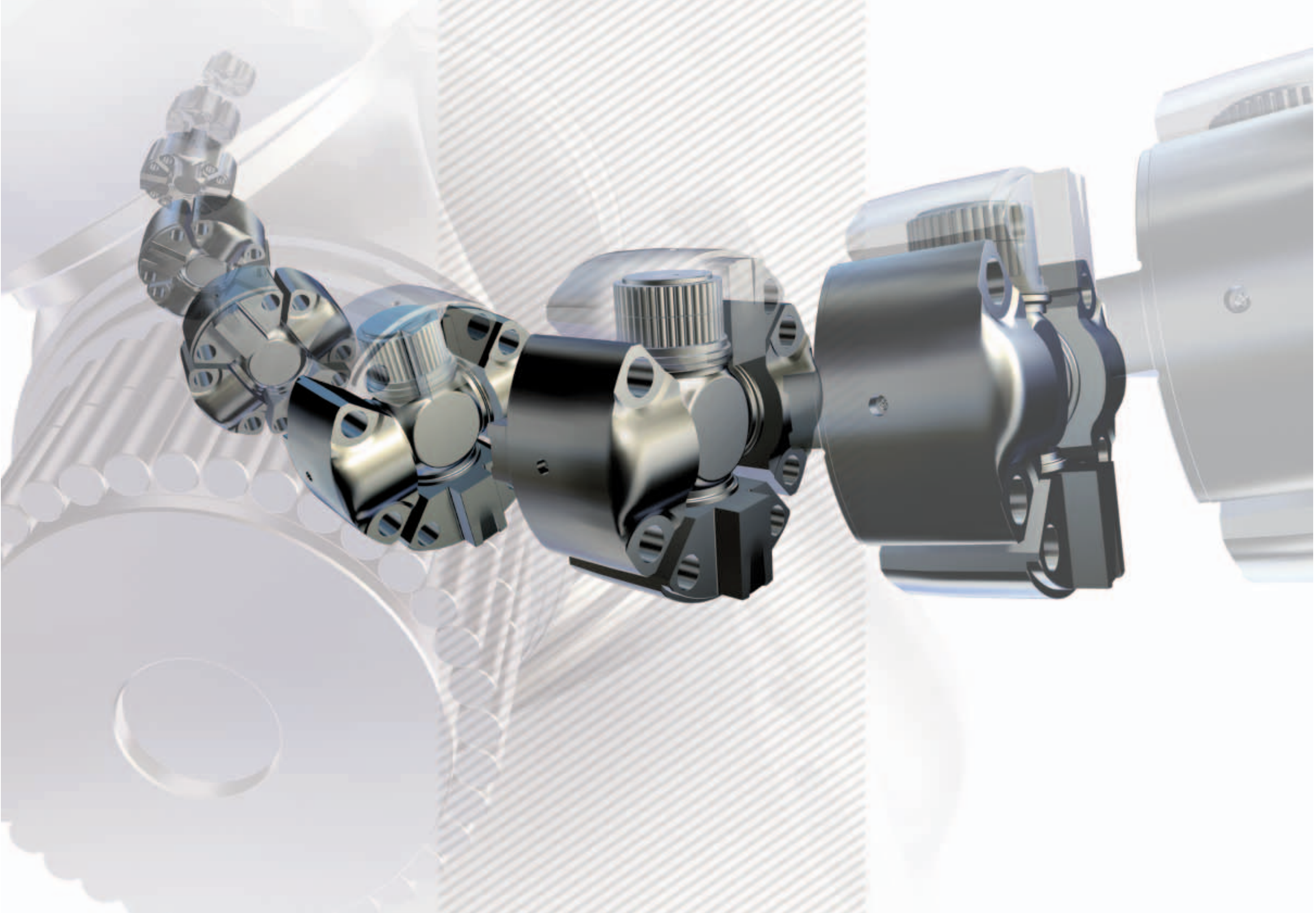
Koyo®

DRIVE SHAFTS for INDUSTRY



JTEKT

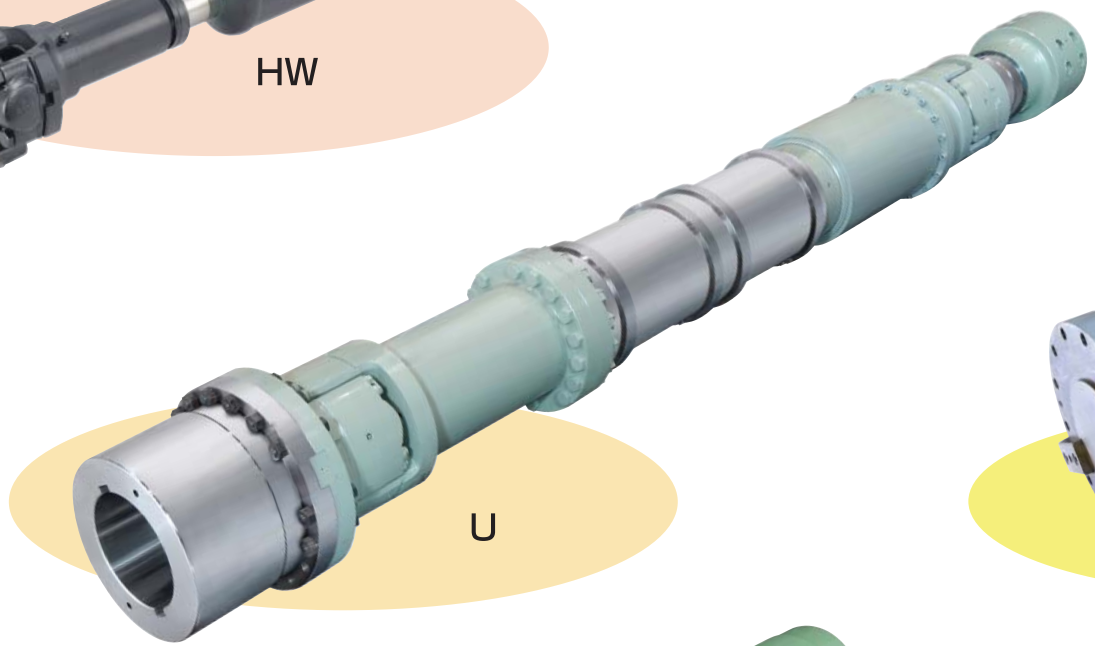
JTEKT CORPORATION

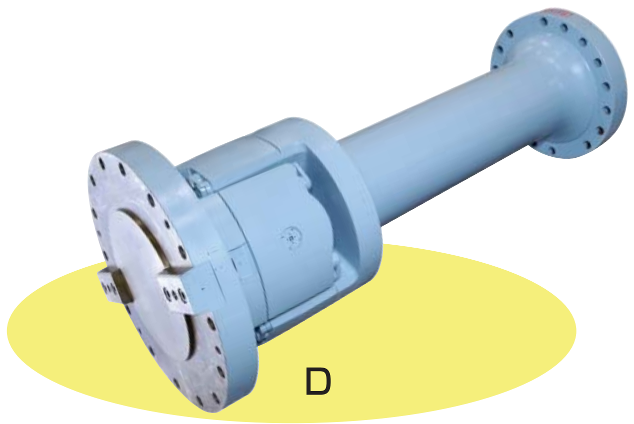
CAT. NO. B2008E-1

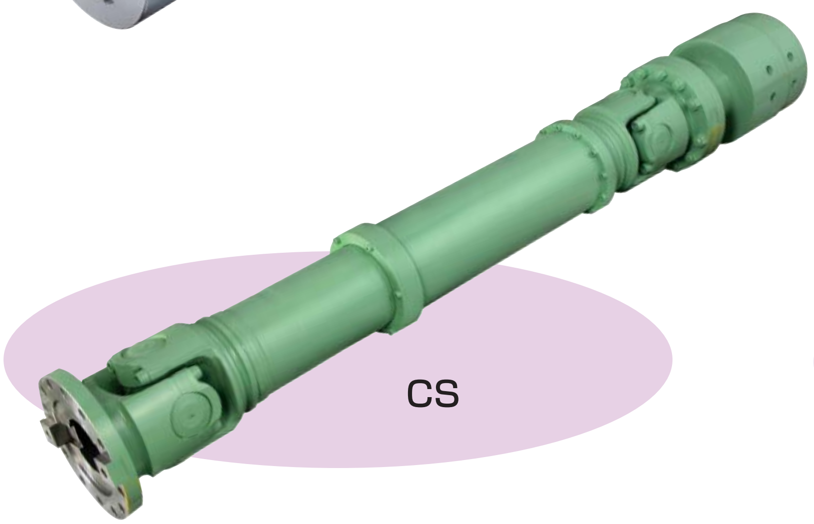
DRIVE SHAFTS for INDUSTRY

Preface

Throughout the manufacturing industry the pursuit of greater power output at higher efficiency is a priority. Under such circumstances, highly sophisticated and economical drive shafts that fit in a limited space are in great demand for use in various equipment and machines.
In response to this demand, JTEKT has renewed its conventional F Series drive shafts and has developed the new CS Series, which feature excellent cost performance, as you will discover in this catalog.
Expanded by this new series, Koyo s drive shaft lineup is certain to satisfy your requirements in various applications, including iron manufacturing machines, rolling mills, construction machines, and rolling stock.
We thank you in advance for your support of Koyo drive shafts.







Contents

1. Introduction to Drive Shafts

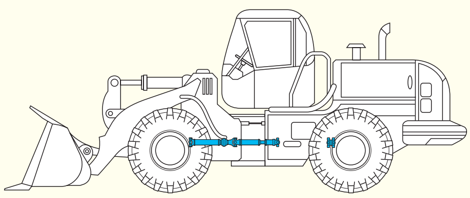
1.1 Functions

A drive shaft acts as an intermediate between a driving shaft and driven shaft that are not aligned on the same axis, and transfers running torque smoothly.

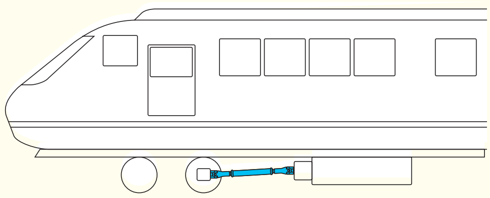
A drive shaft has two universal joints, enabling a flexible connection between a driving shaft and driven shaft.

Each universal joint (cross bearing) has four rolling bearings, realizing low friction and minimizing torque losses.

Propeller shafts of construction machines



Propeller shafts of diesel locomotives



Driving shafts of rolling mills

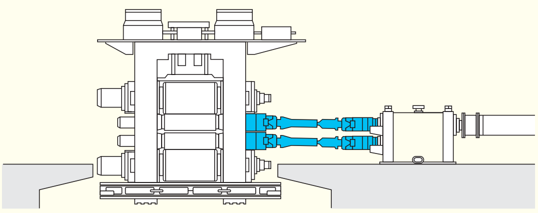


Fig. 1.1 Typical Applications of Drive Shafts

1.2 Appearance and Construction of Drive Shafts

The appearance and component construction of a representative drive shaft is shown below:

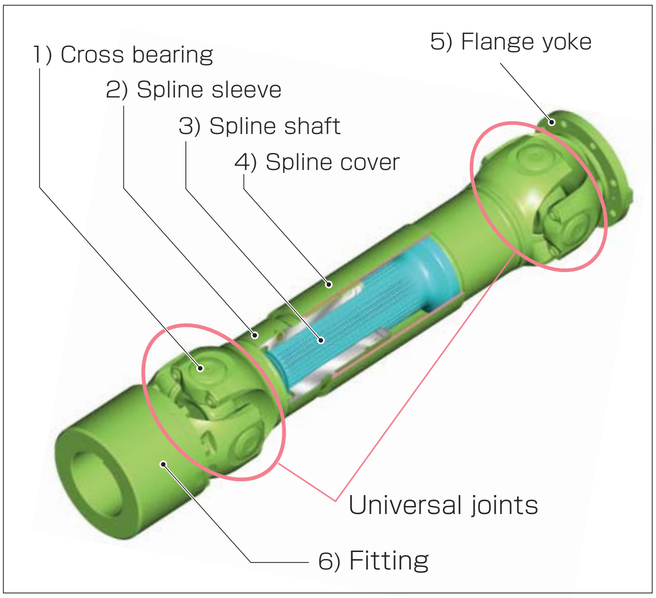


Fig. 1.2 Component Construction of a Representative Drive Shaft

1) Cross bearings

The cross bearings are the most critical components of a drive shaft.
A cross bearing has a cross-shaped shaft and four rolling bearings that individually support each end of the shaft.

2) Spline sleeve

The spline sleeve has a splined bore. In combination with a spline shaft, the sleeve realizes a variable drive shaft installation length.

3) Spline shaft

The spline shaft has straight sided or involute splines, realizing a variable drive shaft installation length in combination with the spline sleeve.

4) Spline cover

The spline cover improves the dust resistance of the spline shaft. This cover is not necessary if the drive shaft is used in a good and clean environment.

5) Flange yoke

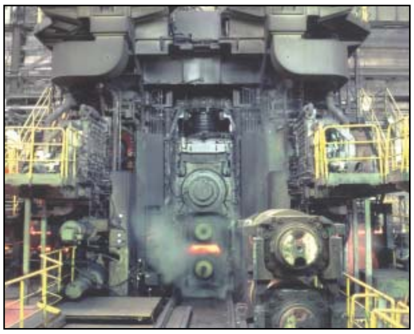
The flange yoke is commonly used to connect a drive unit (such as a motor). A variety of joints are available to suit specifically desired applications.

6) Fitting

The fitting is commonly used to connect a machine.
A variety of joints are available to suit specifically desired applications.

1.3 Koyo Drive Shaft Series and Applications

Rolling mills



CS Series

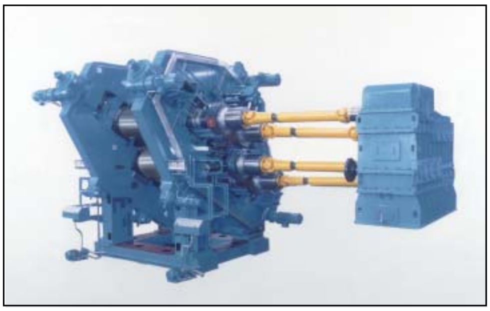
D Series, U Series and T Series

Rolling mills

CS Series

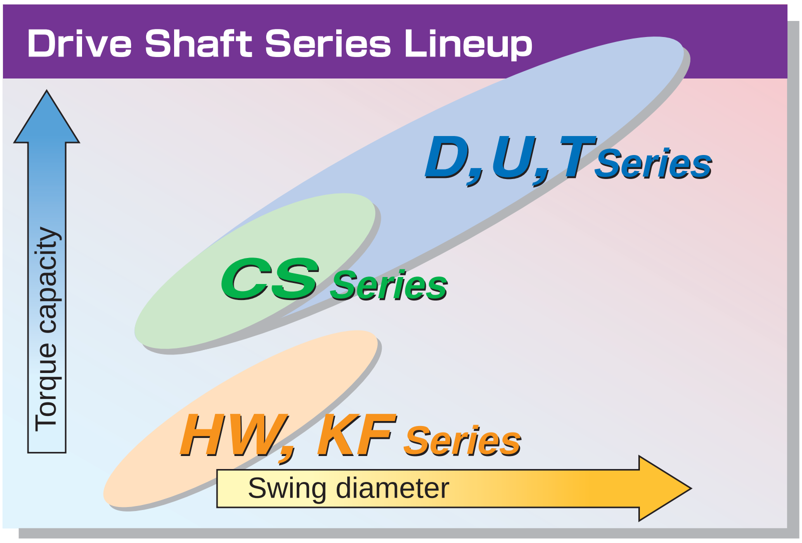
D Series, U Series and T Series

Calender mills
Paper mills



CS Series

KF Series



Rolling stock

HW Series

KF Series

Construction machines

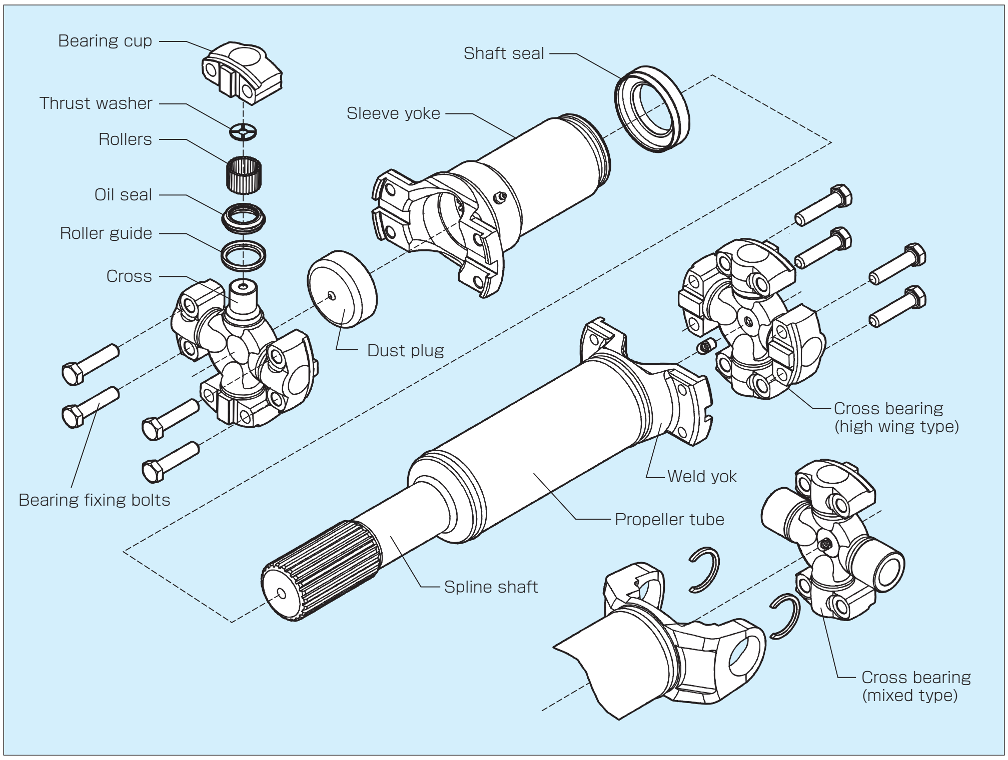
HW Series

2. Drive Shaft Construction

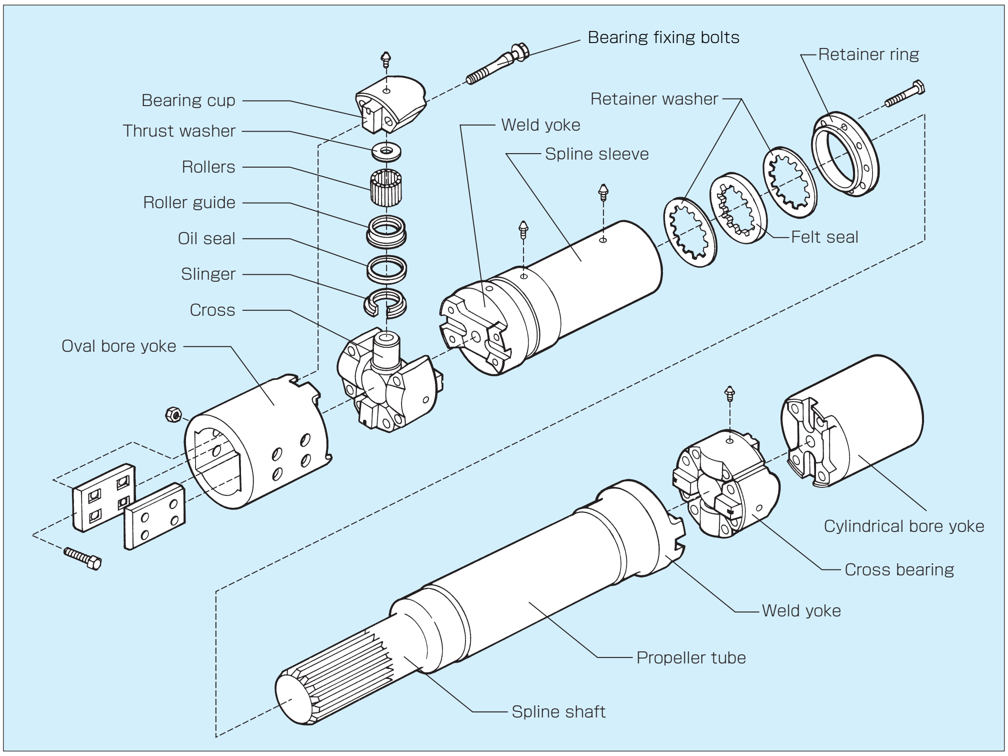
Koyo drive shafts can be classified into two types in construction, depending on the shape of the cross bearings, which serve as universal joints: block type and round type. The features and typical construction of individual types are shown below.

1) Block Type Drive Shafts

With the cross bearings fixed by bolts to the yokes, block type drive shafts transfer torque reliably through the key. The rollers, crosses, and bearing fixing bolts can be greater in size than those of the round type drive shafts, realizing higher capacity.



HW Series



D Series

U Series

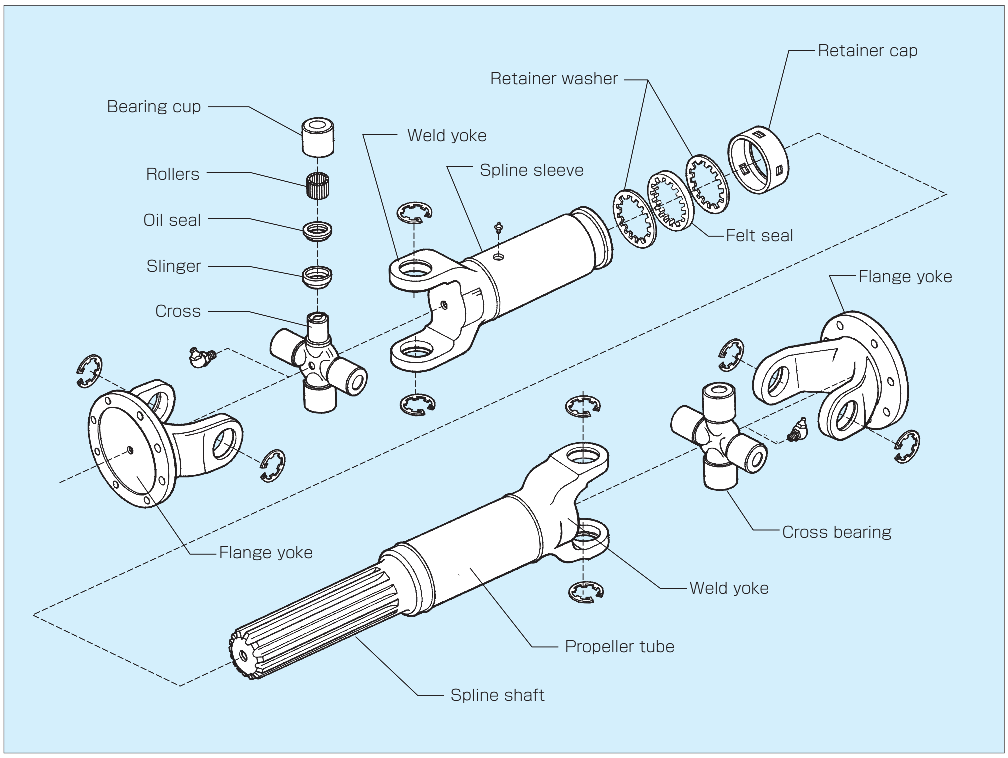
T Series

2) Round Type Drive Shafts

Compared with the block type, this type of drive shaft has cross bearings of simpler construction and is more economical.

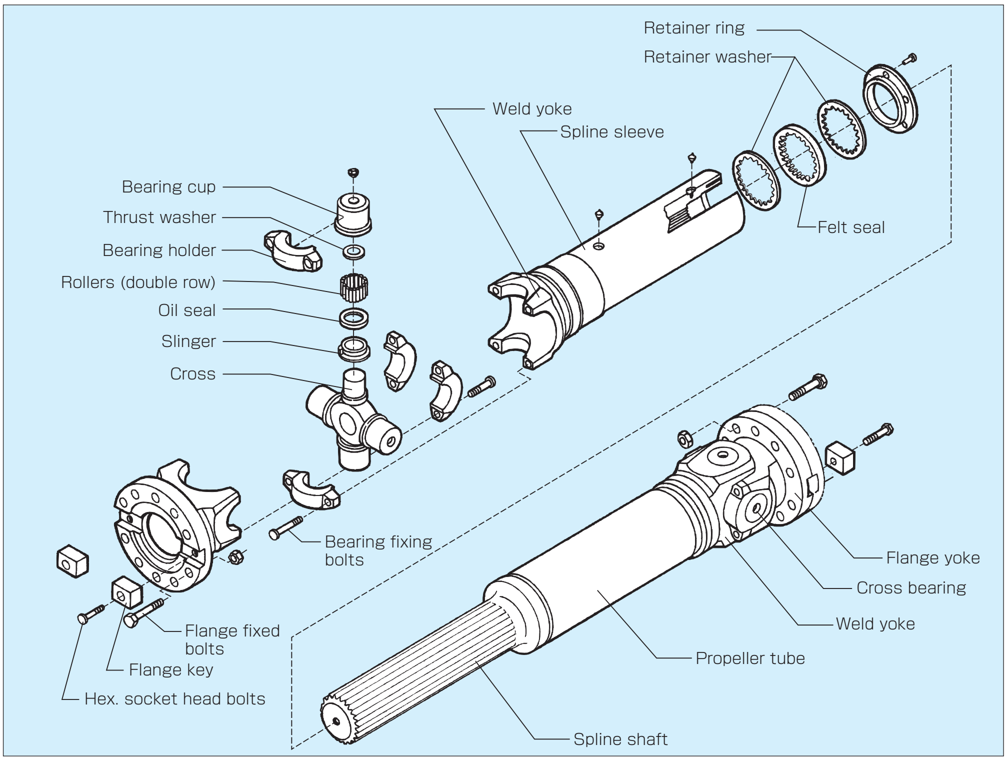
These drive shafts are connected to machines via a flange, enabling easy connection to a variety of machines.

KF Series
(Joint swing diameter: Up to 180 mm)



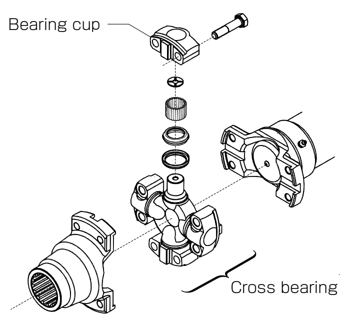
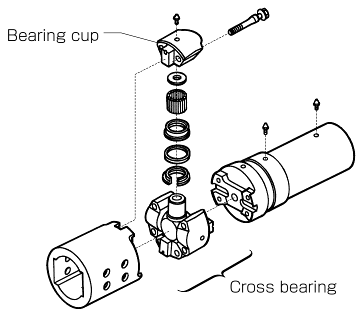
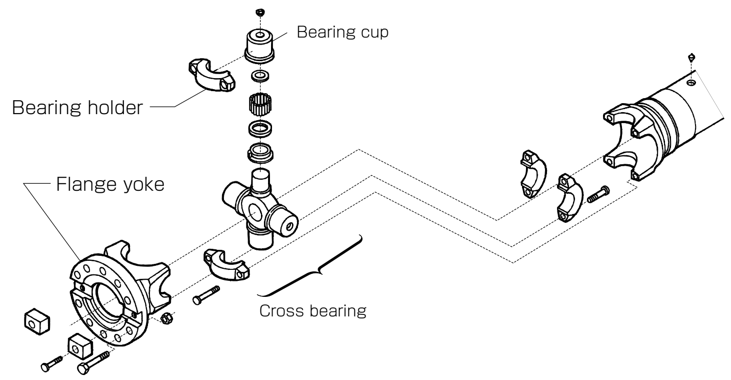
CS Series

KF Series
(Joint swing diameter: 225 mm or greater)



3. Features and Applications of Drive Shafts

The individual Koyo drive shaft series are shown below, along with their features and suitable applications.

		Block Type Drive Shafts		Round Type Drive Shafts	
Construction of universal joints					
Series		HW	D, U, T	CS	KF
Joint swing diameter (mm)		115 ~ 302	325 ~ 1230	180 ~ 285	105 ~ 435
Characteristics*	Torque T_D (kN·m)	1.07 ~ 15.6	39.2 ~ 8 060	32.1 ~ 128	1.27 ~ 166
	Torque T_S (kN·m)	3.23 ~ 47.4	108 ~ 18 800	59 ~ 234	3.62 ~ 558
	Maximum operating angle (°)	10 ~ 25	4 ~ 10	10	15 ~ 30
Features		■ This most common series is especially used in construction machines. ■ Cross bearings are available in two types, making this series of joints useful in various applications. ■ Torque is transferred reliably through the key and keyway.	■ These series are intended for use in extremely heavy duty applications. ■ High dust resistance makes these series optimal for use under severe operating conditions such as in rolling mills. ■ The optimized design, highly strong materials and sophisticated heat treatments ensure high reliability. ■ Torque is transferred reliably through the key and keyway.	■ This highly cost efficient series realized by the most advanced technologies is intended for heavy duty applications. ■ The optimized design, highly rugged materials and sophisticated heat treatments ensure high reliability. ■ Thanks to the flanges, this series is highly compatible with existing equipment.	■ This cost efficient series is intended for light to medium duty applications. ■ Thanks to the flanges, this series is highly compatible with existing equipment. ■ This series is compatible with wideangle operations.
Major applications / Ironmaking machines	Plate mills and hot / cold rolling mills		◎		
	Bar mills, wire/rod mills and tempering mills		◎	◎	△
	Levelers		◎	◎	△
	Continuous casting equipment		△	◎	◎
	Other equipment	△	○	○	◎
Major applications	Industrial machines	○	△	○	◎
	Paper mills and calenders	○	△	◎	◎
	Rolling stock	○			○
	Construction machines and special vehicles	◎			
	Automobiles	△			

***Characteristics** Torque T_D : The reference torque used as the criterion for evaluation of resistance to the maximum torque under normal operating conditions.
T_D divided by the maximum torque should preferably be greater than 1.5.

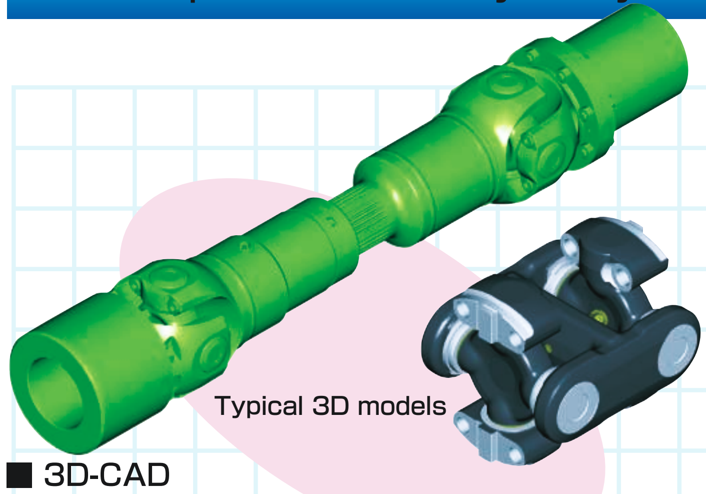
Torque T_S : The reference torque used as the criterion for evaluation of resistance to the breaking torque under emergency conditions.
T_S divided by the breaking torque should preferably be greater than 1.5.

Maximum operating angle: The maximum cross angle allowed by the universal joint.

Legends ◎ : Suited
○ : Applicable
△ : Used in rare cases

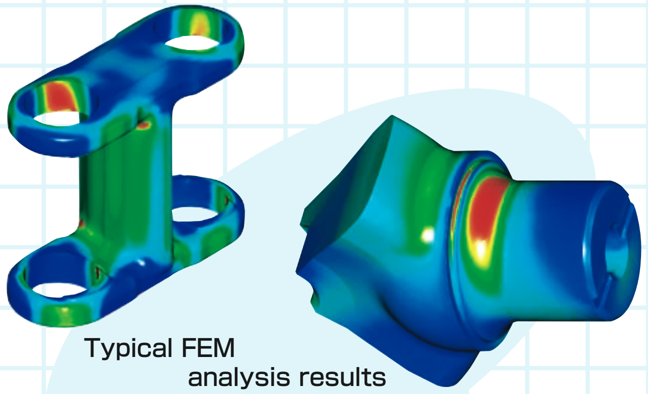
4. Product Development Systems and Evaluation Equipment

Development and Analysis Systems



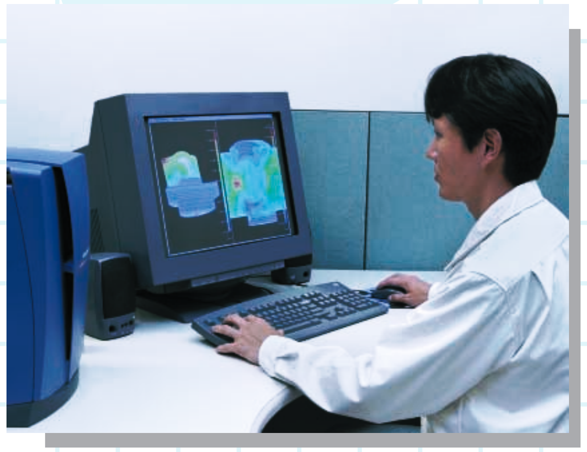
Typical 3D models

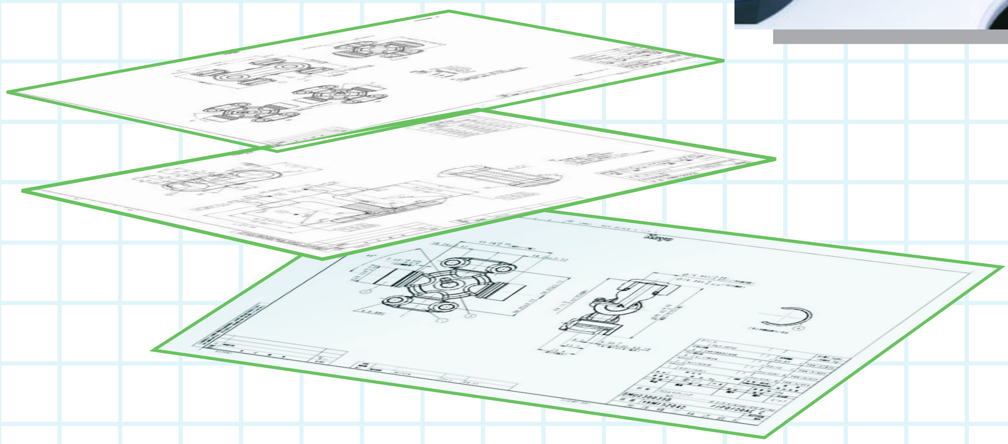
■ 3D-CAD



Typical FEM analysis results

■ FEM analysis

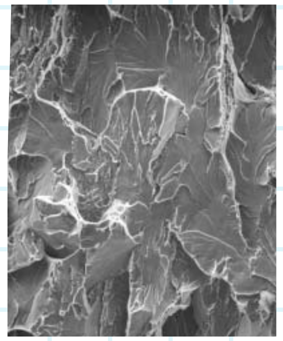




Evaluation and Analysis Equipment

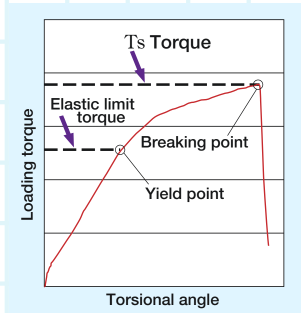
■ Electron probe microanalyzer

● Typical analysis result

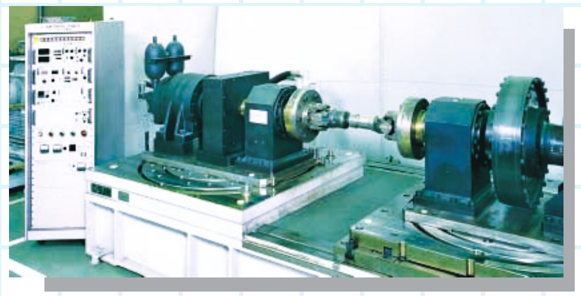


■ Large sized torsional tester

● Typical results of evaluation by large sized torsional tester

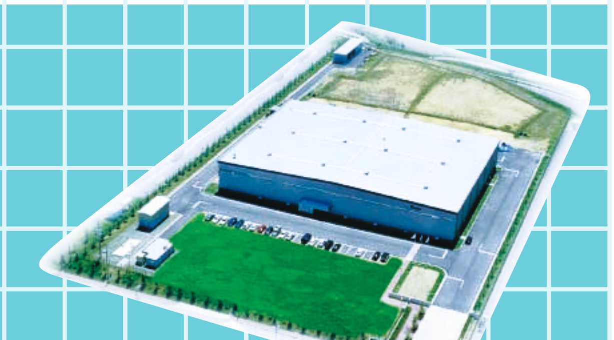


■ Cyclic torsional tester



Production bases

Tokyo Plant
JTEKT Corporation



Gojo Plant
Koyo Machine Industries Co., Ltd.

HW Series

■ Features

The HW Series is widely used in construction machines and industrial machines.
Yoke dimensions are standardized worldwide. A bearing cup is directly fixed to the yoke.
The cross bearings and spline construction of basic reference No. 5 thru 12 are very tightly sealed to each other and are useful in severe environments such as muddy water or dust particles.

Telescoping Type (with propeller tube)

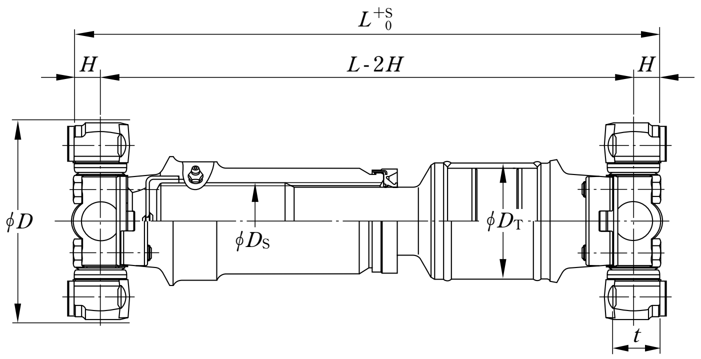


Fig. 1 (High wing type)

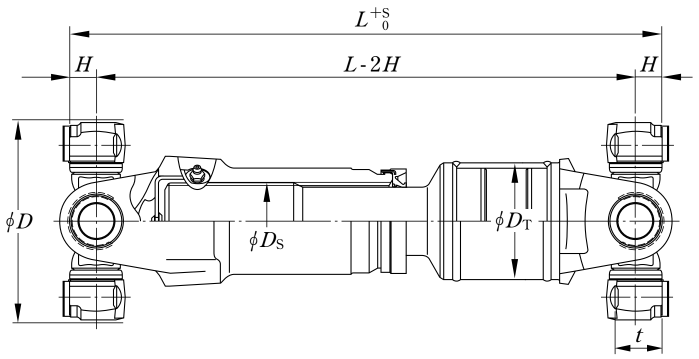


Fig. 2 (Mixed type)

Fixed Type (with propeller tube)

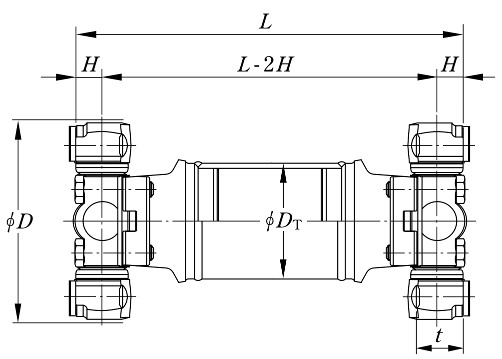


Fig. 1 (High wing type)

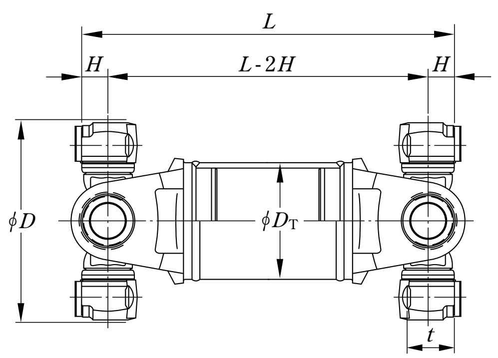


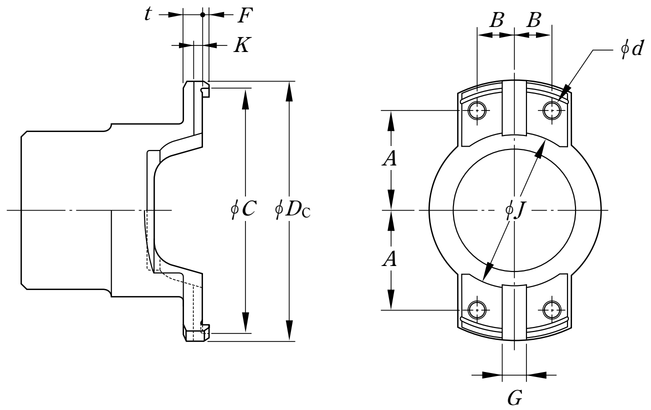
Fig. 2 (Mixed type)

Basic reference No.	Fig.	Swing dia. (mm) D	Torque capacity (N·m) T_R [1]	T_D [2]	T_S [3]	Max. operating angle (°)	Boundary dimensions (mm) H	Propeller tube dia. D_T	Counterbore depth t	Boundary dimensions (mm) Telescoping type: Without propeller tube L	With propeller tube L min.	Allowable telescoping stroke S	Spline dia. D_S	Fixed type: With propeller tube L min.	Bearing fixing bolts: Nominal thread size	Width across flats	Tightening torque (N·m)
4	1	115	466	1 260	3 310	25	15.5	65	25.4	277	327	45	38.1	176	M 8×1.25	13	36～ 40
	2	116				25				294	344	45	40	195			
5	1	122	851	1 770	4 470	10	17.49	65	28.85	288	338	42	45	178	M10×1.25	17	71～ 77
	2	126				25				314	364	55		213			
6	1	149	1 090	2 240	6 400	25	17.49	76.2	29.4	319	369	47	55	216	M10×1.25	17	71～ 77
	2	152				25				325	375	52		213			
7	1	158	1 650	3 760	9 190	20	20.66	90	34.1	385	435	65	60	241	M12×1.25	19	132～155
	2	165				25				389	439	65		230			
8	1	216	2 200	5 380	12 200	21	20.66	110	34.1	415	475	76	65	267	M12×1.25	19	132～155
8.5	1	175	2 570	7 520	13 500	25	27	110	41.3	436	494	70	65	282	M12×1.25	19	132～155
9	1	220	3 450	9 980	18 900	25	27	120	41.3	483	543	63	78	296	M12×1.25	19	132～155
10	1	226	5 580	13 600	33 900	25	32.575	135	50.8	508	578	72	90	353	M14×1.5	22	206～220
12	1	302	8 060	19 300	47 400	25	32.575	139.8	50.8	605	675	83	105	379	M14×1.5	22	206～220

[Notes] 1) T_R refers to the rated torque used for service life calculation (refer to page 31). The material factor K_m is supposed to be 1 in this calculation.
2) T_D refers to the reference torque used as the criterion for evaluation of resistance to the maximum torque under normal operating conditions.
T_D divided by the maximum torque should preferably be greater than 1.5.
3) T_S refers to the reference torque used as the criterion for evaluation of resistance to the breaking torque under emergency conditions.
T_S divided by the breaking torque should preferably be greater than 1.5.

HW Series

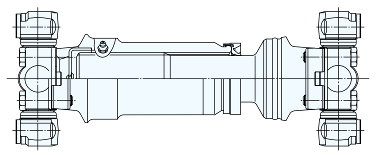
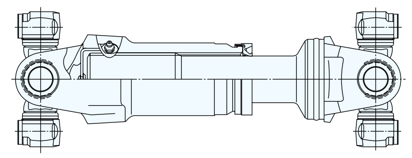
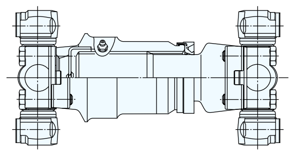
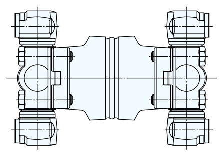
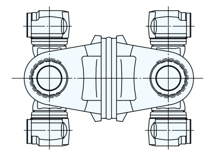
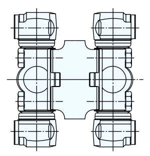
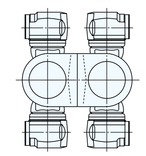
Recommended Dimensions of Coupling Yokes



Basic reference No.	Boundary dimensions (mm)									Bolt holes
	D_c	C	J	F	G	K	A	B	t	d
4	114.3	107.93 $^{+0.05}_{0}$	70	3.2	9.5 $^{+0.05}_{0}$	3.5 $^{+0.5}_{0}$	43.63	18.24	11.8	M 8×1.25
5	121.4	115.06 $^{+0.05}_{0}$	70	4	14.26 $^{+0.05}_{0}$	4.9 $^{+0.5}_{0}$	44.45	21.43	12.6	M10×1.25
6	148.4	140.46 $^{+0.05}_{0}$	90	4	14.26 $^{+0.05}_{0}$	4.9 $^{+0.5}_{0}$	57.15	21.43	12.6	M10×1.25
7	158	148.38 $^{+0.05}_{0}$	92	4.8	15.85 $^{+0.05}_{0}$	5.7 $^{+0.5}_{0}$	58.73	24.61	15.8	M12×1.25
8	215.9	206.32 $^{+0.05}_{0}$	150	4.8	15.85 $^{+0.05}_{0}$	5.7 $^{+0.5}_{0}$	87.3	24.61	17.4	M12×1.25
8.5	174.6	165.07 $^{+0.05}_{0}$	96	4.8	15.85 $^{+0.05}_{0}$	5.7 $^{+0.5}_{0}$	61.91	35.72	19	M12×1.25
9	219.1	209.52 $^{+0.05}_{0}$	135	4.8	15.85 $^{+0.05}_{0}$	5.7 $^{+0.5}_{0}$	84.14	35.72	19	M12×1.25
10	225.4	212.699 $^{+0.051}_{0}$	141	6.4	25.35 $^{+0.07}_{0}$	9.3 $^{+0.5}_{0}$	82.55	46.05	30	M14×1.5
12	301.6	288.90 $^{+0.1}_{0}$	205	6.4	25.35 $^{+0.07}_{0}$	9.3 $^{+0.5}_{0}$	120.65	46.05	30	M14×1.5

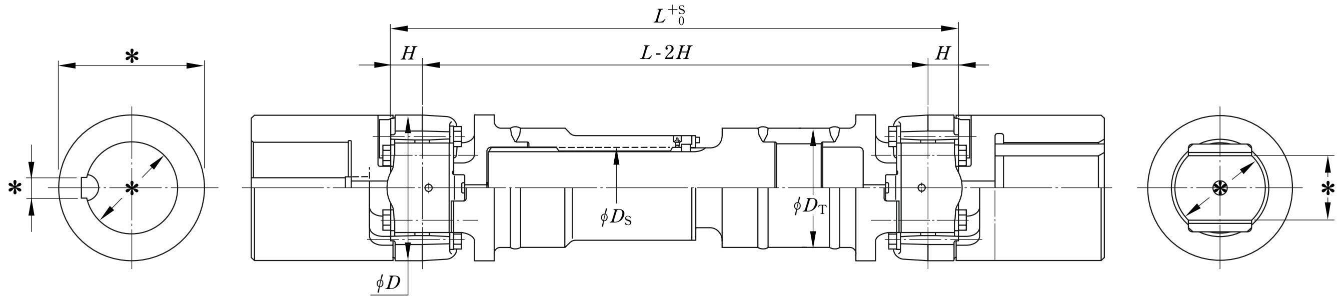
■ Designs available to order

When installation space is limited, this series can be designed specifically to fit in the available space.
The assembling components are shown below.
For more details on these designs, consult JTEKT.

	Components	Fig. 1 (high wing type)	Fig. 2 (mixed type)
Telescoping type	Without propeller tube		
	With shaft yoke		
Fixed type	Without propeller tube		
	With coupling yoke		

D Series

Telescoping Type (with propeller tube)



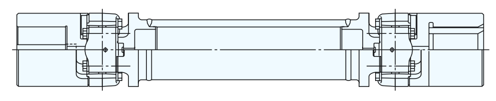
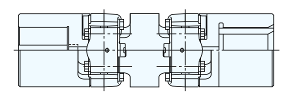
Dimensions marked with an asterisk (✱) need to be determined to suit existing equipment.
Please provide the specifications of your equipment when placing an inquiry.

■ Features

This series is suitable for use under severe conditions, such as in driving rolling mill rolls. Based on standardized cross bearings, this series can be designed to suit a wide range of dimensions and a wide variety of fitting configurations.

■ Designs available to order

The fixed type can be designed to order, assembling components shown on the right.
For more details on these designs, consult JTEKT.

With propeller tube	
With coupling yoke	

Basic reference No.	Swing dia. (mm) D	Torque capacity (kN·m)			Max. operating angle (°)	Boundary dimensions (mm)					Bearing fixing bolts			
		T_R 1)	T_D 2)	T_S 3)		L 4) min.	H	Propeller tube dia. D_T	Spline dia. 5) D_S	Allowable telescoping stroke S	Nominal thread size	Width across flats	Tightening torque (N·m)	Number of bolts per bearing
D22032	160	2.83	14.7	43.1	10	585	30	139.8	101.6	80	M16×1.5	17	185± 20	8
D26038	190	5.33	24.5	71.6	10	677	38	159	114.3 (95)	95	M18×1.5	19	285± 20	8
D30044	220	8.54	39.2	108	10	760	45	177.8	127 (120)	110	M20×2	22	370± 20	8
D34052	260	15.1	68.6	186	10	873	52	216.3	152.4 (140)	125	M24×2	27	645± 30	8
D38060	300	22.8	98.1	284	10	965	60	244.5	177.8 (160)	135	M30×2	32	1 180± 50	8
D44070	350	38.2	167	451	10	1 080	70	298.5	203.2 (180)	155	M33×2	36	1 720± 70	8
D48080	400	54.9	255	667	8	1 220	80	339.7	225 (200)	175	M39×3	50	3 040±200	8
D50085	425	66.9	314	804	8	1 284	86	355.6	250	185	M42×3	50	4 020±200	8
D54090	450	80.4	373	951	8	1 348	92	381	250	195	M42×3	50	4 020±200	8
D56100	500	107	520	1 270	8	1 503	107	410	275	205	M48×3	60	5 980±300	8
D58110	550	146	706	1 770	6	1 604	116	450	300	220	M52×3	65	7 650±300	8
D60120	600	195	932	2 260	6	1 730	125	490	325	235	M58×3	70	10 300±300	8
D62130	650	249	1180	2 840	6	1 849	136	530	350	250	M62×3	75	12 700±300	8
D64140	700	293	1470	3 530	6	1 949	146	580	375	265	M68×3	85	17 100±500	8

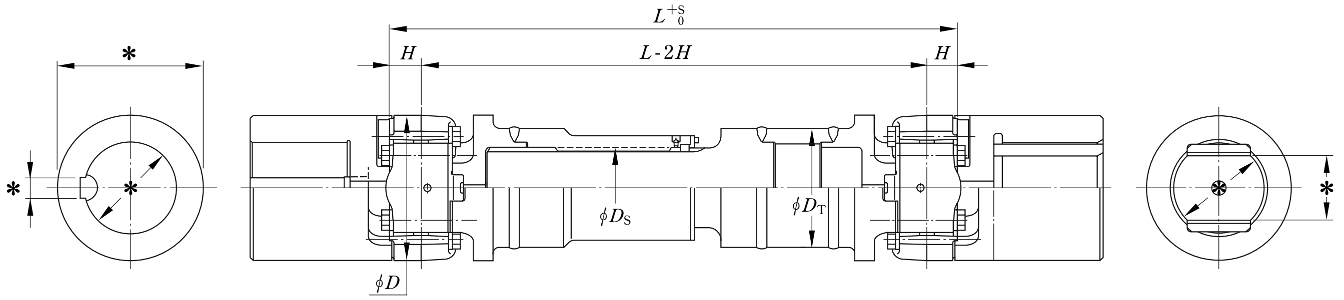
Basic reference No.	Swing dia. (mm) D	Torque capacity (kN·m)			Max. operating angle (°)	Boundary dimensions (mm)					Bearing fixing bolts			
		T_R 1)	T_D 2)	T_S 3)		L 4) min.	H	Propeller tube dia. D_T	Spline dia. 5) D_S	Allowable telescoping stroke S	Nominal thread size	Width across flats	Tightening torque (N·m)	Number of bolts per bearing
D66150	750	371	1 860	4 410	6	2 090	155	620	400	290	M72×4	90	20 400±500	8
D68160	800	449	2 260	5 300	6	2 225	170	670	450	300	M76×4	95	24 500±500	8
D71170	850	497	3 350	6 200	7	2 337	178	710	500	320	M48×2	50	5 590±200	24
D72180	900	591	3 650	6 600	7	2 445	190	750	500	335	M48×2	50	5 590±200	24
D7E184	920	621	3 920	8 050	7	2 495	190	780	550	340	M52×2	50	7 350±300	24
D74190	950	654	3 500	9 250	7	2 564	196	810	550	350	M56×3	60	9 120±300	24
D75194	970	697	4 140	10 300	7	2 594	196	830	550	370	M56×3	60	9 120±300	24
D76204	1 020	924	4 090	8 050	7	2 654	211	850	550	385	M52×3	55	7 650±300	24
D7J214	1 070	1 040	6 090	13 500	6	2 900	230	890	600*	400*	M64×3	65	14 200±300	24
D81220	1 100	1 100	7 160	13 200	6	2 970	250	920	600*	415*	M64×3	65	14 200±300	24
D8B226	1 130	1 200	6 800	15 200	6	3 070	260	950	650*	430*	M68×3	70	17 100±500	24
D8E246	1 230	1 530	8 060	18 800	6	3 165	260	1 030	650*	450*	M72×4	75	20 400±500	24

[Notes] 1) T_R refers to the rated torque used for service life calculation (refer to page 31). The material factor K_m is supposed to be 3 in this calculation.
2) T_D refers to the reference torque used as the criterion for evaluation of resistance to the maximum torque under normal operating conditions. T_D divided by the maximum torque should preferably be greater than 1.5.
3) T_S refers to the reference torque used as the criterion for evaluation of resistance to the breaking torque under emergency conditions. T_S divided by the breaking torque should preferably be greater than 1.5.
4) L refers to the minimum dimension when the shaft has neither propeller tube nor welded connection.
5) The parenthesized values refer to the involute spline diameter.

[Remark] The values marked with an asterisk (✱) are provided for reference purposes.

U Series

Telescoping Type (with propeller tube)



Dimensions marked with an asterisk (*) need to be determined to suit existing equipment.
Please provide the specifications of your equipment when placing an inquiry.

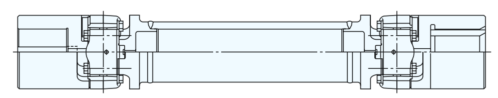
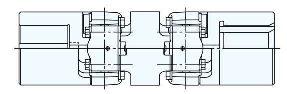
Basic reference No.	Swing dia. (mm) D	Torque capacity (kN·m)			Max. operating angle (°)	Boundary dimensions (mm)					Bearing fixing bolts			
		T_R 1)	T_D 2)	T_S 3)		L 4) min.	H	Propeller tube dia. D_T	Spline dia. D_S	Allowable telescoping stroke S	Nominal thread size	Width across flats	Tightening torque (N·m)	Number of bolts per bearing
U45073	365	45.5	255	510	4	1 185	75	339.7	225	170	M39×2	41	2 840±150	8
U4H078	390	53.3	324	618	4	1 240	80	355.6	250	180	M42×2	46	3820±200	8
U49084	420	62.7	392	775	4	1 309	86	381	250	190	M45×2	50	4 900±200	8
U53088	440	77.1	471	892	4	1 388	92	406.4	279.4	205	M45×2	55	5 050±200	8
U5E095	475	94.1	649	1 170	4	1 465	100	420	279.4	210	M48×2	55	5 880±200	8
U55098	490	108	657	1 270	4	1 503	107	440	279.4	215	M52×2	60	7 350±300	8
U5G105	525	127	814	1 470	4	1 630	110	470	325	220	M52×3	65	7 650±300	8
U57108	540	140	1 160	1 780	4	1 674	116	485	350	230	M56×2	60	9 120±300	8
U59118	590	180	1 350	2 270	4	1 775	125	530	375	250	M36×2	36	2 350±100	24
U63128	640	229	1 910	2 920	4	1 899	136	580	400	265	M39×2	36	2 940±150	24
U6S132	660	255	2 010	3 030	4	1 963	142	600	400	275	M39×2	36	2 940±150	24
U6D138	690	285	2 390	3 710	4	2 049	146	620	450	285	M42×2	41	4 270±200	24

■ Features

The U Series is mainly intended for non reversing mills, such as the finishing stand of a hot strip mill.

■ Designs available to order

The fixed type can be designed to order, assembling components are shown on the right.
For more details on these designs, consult JTEKT.

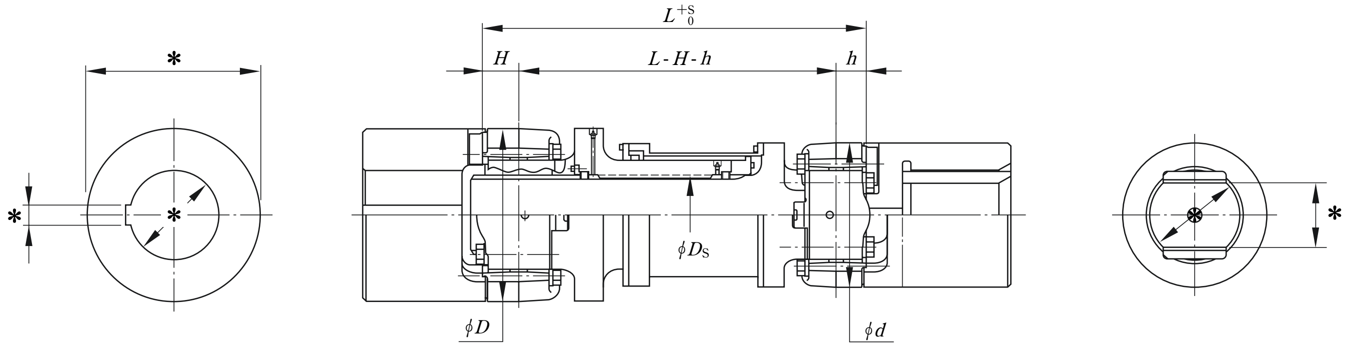
With propeller tube	
With coupling yoke	

Basic reference No.	Swing dia. (mm) D	Torque capacity (kN·m)			Max. operating angle (°)	Boundary dimensions (mm)					Bearing fixing bolts			
		T_R 1)	T_D 2)	T_S 3)		L 4) min.	H	Propeller tube dia. D_T	Spline dia. D_S	Allowable telescoping stroke S	Nominal thread size	Width across flats	Tightening torque (N·m)	Number of bolts per bearing
U65148	740	360	2 690	4 770	4	2 160	155	670	450	305	M45×2	46	4 900±200	24
U67152	760	398	3 090	4 840	4	2 195	160	685	450	310	M45×2	46	4 900±200	24
U6J156	780	416	3 390	5 690	4	2 235	165	705	500	315	M48×2	50	5 590±200	24
U69168	840	491	3 920	6 650	4	2 357	178	760	500	325	M52×2	55	7 650±300	24

[Notes]
1) T_R refers to the rated torque used for service life calculation (refer to page 31). The material factor K_m is supposed to be 3 in this calculation.
2) T_D refers to the reference torque used as the criterion for evaluation of resistance to the maximum torque under normal operating conditions. T_D divided by the maximum torque should preferably be greater than 1.5.
3) T_S refers to the reference torque used as the criterion for evaluation of resistance to the breaking torque under emergency conditions. T_S divided by the breaking torque should preferably be greater than 1.5.
4) L refers to the minimum dimension when the shaft has neither propeller tube nor welded connection.

[Remark] Consult JTEKT for U series products with a swing diameter of between 285 mm and 345 mm.

T Series



Dimensions marked with an asterisk (*) need to be determined to suit existing equipment.
Please provide the specifications of your equipment when placing an inquiry.

■ Features

The T Series is intended for such applications where telescoping function is required in a small space. Because one of the cross bearings needs to be hollow to enable the required stroke, this series is applicable in such cases where the swing diameter has a given allowance on either the driving side or driven side.

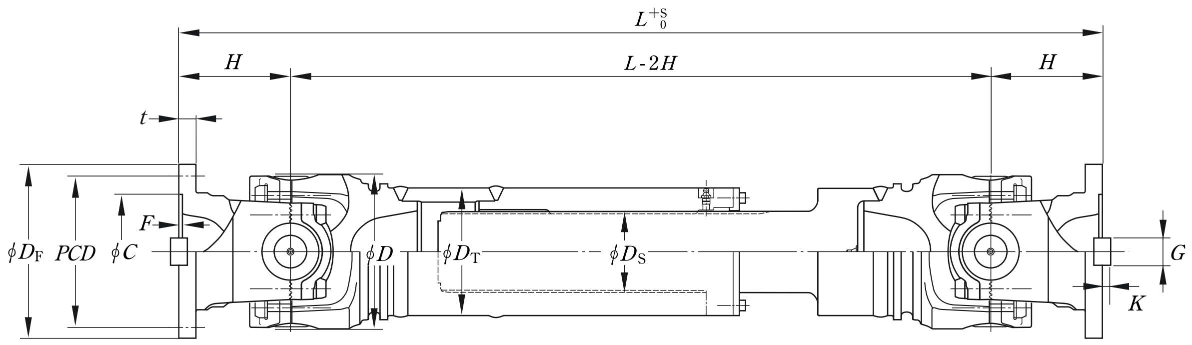
Basic reference No.	Swing dia. (mm) D (d)	Torque capacity (kN·m)			Max. operating angle (°)	Boundary dimensions (mm)					Bearing fixing bolts			
		T_R 1)	T_D 2)	T_S 3)		L min.	H (h)	Spline dia. D_S	Allowable telescoping stroke S		Nominal thread size	Width across flats	Tightening torque (N·m)	Number of bolts per bearing
T42065 (D30044)	325 (220)	16.9	39.2	108	10	699	67 (45)	127	180		M24×2	27	645± 30	8
T48080 (D38060)	400 (300)	30.8	98.1	284	10	870	80 (60)	177.8	210		M30×2	32	1 180± 50	8
T54090 (D44070)	450 (350)	45.0	167	451	10	969	92 (70)	203.2	250		M33×2	36	1 720± 70	8
TZ56100 (D48080)	500 (400)	74.1	255	667	8	1 080	107 (80)	225	280		M39×3	50	3 030±200	8
T58110 (D54090)	550 (450)	82.5	373	951	8	1 196	116 (92)	250	305		M42×3	50	4 020±200	8
T60120 (D56100)	600 (500)	111	520	1 270	8	1 319	125 (107)	275	335		M48×3	60	5 980±300	8
T62130 (D58110)	650 (550)	142	706	1 770	6	1 414	136 (116)	300	355		M52×3	65	7 650±300	8
T66150 (D62130)	750 (650)	212	1 180	2 840	6	1 617	155 (136)	350	415		M62×3	75	12 700±300	8

[Notes] 1) T_R refers to the rated torque used for service life calculation (refer to page 31). The material factor K_m is supposed to be 3 in this calculation.
2) T_D refers to the reference torque used as the criterion for evaluation of resistance to the maximum torque under normal operating conditions. T_D divided by the maximum torque should preferably be greater than 1.5.
3) T_S refers to the reference torque used as the criterion for evaluation of resistance to the breaking torque under emergency conditions. T_S divided by the breaking torque should preferably be greater than 1.5.

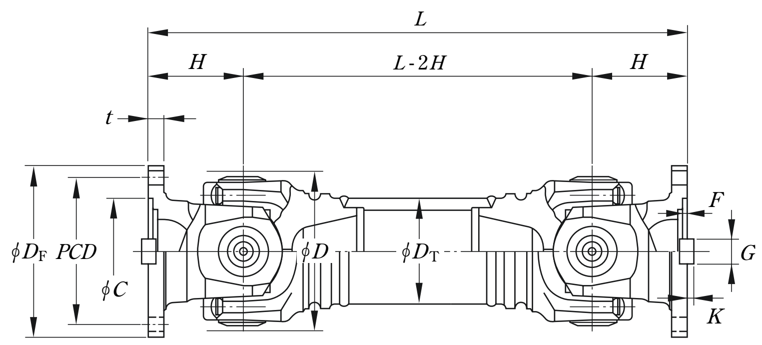
[Remark] The specifications shown in blue refer to those of the D series products coupled with the corresponding T series products.

CS Series

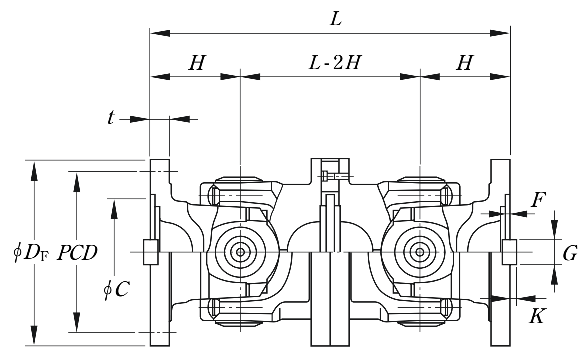
Telescoping Type (with propeller tube)



Fixed type (with propeller tube)



Fixed type (with double flanges)



For the flange dimensions (PCD, C, F, G, K and t) that suit the individual flange outside diameter (D_F) and for the flange bolt-hole details, refer to the table of cylindrical bore dimensions on page 24.

Basic reference No.	Swing dia. (mm) D	Torque capacity (N·m)			Max. operating angle (°)	Boundary dimensions (mm)								Bearing fixing bolts			Flange outside dia. (mm)
		T_R	T_D	T_S		H	Propeller tube dia. D_T	Telescoping type: Propeller tube dia. L	Telescoping type: Without propeller tube L min.	Telescoping type: Allowable telescoping stroke S	Telescoping type: Spline dia. D_S	Fixed type with propeller tube L min.		Nominal thread size	Width across flats	Tightening torque (N·m)	
CS180	180	5 710	32 100	59 000	10	130	152.4	975	1 025	105	95	580		M14×1.5	12	145±10	200 225 250
CS200	200	8 170	44 100	81 000	10	145	165.2	1 050	1 110	110	105	640		M16×1.5	14	215±20	225 250 285
CS225	225	11 600	62 800	115 000	10	160	185.0	1 180	1 240	115	120	710		M18×2	14	305±20	250 285 315
CS250	250	15 700	86 100	158 000	10	180	203.0	1 325	1 385	125	140	780		M20×2	17	435±20	285 315 350
CS285	285	23 100	128 000	234 000	10	205	229.0	1 480	1 550	140	160	890		M22×2	17	585±30	315 350 390

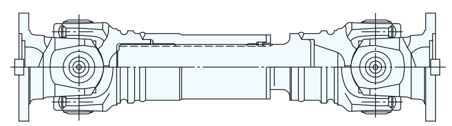
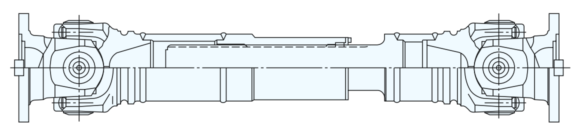
[Notes]
1) T_R refers to the rated torque used for service life calculation (refer to page 31). The material factor K_m is supposed to be 3 in this calculation.
2) T_D refers to the reference torque used as the criterion for evaluation of resistance to the maximum torque under normal operating conditions. T_D divided by the maximum torque should preferably be greater than 1.5.
3) T_S refers to the reference torque used as the criterion for evaluation of resistance to the breaking torque under emergency conditions. T_S divided by the breaking torque should preferably be greater than 1.5.

■ Features

The CS Series is optimized to demonstrate the utmost performance in non reversing equipment such as bar/wire rod rolling mills and continuous casting equipment.
A conventional product can be replaced by a smaller CS Series product, which features utmost service life and strength enhanced to the highest possible degree.

■ Designs available to order

When installation space is limited or when a stroke needs to be long, this series can be designed to order. Assembling components are shown below.
For more details on these designs, consult JTEKT.

Telescoping type without propeller tube	
Long telescoping type	

KF Series

Telescoping Type (with propeller tube)

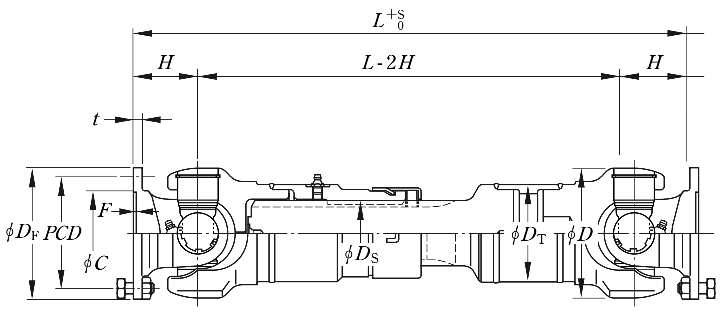


Fig. 1

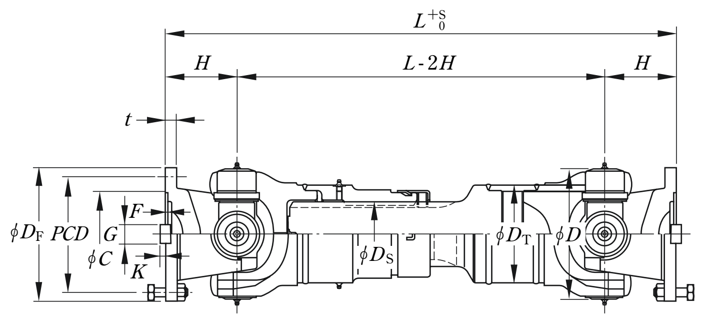


Fig. 2

Fixed type (with propeller tube)

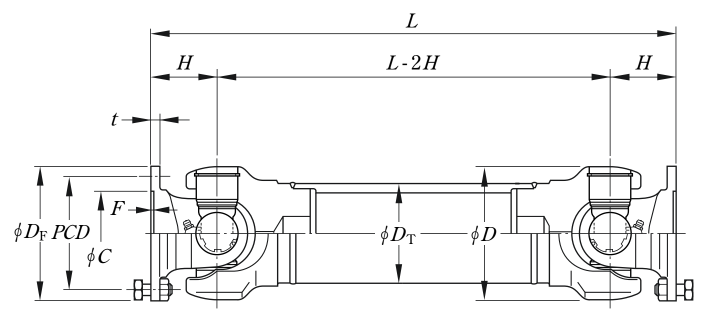


Fig. 1

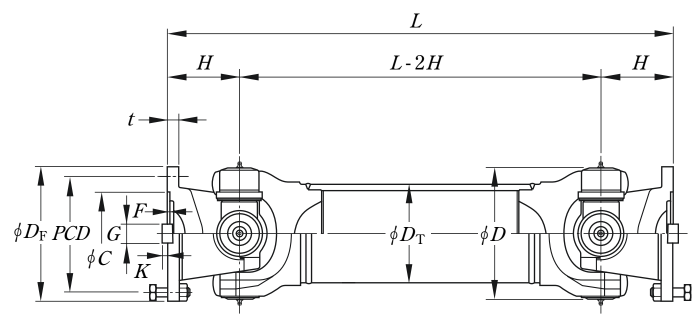


Fig. 2

Basic reference No.	Fig.	Swing dia. (mm) D	Torque capacity (N·m)			Max. operating angle (°)	Boundary dimensions (mm)								Bearing fixing bolts			Flange outside dia. (mm)
			T_R 1)	T_D 2)	T_S 3)		H 4)	Propeller tube dia. D_T	Telescoping type: Propeller tube dia. L	Telescoping type: Without propeller tube L min.	Telescoping type: Allowable telescoping stroke S	Telescoping type: Spline dia. D_S	Fixed type with propeller tube Lmin.		Nominal thread size	Width across flats	Tightening torque (N·m)	
KFZ100	1	105	735	1 270	3 620	30	70 —	73	510 —	550 —	60	45	320 —		—	—	—	120 —
KF120	1	120	882	2 940	11 700	20	60 62	89.1	495 499	535 539	70	58	310 314		—	—	—	120 150
KF150	1	150	1 860	5 880	22 500	20	72 74	114.3	577 581	617 621	70	70	354 358		—	—	—	150 180
KF180	1	180	3 280	11 700	39 200	18	82 90	127	664 680	714 730	90	82	404 420		—	—	—	180 225
EZ26045	2	225	6 370	20 500	78 400	15	123 128	165.2	845 855	895 905	90	105	536 546		M16×1.5	14	185±10	225 250
EZ28050	2	250	8 820	29 400	107 000	15	128 130	203	920 924	980 984	110	120	586 590		M18×2	14	240±20	250 285
EZ32057	2	285	13 700	44 100	156 000	15	143 148	216.3	1 015 1 025	1 075 1 085	110	140	666 676		M18×2	14	240±20	285 315
EZ34063	2	315	18 900	58 800	205 000	15	163 166	244.5	1 131 1 137	1 201 1 207	135	160	726 732		M20×2	17	360±20	315 350
KFZ350	2	350	25 500	88 200	294 000	15	175 180	244.5	1 195 1 205	1 265 1 275	135	180	780 790		M22×1.5	17	745±40	350 390
KFZ390	2	390	35 300	127 000	402 000	15	195 —	273.1	1 335 —	1 425 —	140	200	880 —		M27×1.5	19	1 460±80	390 —
KFZ435	2	435	51 000	166 000	558 000	15	220 —	318.5	1 470 —	1 570 —	140	200	1 010 —		M27×1.5	19	1 460±80	435 —

[Notes] 1) T_R refers to the rated torque used for service life calculation (refer to page 31). The material factor K_m is supposed to be 1 for the drive shafts whose swing diameter is 180 mm or less, and to be 3 for those whose swing diameter is between 225 mm and 435 mm in this calculation.
2) T_D refers to the reference torque used as the criterion for evaluation of resistance to the maximum torque under normal operating conditions. T_D divided by the maximum torque should preferably be greater than 1.5.
3) T_S refers to the reference torque used as the criterion for evaluation of resistance to the breaking torque under emergency conditions. T_S divided by the breaking torque should preferably be greater than 1.5.
4) The flanges of the products other than **KFZ 100, KFZ 390** and **KFZ 435** can be selected from between two types. The upper value in the cell of dimension H in the table corresponds to the upper value in the cell of the flange outside diameter (D_F), while the lower value of the cell of dimension H corresponds to the lower value in the cell of diameter D_F.

Fixed type (with double flanges)

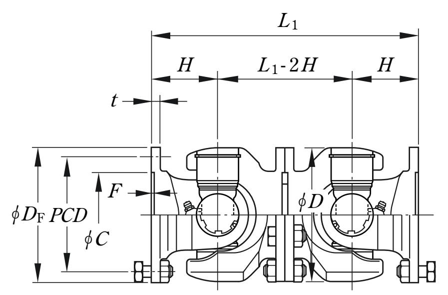


Fig. 1

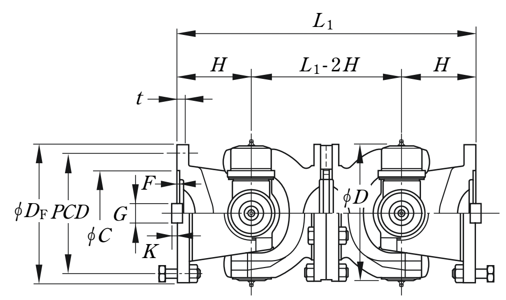


Fig. 2

For the flange dimensions (PCD, C, F, G, K and t) that suit the individual flange outside diameter (D_F) and for the flange bolt hole details, refer to the table of cylindrical bore dimensions on page 25.

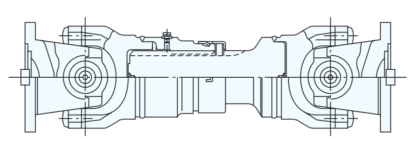
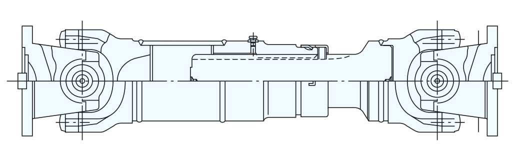
■ Features

The KF Series products have the following features depending on the swing diameter.

- **Swing diameter: 180 mm or less**
  The products are suitable for applications where the maximum operating angle is between 18¡ to 30¡. They are suited to light load applications.These products are compatible with a wide variety of equipment. In addition they are economical, with the yokes being integrated.
- **Swing diameter: 225 to 435 mm**
  The products are suitable for applications where the maximum operating angle is no more than 15¡. They are suited to medium load applications.
  Their yokes can be disassembled, so that their cross bearings can be replaced easily.

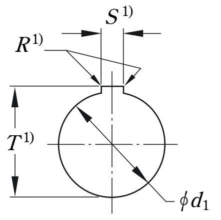
■ Designs available to order

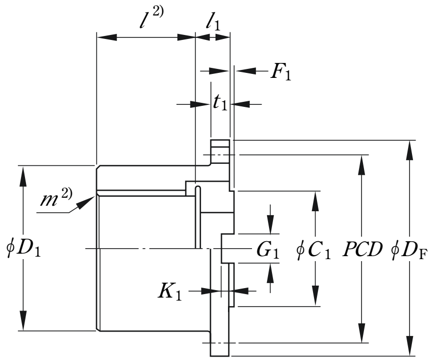
When installation space is limited or when a stroke needs to be long, this series can be designed to order. Assembling components are shown below.
For more details on these designs, consult JTEKT.

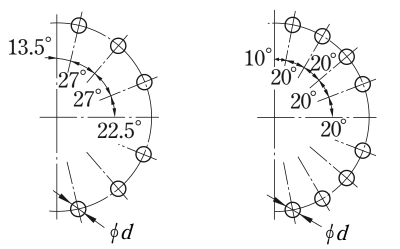
Telescoping type without propeller tube	
Long telescoping type	

CS/KF Series Basic Dimensions of Flange Coupling with Cylindrical Bore

CS Series





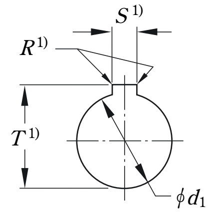


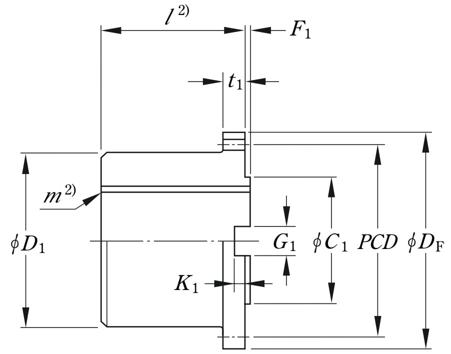
(Arrangement of bolt holes on the flange)

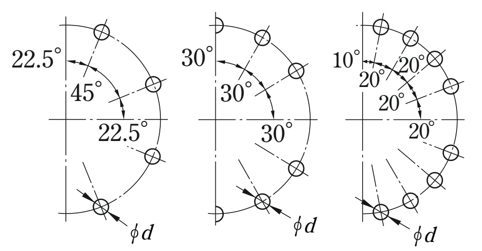
Flange outside dia. D_F (mm)	Boundary dimensions[3] (mm)								Flange bolt holes			Flange fixing bolts	
	D_1 max.	d_1[4] max.	l_1	C / C_1	F / F_1	G(e9) / G_1(JS9)	K / K_1	t / t_1	PCD (mm) ±0.1	Dia. d (mm)	Number	Nominal thread size	Tightening torque (N·m)
200	150	94	25	100 H7/f8	5 / 4.5	32	10	20	172	15(drilled)	12	M14×1.5	175± 10
225	172	107	27	110 H7/f8	5 / 4.5	36	11	22	196	17(drilled)	12	M16×1.5	265± 20
250	191	119	30	125 H7/f8	6 / 5	40	12.5	25	218	19(drilled)	12	M18×2.0	360± 20
285	215	134	33	140 H7/f8	7 / 6	45	15	28	245	21(drilled)	12	M20×2.0	500± 30
315	246	154	37	155 H7/f8	8 / 7	50	16	32	278	23(drilled)	12	M22×2.0	675± 40
350	278	173	41	175 H7/f8	8 / 7	56	18	36	310	23(drilled)	16	M22×2.0	675± 40
390	309	193	45	200 H7/f8	8 / 7	70	20	40	345	25(drilled)	16	M24×2.0	900± 50

[Notes]
1) The keyway dimensions (S, T and R) shall be determined in conformity with JIS B 1301.
2) The dimensions l and m are determined according to customer specifications. (When not specified, l is recommended to be d_1 multiplied by between 1.2 and 1.5 and m to be d_1 multiplied by about 0.02.)
3) The upper line value in each cell is a dimension for the drive shaft end and the lower line value is a dimension for the cylindrical bore flange coupling end.
4) The d_1 max. dimensions are approximately D_1 divided by 1.6.

KF Series







(Arrangement of bolt holes on the flange)

Flange outside dia. D_F (mm)	Boundary dimensions[3] (mm)							Flange bolt holes			Flange fixing bolts	
	D_1 max.	d_1[4] max.	C / C_1	F / F_1	G(e9) / G_1(JS9)	K / K_1	t / t_1	PCD (mm) ±0.1	Dia. d (mm)	Number	Nominal thread size	Tightening torque (N·m)
120	84	52	75 H7/h7	2.5 / 2	—	—	8	101.5	10(C12)	8	M10×1.25	64± 5
150	110.5	69	90 H7/h7	2.5 / 2	—	—	10	130	12(C12)	8	M12×1.25	110± 5
180	133	83	110 H7/h7	2.5 / 2	—	—	12	155.5	14(C12)	8	M14×1.5	175± 10
200	150	94	140 H7/f8	5 / 4.5	32	9	18	172	15(drilled)	8	M14×1.5	175± 10
225	172	107	140 H7/f8	5 / 4.5	32	9	20	196	17(drilled)	8	M16×1.5	265± 20
250	191	119	140 H7/f8	6 / 5	40	12.5	25	218	19(drilled)	8	M18×2.0	360± 20
285	215	134	175 H7/f8	7 / 6	40	15	27	245	21(drilled)	8	M20×2.0	500± 30
315	248	155	175 H7/f8	8 / 7	40	15	32	280	23(drilled)	10	M22×2.0	675± 40
350	278	173	220 H7/f8	8 / 7	50	16	35	310	23(drilled)	10	M22×2.0	675± 40
390	309	193	220 H7/f8	8 / 7	70	18	40	345	25(drilled)	10	M24×2.0	900± 50
435	344	215	250 H7/f8	10 / 9	80	20	42	385	28(drilled)	16	M27×2.0	1 320± 70
480	379	235	250 H7/f8	12 / 11	90	22.5	47	425	31(drilled)	16	M30×2.0	1 810±100
550	446	278	295 H7/f8	12 / 11	100	22.5	50	492	31(drilled)	16	M30×2.0	1 810±100

[Notes]
1) The keyway dimensions (S, T and R) shall be determined in conformity with JIS B 1301.
2) The dimensions l and m are determined according to customer specifications. (When not specified, l is recommended to be d_1 multiplied by between 1.2 and 1.5 and m to be d_1 multiplied by about 0.02.)
3) The upper line value in each cell is a dimension for the drive shaft end and the lower line value is a dimension for the cylindrical bore flange coupling end.
4) The d_1 max. dimensions are approximately D_1 divided by 1.6.

6.1 Structure and Working Principle

The hydraulic expansion type torque limiter transmits torque by the friction between the shaft components and the welded coupling assemble, which is generated by the bore shrinkage of the welded coupling assemble when oil is filled and pressurized in the hydraulic expansion chamber.
The torque can be set in proportion to hydraulic pressure, which is simultaneously released by the decompression of oil, thanks to the breakage of the shear valve coming concurrently with slipping of torque transmission surface, if the excessive torque beyond set value is generated.
The following illustration shows an example of the hydraulic expansion type torque limiter applied to a rolling mill.

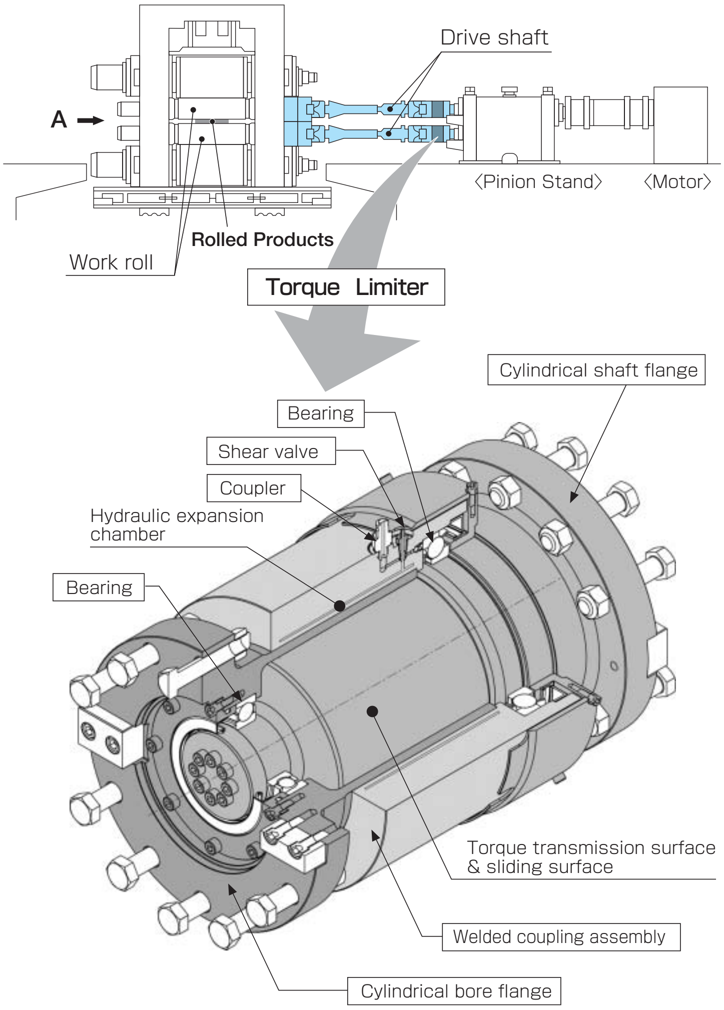


Fig. 6.1 Installation Position and Structure of Hydraulic Expansion Type Torque Limiter

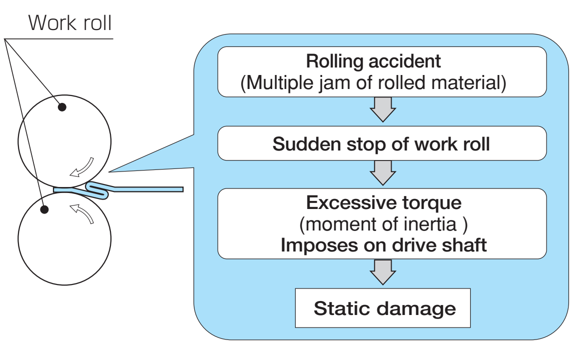


Fig. 6.2 View A (Example of Abnormal Rolling)

6.2 Comparison of Conventional Product

The shear pin type torque limiter has been used as the implement to release torque, however, the maintenance of surrounding parts of the shear pin is required in case the shear pin is broken, which leads to a lot of time consuming for replacement. Furthermore, the pin needs to be periodically replaced in the overhaul in order to prevent the accumulated metal fatigue of the pin. Compared with the share pin type torque limiter, the hydraulic expansion type torque limiter requires only share valve replacement for repair. Since it is not required to replace the shear valves during periodical inspection, it will improve the overhaul time.

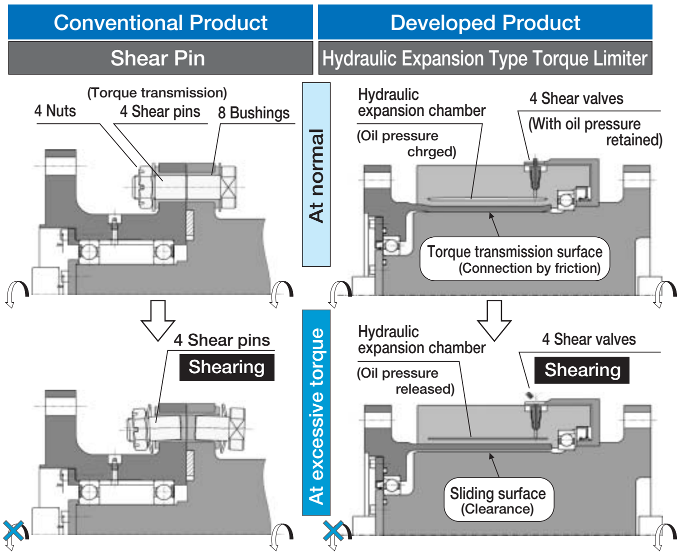


Fig. 6.3 Working Principle of Shear Pin & Hydraulic Expansion Type Torque Limiter

Table 6.1 Merits of Hydraulic Expansion Type Torque Limiter

		Shear pin (Conventional product)	Hydraulic expansion type torque limiter (Developed product)
At periodic check		Periodic replacement required due to fatigue accumulation.	Not required periodic replacement of shear valve.
At repair	Replacement parts	◆ 4 shear pins ◆ 4 nuts ◆ 8 bushes	◆ 4 shear valves
	Required man-hours for parts replacement	1	1/4

7.1 Ball Burnishing on Cross Shaft

The flaking life can be improved by the ball burnishing on cross raceway. This process is a type of plastic working process, which is applied by rolling contact of super-hard ball backed up hydraulically on the cross raceway surface.

■ Features

1) The hardness of the surface becomes higher than that of the carburized original material.
2) The subsurface residual compressive stress is higher than that of the carburized material and deeper than that by the shot peening.
3) Raceway roughness of the machined surface is improved. And no further finishing process is required after ball burnishing process.
4) As the ball burnishing fixture can be used by attaching to lathe or other machine, there is actually no limitation in size of workpieces.

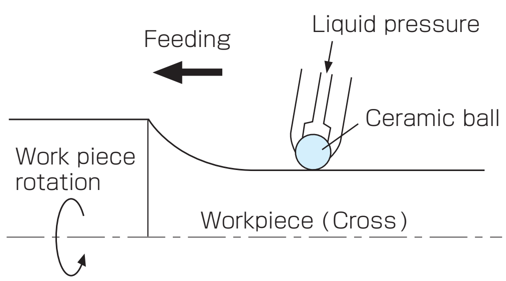


Fig. 7.1 Ball Burnishing Processing Method

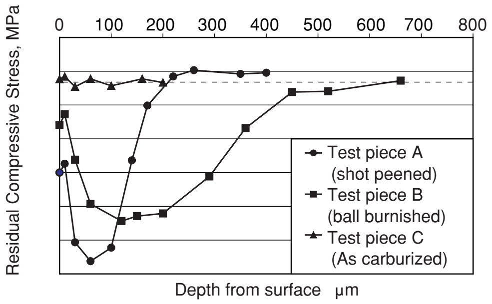


Fig. 7.2 Measurement Result of Residual Compressive Stress

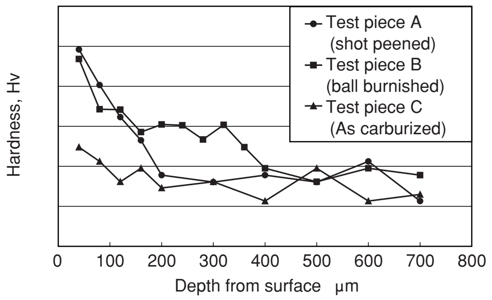


Fig. 7.3 Measurement Result of Hardness

7.2 Application of Different Diameter Rollers for Cross & Bearing

Because the cross is an elastic cantilever beam and the bearing has some radial clearance, the load on the cross generally becomes heavier toward to the end of the cross.

In order to improve this phenomenon, load on the roller is made uniform by designing the roller to have a minutely smaller diameter at the very close end, which would improve flaking life. (Refer to Fig 7.4)

It is required that the detailed investigation takes into account multitude of JTEKT records and the technology of theoretical analysis by FEM, when this would be applied.

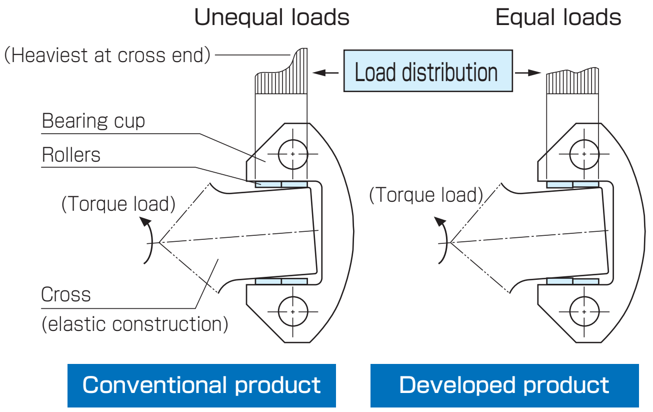


Fig. 7.4 Effect of Rollers Different in Diameter

7. Introduction of New Technologies

7.3 Application of Form Rolling to Bearing Set Bolt

The thread of the bearing set bolt has conventionally been machined after heat treatment. However, by switching this process to form rolling, allowable fatigue stress at the bottom radii of the thread increases significantly. It was confirmed by JTEKT original evaluation test that the allowable stress was improved 1.9 times.

■ Features

1) Fiber flow is formed along the shape of the thread. (Refer to Fig. 7.5)
2) Residual compressive stress at subsurface beneath the bottom radius of the thread increases. (Refer to Fig. 7.6)

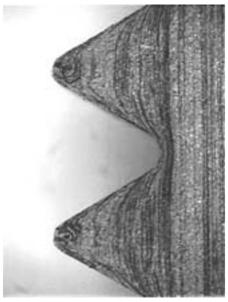


Fig. 7.5 Fiber Flow of Rolled Thread

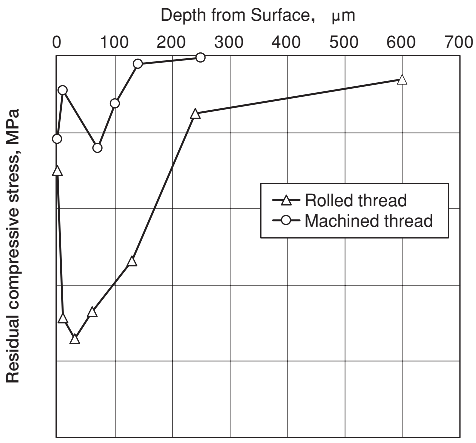


Fig. 7.6 Residual Compressive Stress Distribution of Rolled Thread

7.4 Thermal Spraying Coat of Tungsten Carbide (WC) on Bearing Cup Key

To avoid corrosion on the side face of bearing cup key applying carburizing heat treatment, one possible method is to apply thermal spraying coat of tungsten carbide (WC) on these surfaces.

■ Effects

The following effects are expected in case the generation of clearance due to corrosion at the key area is restrained.

1) The bending stress of bolt can be alleviated, which leads to the restraint of strength reduction.
2) The heavier load on raceways at the end of the cross can be restrained, which expects longer fatigue life for cross & bearing.

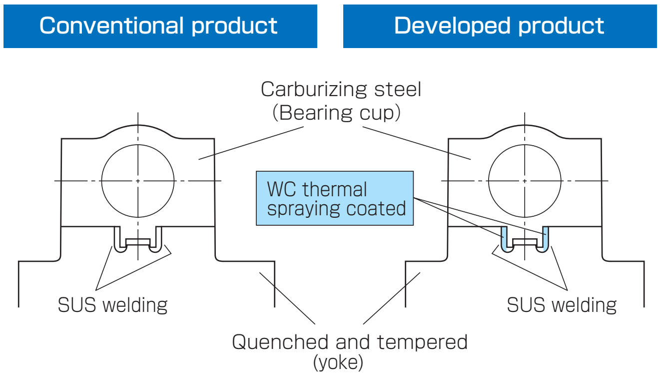


Fig. 7.7 Structure of Key and Details of WC Thermal Sprayed Part

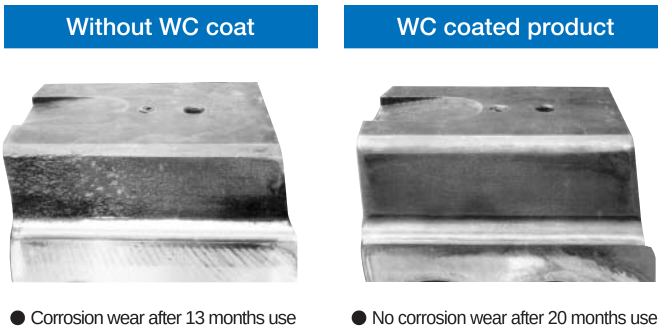


Fig. 7.8 Effect of Thermal Spraying Coat of Tungsten Carbide (WC)

8.1 General Characteristics of Universal Joints

1) Single Universal Joints

The driving shaft and driven shaft intermediated by a universal joint has the following relationship between their rotation angles:

$$\tan\phi_2 = \cos\theta \cdot \tan\phi_1$$

where ϕ_1 : Rotation angle of driving shaft
ϕ_2 : Rotation angle of driven shaft
θ : Shaft operating angle

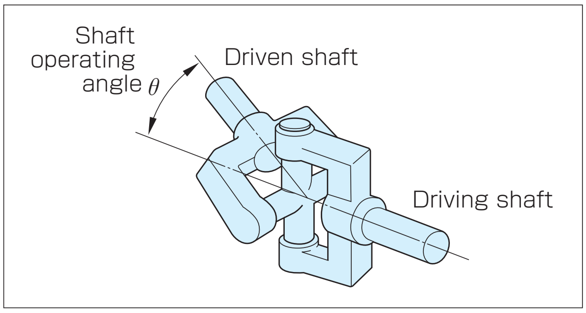


Fig. 8.1 Single Universal Joint

This means that, even if the rotational speed and torque of the driving shaft are constant, the driven shaft is subject to fluctuation in rotational speed and torque.
The speed ratio between the driving shaft and driven shaft can be obtained by differentiating equation (1) with respect to time (t), where ϕ_1 is by $\omega_1 \cdot t$ and ϕ_2 by $\phi_2 \cdot t$:

$$\frac{\omega_2}{\omega_1} = \frac{\cos\theta}{1-\sin^2\phi_1 \cdot \sin^2\theta}$$

where ω_1 : Rotational angular velocity of driving shaft (rad/s)
ω_2 : Rotational angular velocity of driven shaft (rad/s)
ω_2/ω_1 : Angular velocity ratio

Equation (2) can be expressed in diagram form as shown in Fig. 8.2. The maximum value and minimum value of the angular velocity ratio can be expressed as follows:

$$(\omega_2/\omega_1)\text{max.} = 1/\cos\theta \cdots\cdots \phi_1=90^\circ$$
$$(\omega_2/\omega_1)\text{min.} = \cos\theta \cdots\cdots \phi_1=0^\circ$$

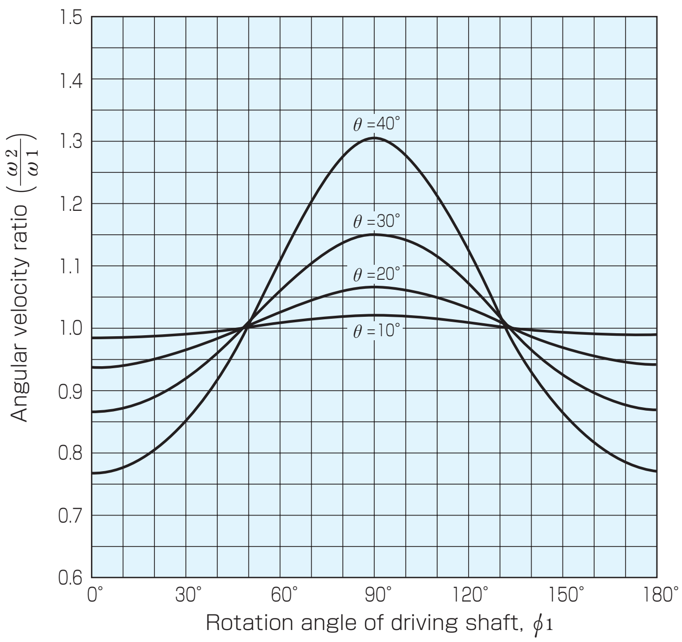


Fig. 8.2 Angular Velocity Fluctuation

The maximum fluctuation rate of angular velocity in a universal joint can be expressed by the following equation:

$$\frac{(\omega_2\text{max.} - \omega_2\text{min.})}{\omega_1} = \frac{1}{\cos\theta} - \cos\theta$$

The torque ratio between input and output can be expressed by the diagram shown in Fig. 8.3. The maximum value and minimum value can be obtained as shown below, respectively:

$$(T_2/T_1)\text{max.} = 1/\cos\theta \cdots\cdots \phi_1= 0^\circ$$
$$(T_2/T_1)\text{min.} = \cos\theta \cdots\cdots \phi_1=90^\circ$$

where T_1 : Input torque
T_2 : Output torque
T_2/T_1 : Torque ratio

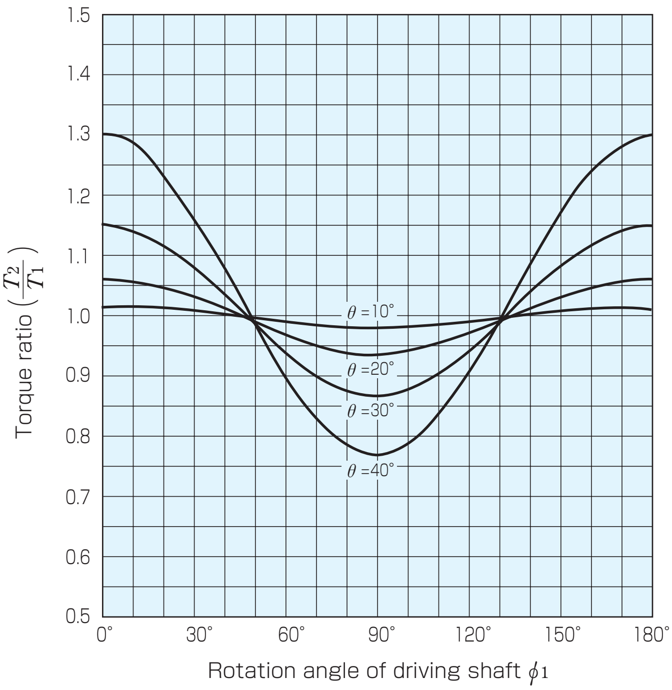


Fig. 8.3 Torque Fluctuation

8. Technical Data

2) Double Universal Joints
Universal joints are usually installed in pairs. When assembled as shown in Fig. 8.4 (that is with equal operating angles in both joints and yokes connected to the same shaft in line and all three shafts in the same plane), the complete drive consisting of the two joints and the connecting shaft will transmit uniform angular velocity.

When two universal joints are installed without any of the above conditions being satisfied, the second joint will not compensate for the angular fluctuation by the first joint.

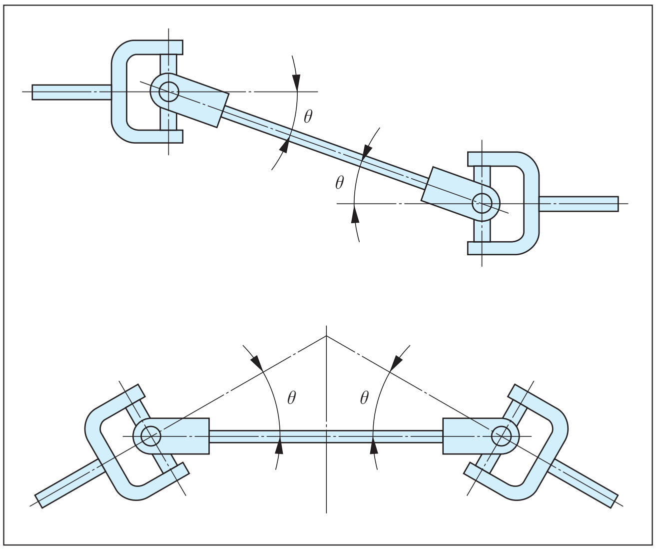


Fig. 8.4 Installation of Double Universal Joints

3) Secondary Couples
It is often necessary to consider the secondary couples imposed by universal joints operating at an angle; especially under high angle or large torque. These couples must be taken into account in designing the shafts and supporting bearings.
The secondary couples in the universal joints are in the planes of the yoke. These couples are about the intersection of the shaft axis. They impose a load on the bearings and a bending stress in the shaft connecting the joints, and they fluctuate from maximum to zero every 90¡ of shaft revolution. The broken lines in Fig. 8.5 indicate the effect of these secondary couples on the shafts and bearings.
The formula for maximum secondary couple is as follows:

$$M_1 \text{ max.} = T \tan\theta \text{ (for driving shaft)}$$
$$M_2 \text{ max.} = T \sin\theta \text{ (for driven shaft)}$$

where M_1: Secondary couple on driving shaft (N・m)
M_2: Secondary couple on driven shaft (N・m)
T : Driving torque (N・m)
θ : Shaft operating angle

The ratio of the secondary couple to the driving torque is shown in Fig. 8.5. The secondary couple M_1 and M_2 can be obtained by multiplying M_1/T or M_2/T by the driving torque T.

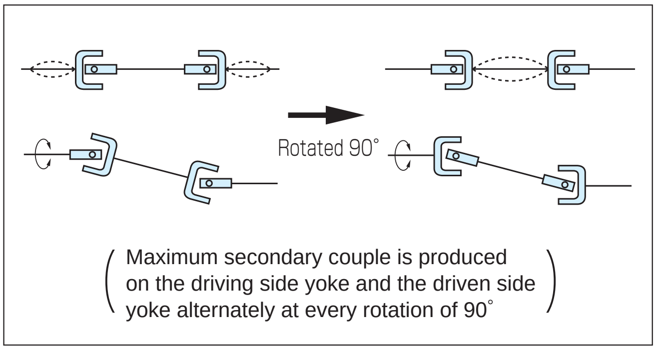


Fig. 8.5 Effect of Secondary Couple

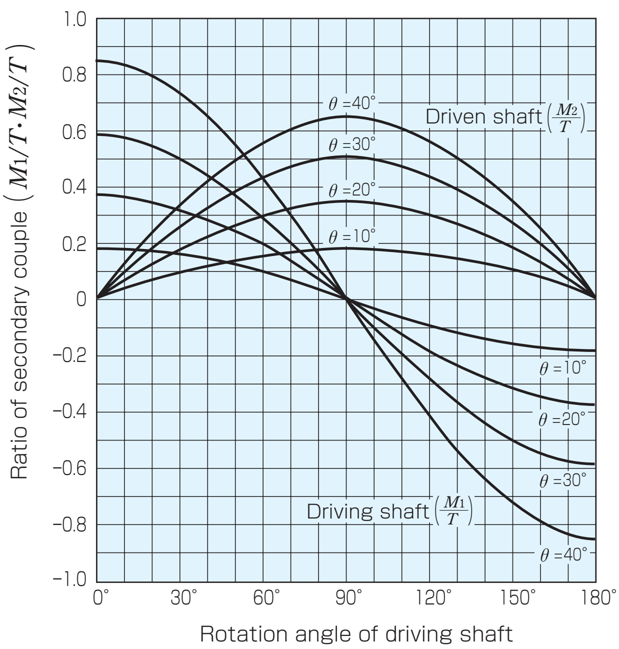


Fig. 8.6 Fluctuation of Secondary Couple to Driving Torque

8.2 Drive Shaft Selection

A drive shaft should be selected so as to satisfy the required strength, service life, operating angle and dimensions necessitated by its purpose.

Practically, the strength and service life of the universal joints should be examined first as shown in the following steps. Once these requirements be satisfied, the universal joint will satisfy its purpose in most of the cases.

1) Load Torque of Drive Shaft

The function of the drive shaft is to transmit a given torque at a certain operating angle and a certain rotational speed. Load torque should be first determined to select the size of a desired drive shaft.

A maximum torque including an impact torque and a mean torque should be known, and it is essential for selecting an appropriate drive shaft to understand the correct maximum torque and mean torque.

Maximum torque:
 Value to determine if the strength of each part is sufficient.
Mean torque:
 Value necessary to calculate the service life

2) Mean Torque

It is apparent that all kinds of machines are not operating thoroughly by their maximum torque. Therefore, if a drive shaft is selected according to a service life calculated from the maximum torque, it results in being uneconomically larger than necessary.
So, it is reasonable to set up a longer expected service life, if the application condition are severe; and shorter, if the conditions are easy.
If, for instance, a job is expressed as in the table below,

Drive stage	1	2	3 · · · · · Z
Torque (N・m)	T_1	T_2	$T_3 \cdots T_Z$
Rotation speed (min^{-1})	n_1	n_2	$n_3 \cdots n_Z$
Time ratio (%)	t_1	t_2	$t_3 \cdots t_Z$

the cube root of mean torque (T_m) and the arithmetical mean of rotation speed (n_m) are yielded from the following equations.

$$T_m = \sqrt[3]{\frac{(T_1^3\ n_1 \cdot t_1 + \cdots\cdots + T_Z^3 \cdot n_Z \cdot t_Z)}{(n_1 \cdot t_1 + \cdots\cdots + n_Z \cdot t_Z)}}$$

$$n_m = \frac{(n_1 \cdot t_1 + \cdots\cdots + n_Z \cdot t_Z)}{(t_1 + \cdots\cdots + t_Z)}$$

3) Selection Based on Strength

A drive shaft should be selected so that the normal maximum torque shall not exceed the " T_D torque." However, it is difficult to determine the true maximum torque, and the engine capacity or motor capacity is used as the maximum torque in many cases. In consideration of the torque amplification factor (TAF) of the drive shaft and various imponderables, the safety factor (f_S) of no less than 1.5 should be considered as the most desirable.

$f_S = T_D$ /maximum torque under normal operating conditions > 1.5

The maximum torque that may occur in an emergency should be determined using " T_S torque." The safety factor (f_S) of no less than 1.5 should be considered as desirable in this case as well.

$f_S = T_S$ /breaking torque under emergency conditions > 1.5

To select a drive shaft based on a safety factor of 1.5 or less, consult JTEKT as close examination is required in consideration of previous performance records.

4) Selection Based on Service Life

There is no worldwide standard for service life calculation of universal joint bearings (cross bearings) and the service life is calculated according to the unique method developed by each manufacturer.
JTEKT employs the following empirical equation based on extensive experimentation (conforming to SAE).
The service life L_h is defined as the expected number of operating hours before an indentation of 0.25 mm develops on the rolling contact surface of the bearing. The use of the bearings over the service life L_h may be practical on a low speed machine such as a rolling mill.

$$L_h = 3000\ K_m \left(\frac{T_R \cdot K_n \cdot K_\theta}{T_m} \right)^{2.907}$$

where
L_h : Average calculated bearing life (h)
K_m : Material factor = 1 to 3
T_R : Rated torque (N・m)
T_m : Mean torque (N・m)
K_n : Speed factor = $10.2/n^{0.336}$
K_θ : Angle factor = $1.46/\theta^{0.344}$
n : Rotation speed (min^{-1})
θ : Shaft operating angle (°)

Note: A drive shaft should be selected by considering the type of the machine, peripheral equipment, particular operating conditions, and other factors. The method outlined in this catalog is a common rough guide. It is recommended to consult JTEKT for details.

8.3 Balance Quality of Drive Shafts

If a rotating drive shaft is unbalanced, it may adversely influence the equipment and ambient conditions, thus posing a problem.

JTEKT designs and manufactures drive shafts to satisfy the balance quality requirements specified in JIS B 0905.

1) Expression of balance quality

The balance quality is expressed by the following equation:

Balance quality $= e\omega$

or

Balance quality $= en/9.55$

where e : Amount of specific unbalance (mm)
This amount is the quotient of the static unbalance of a rigid rotor by the rotor mass. The amount is equal to the deviation of the center of the rotor mass from the center line of the shaft.

ω : Maximum service angular velocity of the rotor (rad/s)

n : Rotational speed (min^{-1})

2) Balance quality grades

The JIS specifies the balance quality grades from G0.4 to G4000. Generally, the three grades described in Table 8.1 below are commonly used.
We apply grade G16 to high speed drive shafts unless otherwise specified.

3) Correction of the unbalance of drive shafts

JTEKT corrects the unbalance of drive shafts to the optimal value by the two plane balancing method, using the latest balance system.

To correct the balance of a drive shaft, it is critical to correct the balance between two planes each near the two individual universal joints, instead of by the one plane balancing as used to balance car wheels.

Especially in the case of a long drive shaft, this two plane balancing method is the only way to acquire good results.

Table 8.1 Recommended Balance Quality Grades (Excerpt from JIS B 0905)

Balance quality grade	Upper limit value of balance quality ($e\omega$)	Recommended applicable machines
G40	40	Car wheels, wheel rims, wheel sets and drive shafts Crankshaft systems of elastically mounted high speed four stroke engines (gasoline or diesel) with six or more cylinders Crankshaft systems of the engines of automobiles, trucks and rolling stock
G16	16	Drive shafts with special requirements (propeller shafts and diesel shafts) Components of crushing machines Components of agricultural machines Components of the engines of automobiles, trucks and rolling stock (gasoline or diesel) Crankshaft systems with six or more cylinders with special requirements
G 6.3	6.3	Devices of processing plants Ship engine turbine gears (for merchant ships) Centrifugal drums Papermaking rolls and printing rolls Fans Assembled aerial gas turbine rollers Flywheels Pump impellers Components of machine tools and general industrial machines Medium or large electric armatures (of electric motors having at least 80 mm in the shaft center height) without special requirements Small electric armatures used in vibration insensitive applications and/or provided with vibration insulation (mainly mass produced models) Components of engines with special requirements

8.4 Recommended Tightening Torque for Flange Bolts

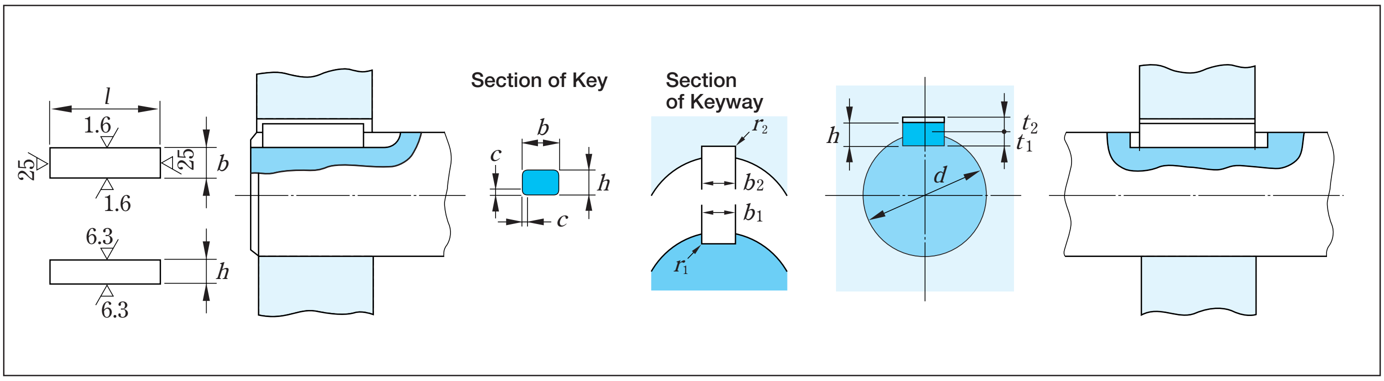
	Designation	Pitch (mm)	Width across flats (mm)	Tightening torque (N·m)	Tightening force (N)
Coarse screw thread	M 6	1	10	12±1	11 500
	M 8	1.25	13	29±2	21 100
	M10	1.5	17	59±5	33 500
	M12	1.75	19	98±5	47 400
	M14	2	22	155±10	65 400
	M16	2	24	245±20	91 800
	M18	2.5	27	345±20	114 000
	M20	2.5	30	480±30	144 000
	M22	2.5	32	645±40	179 000
	M24	3	36	825±50	207 000
	M27	3	41	1 230±70	276 000
	M30	3.5	46	1 670±100	334 000
	M33	3.5	50	2 260±150	417 000
	M36	4	55	2 840±150	479 000
	M39	4	60	3 730±200	582 000
	M42	4.5	65	4 610±300	665 000
	M45	4.5	70	5 790±300	783 000
	M48	5	75	6 960±400	876 000
	M52	5	80	9 020±500	1 060 000
	M56	5.5	85	11 300±600	1 240 000
	M60	5.5	90	13 700±700	1 410 000
	M64	6	95	16 700±900	1 610 000
	M68	6	100	20 100±1000	1 840 000

	Designation	Pitch (mm)	Width across flats (mm)	Tightening torque (N·m)	Tightening force (N)
Fine screw thread	M 6	0.75	10	14±1	12 900
	M 8	1	13	31±2	23 000
	M10	1.25	17	64±5	37 200
	M12	1.25	19	105±5	54 400
	M12	1.5	19	105±5	52 800
	M14	1.5	22	175±10	75 400
	M16	1.5	24	265±20	102 000
	M18	2	27	360±20	123 000
	M20	2	30	500±30	153 000
	M22	2	32	675±40	191 000
	M24	2	36	900±50	233 000
	M27	2	41	1 320±70	305 000
	M30	2	46	1 810±100	378 000
	M33	2	50	2 450±150	468 000
	M36	3	55	3 040±150	523 000
	M39	3	60	3 920±200	624 000
	M42	3	65	5 000±300	740 000
	M45	3	70	6 180±300	855 000
	M48	3	75	7 550±400	979 000
	M52	3	80	9 610±500	1 160 000
	M56	3	85	12 300±700	1 380 000
	M60	3	90	14 700±800	1 560 000
	M64	3	95	18 100±1000	1 810 000
	M68	3	100	21 600±1000	2 040 000

[Remarks] 1) The recommended values are applicable to the following bolts.
Hexagon head bolts of JIS strength class 10.9 (bolt holes is JIS class 1)
Non treated (including blackening), grease lubrication (μ = 0.125 to 0.14)

2) The values are also applicable to class 2 bolt holes and reamer bolt holes as well as hexagon socket head cap screws as far as the designation and pitch are identical.

8.5 Shape and Dimensions of Parallel Key and Keyway (JIS B 1301)



Unit: mm

Nominal size of key $b \times h$	Dimension of key: b Basic dimension	b Tolerance (h9)	h Basic dimension	h Tolerance		c	l [1]	Dimension of keyway: Basic dimension of b_1 and b_2	Close grade: b_1 and b_2 Tolerance (P9)	Normal grade: b_1 Tolerance (N9)	Normal grade: b_2 Tolerance (JS9)	r_1 and r_2	Basic dimension of t_1	Basic dimension of t_2	Tolerance of t_1 and t_2	Informative note: Applicable shaft dia. d [2]
2× 2	2	0 −0.025	2	0 −0.025	h9	0.16 ~0.25	6~ 20	2	−0.006 −0.031	−0.004 −0.029	±0.0125	0.08 ~0.16	1.2	1.0	+0.1 0	6~ 8
3× 3	3		3				6~ 36	3					1.8	1.4		8~ 10
4× 4	4	0 −0.030	4	0 −0.030			8~ 45	4	−0.012 −0.042	0 −0.030	±0.0150		2.5	1.8		10~ 12
5× 5	5		5			0.25 ~0.40	10~ 56	5				0.16 ~0.25	3.0	2.3		12~ 17
6× 6	6		6				14~ 70	6					3.5	2.8		17~ 22
(7× 7)	7	0 −0.036	7	0 −0.036			16~ 80	7	−0.015 −0.051	0 −0.036	±0.0180		4.0	3.0	+0.2 0	20~ 25
8× 7	8		7	0 −0.090	h11		18~ 90	8					4.0	3.3		22~ 30
10× 8	10		8			0.40 ~0.60	22~110	10				0.25 ~0.40	5.0	3.3		30~ 38
12× 8	12	0 −0.043	8				28~140	12	−0.018 −0.061	0 −0.043	±0.0215		5.0	3.3		38~ 44
14× 9	14		9				36~160	14					5.5	3.8		44~ 50
(15×10)	15		10				40~180	15					5.0	5.0		50~ 55
16×10	16		10				45~180	16					6.0	4.3		50~ 58
18×11	18		11	0 −0.110			50~200	18					7.0	4.4		58~ 65
20×12	20	0 −0.052	12			0.60 ~0.80	56~220	20	−0.022 −0.074	0 −0.052	±0.0260	0.40 ~0.60	7.5	4.9		65~ 75
22×14	22		14				63~250	22					9.0	5.4		75~ 85
(24×16)	24		16				70~280	24					8.0	8.0		80~ 90
25×14	25		14				70~280	25					9.0	5.4		85~ 95
28×16	28		16				80~320	28					10.0	6.4		95~110
32×18	32	0 −0.062	18				99~360	32	−0.026 −0.088	0 −0.062	±0.0310		11.0	7.4		110~130
(35×22)	35		22	0 −0.130		1.00 ~1.20	100~400	35				0.70 ~1.00	11.0	11.0	+0.3 0	125~140
36×20	36		20				—	36					12.0	8.4		130~150
(38×24)	38		24				—	38					12.0	12.0		140~160
40×22	40		22				—	40					13.0	9.4		150~170
(42×26)	42		26				—	42					13.0	13.0		160~180
45×25	45		25				—	45					15.0	10.4		170~200
50×28	50		28				—	50					17.0	11.4		200~230
56×32	56	0 −0.074	32	0 −0.160		1.60 ~2.00	—	56	−0.032 −0.106	0 −0.074	±0.0370	1.20 ~1.60	20.0	12.4		230~260
63×32	63		32				—	63					20.0	12.4		260~290
70×36	70		36				—	70					22.0	14.4		290~330
80×40	80		40			2.50 ~3.00	—	80				2.00 ~2.50	25.0	15.4		330~380
90×45	90	0 −0.087	45				—	90	−0.037 −0.124	0 −0.087	±0.0435		28.0	17.4		380~440
100×50	100		50				—	100					31.0	19.5		440~500

[Notes] 1) Dimension l shall be selected among the following within the range given in Table.
The dimensional tolerance on l shall be generally h12 in JIS B0401.
6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 70, 80, 90, 100, 110, 125, 140, 160, 180, 200, 220, 250, 280, 320, 360, 400

2) The applicable shaft diameter is appropriate to the torque corresponding to the strength of the key.

[Remark] The nominal sizes given in parentheses should be avoided from use, as possible.

[Reference] Where the key of the smaller tolerance than that specified in this standard is needed, the tolerance on width b of the key shall be h7. In this case, the tolerance on height h shall be h7 for the key 7× 7 or less in nominal size and h11 for the key of 8 × 7 or more.

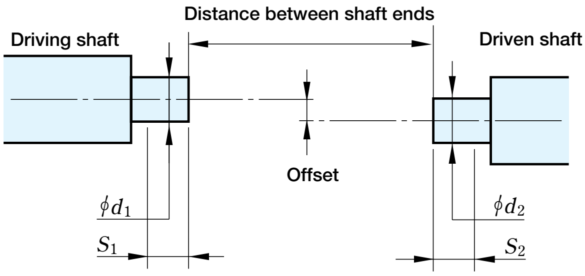
9. Drive Shaft Selection Sheets

(1) Drive Shafts for Ironmaking Machines and Rolling Mills

Item	Necessity	Description	Remarks
Name of the machine			
Location of installation			
① Rated motor output (kW)	○		
② Motor speed (min^{-1})	○	Min. Max.	
③ Reduction ratio	○		
Drive shaft			
④ Number of drive shafts per motor	○		
⑤ Torque transmission (kN·m)	○	Normal Normal max. Emergency max.	
⑥ Rotational speed (min^{-1})	○	Min. Max.	Unnecessary if ② and ③ are filled in.
⑦ Direction(s) of rotation (Circle one of the two listed on the right.)	○	Non reversing Reversing	
⑧ Limit swing dia. (mm)	△		
⑨ Required stroke (mm)	○		
⑩ Pinion PCD (mm)	△		Enter when the shaft is used for reduction rolls as an example.
⑪ Roll minimum dia. (mm)	△		
⑫ Paint color	△		Black if not specified
⑬ Ambient temperature (℃)	△		
⑭ Special environmental conditions	△		Water, steam, etc.

⑮ Installation dimensions (Must be filled out.)

○: Must be filled in.
△: Should be filled in as appropriate.



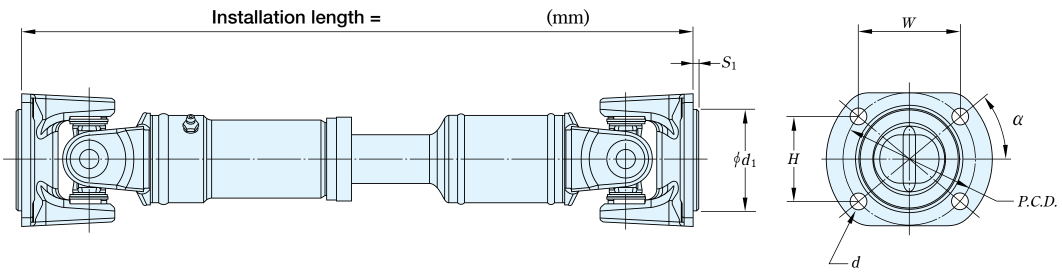
Distance between shaft ends (mm)		
Offset		
	Horizontal (mm)	
	Vertical (mm)	
Fit		
Driving shaft	ϕd_1 (mm)	
	S_1 (mm)	
Driven shaft	ϕd_2 (mm)	
	S_2 (mm)	

(2) Drive Shafts for Construction Machines

Item	Necessity	Description	Remarks
Name of the machine			
Location of installation			
① Engine torque (kN·m/ min^{-1})	△	Max.	
② Engine speed (min^{-1})	△	Normal Max.	
③ Reduction ratio (for multiple-ratio transmission, fill out table ⑮.)	△		
Drive shaft			
④ Series or function	○		
⑤ Torque transmission (kN·m)	○	Normal Max. Emergency max.	
⑥ Rotational speed (min^{-1})	○	Normal Max.	
⑦ Operating angle (°)	○	Normal Max.	
⑧ Limit swing dia. (mm)	○		
⑨ Required stroke (mm)	○		
⑩ Paint color	△		Black if not otherwise specified
⑪ Ambient temperature (℃)	△		
⑫ Special environmental conditions	△		
⑬ Service life requirement (h)	○		

⑭ Installation dimensions (Must be filled out.)

○: Must be filled in.
△: Should be filled in as appropriate.



⑮ Operating conditions

Speed	1	2	3	4	5	6	R
Reduction ratio							
Percentage of use (%)							
Ave. speed (min^{-1})							

For HW Series products, the below dimensions do not need to be filled in.

Fit	d_1 (mm)	
	S_1 (mm)	
Bolt holes	d (mm)	
	P.C.D. (mm)	
	W (mm)	
	H (mm)	
	α (mm)	

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