KLEIN Propeller Shafts Germany — KLEIN Propeller Shafts Germany — KLEIN Propeller Shafts Germany -

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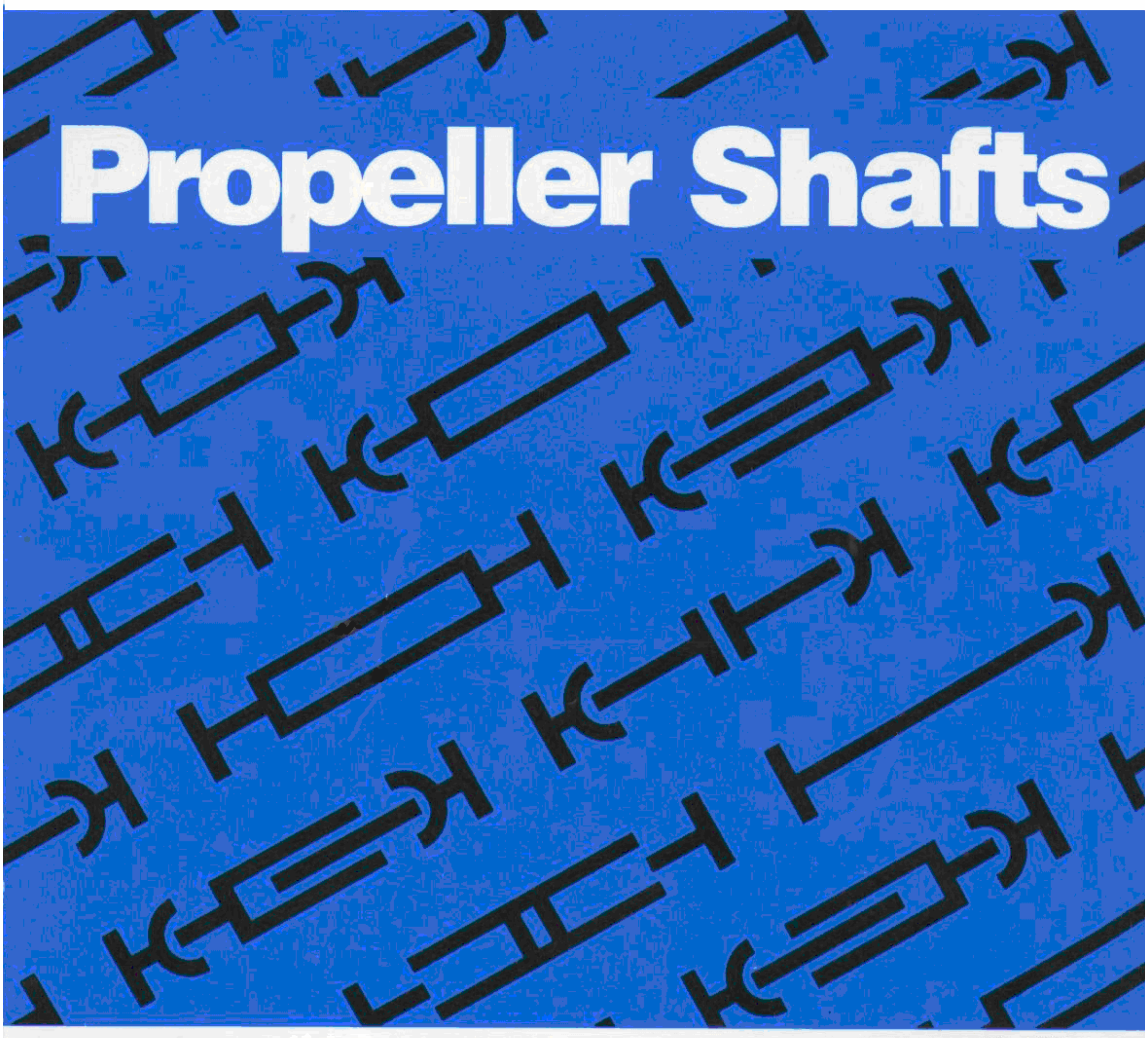


Propeller Shafts

5th. edition

We develop, test and build the latest high performance propeller shafts in two factories in Esslingen.

Our product range now contains hundreds of different designs technically perfected for many applications.

This catalogue shows our latest developments which have been improved further over the previous series.

These new propeller shafts are both lighter and cheaper for the same transferrable torque. In some cases the useful life has been extended. All technical features of the previously best designs have been retained: roller bearings and multilip seals on the joint bearings and sliders for longer life, flat face plates in the joint bearings and plastic coating on the sliders for less friction.

These shafts thus represent the latest state of technical development in this field.

Reliable production processes and a quality management system to DIN EN ISO 9001 ensure that each individual propeller shaft is perfect.

We would be pleased to help in the selection of shafts. Contact us and take advantage of our wide experience; we will do everything possible to meet your requirements.

Contents

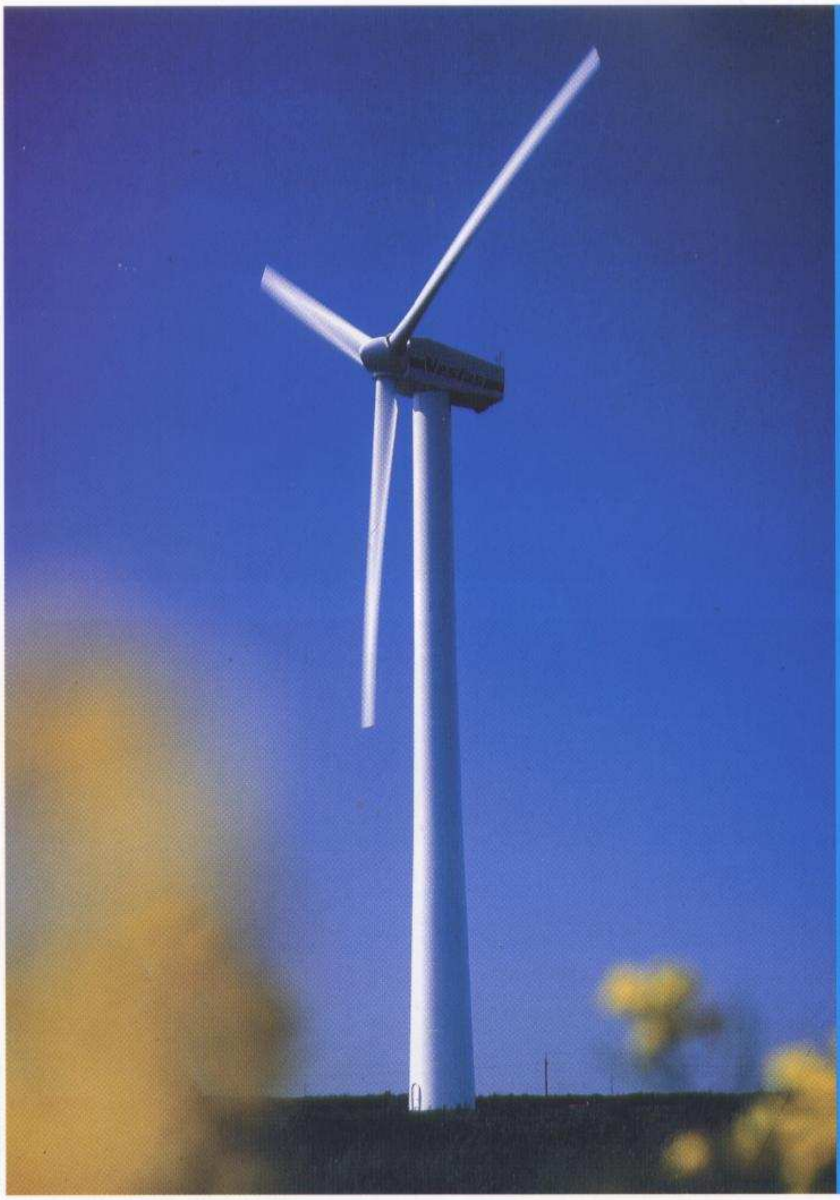

3538


AT740C


COACH OF THE YEAR
1994
Lions Star
MAN
M AN 9723

KLEIN
Propeller Shafts

proven on international roads and unequalled on site.


Vestas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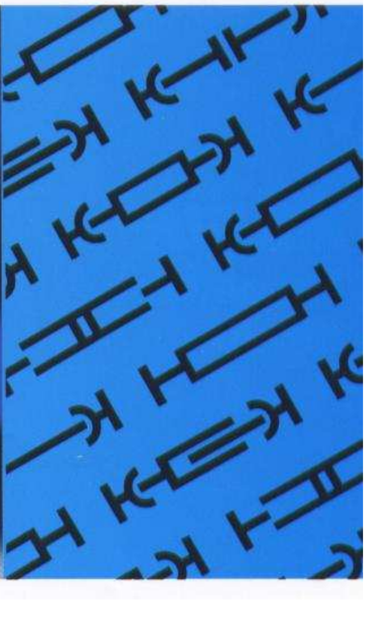

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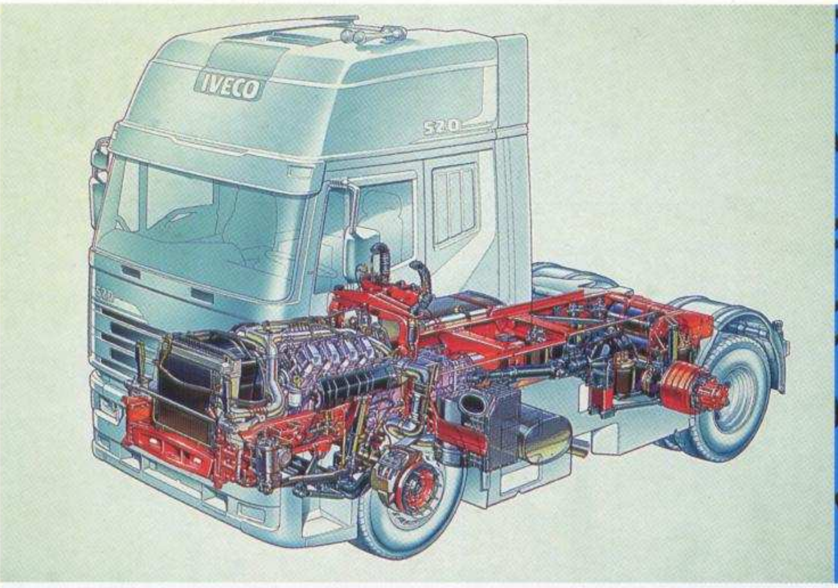
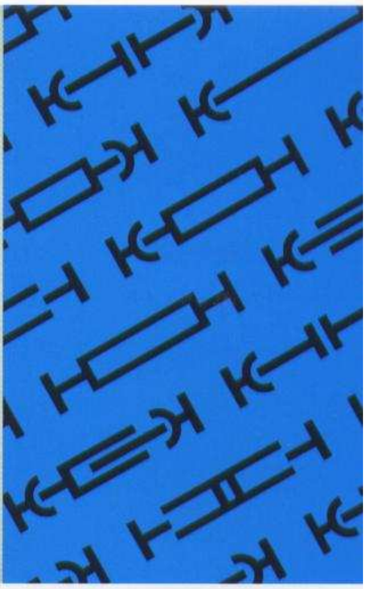
Propeller Shafts

powerful and reliable in special applications.


IVECO
520




IVECO
EuroStar
IVECO
K-ML 508


PIRELLI
competizioni
PIRELLI
competizioni
PIRELLI
MAN
M-RD 134

Product Range

Double flanged joint assemblies

KLEIN

Double flanged joint assemblies

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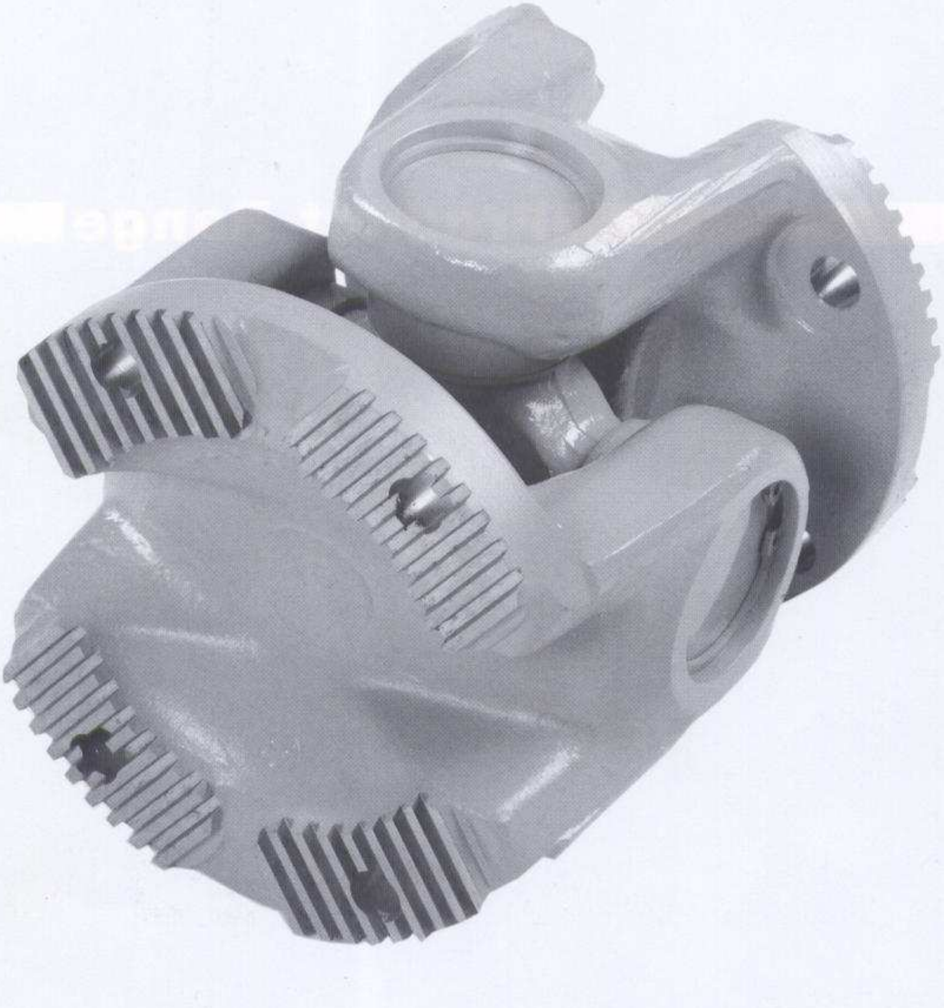

Internet: http//klein-gelenkwellen.de

KLEIN

Double flanged joint assemblies

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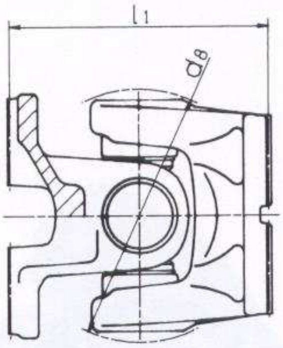

Function torque capacity M_{FG}	**Nm**	**2700**	**5500**	**5500**	**6000**	**10200**	**10200**	**11550**
Type and size		**001 200**	**001 195**	**001 196**	**001 253**	**001 375**	**001 376**	**001 411**
Swing-∅ d_8	mm	104	125	125	125	138	138	156
Max. deflection angle ß	degree	15°	35°	35°	35°	35°	35°	35°
Joint lenght l_1	mm	96	150	150	150	172	172	190
Joint load rating T	Nm	1110	1460	1460	1675	2260	2260	3040
Weight G	kg	4,0	3,0	3,8	5,0	9,0	9,4	11,4
Mass moment of inertia J_m	kgm^2	0,0062	0,0066	0,0068	0,0081	0,0211	0,0235	0,0282

For flange types see tables on pages 61-69.

KLEIN

Double flanged joint assemblies

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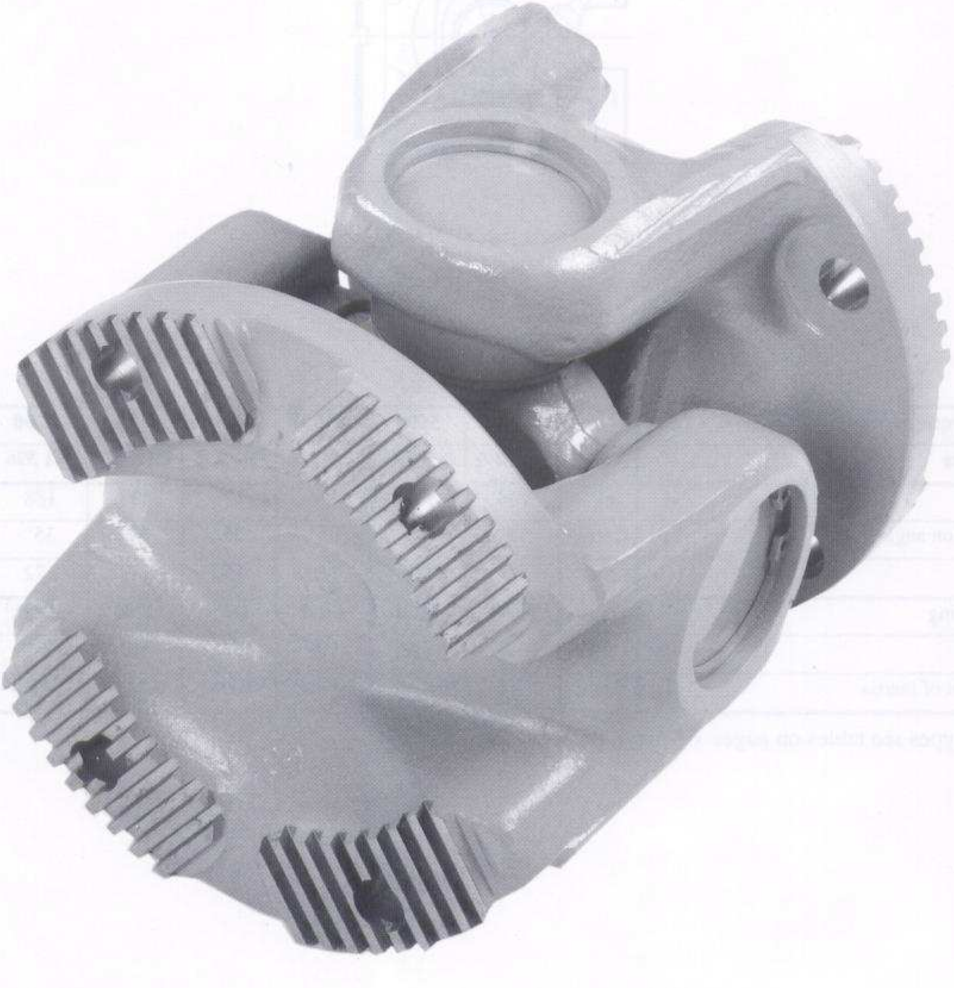
Type 001



Double flanged joint assemblies

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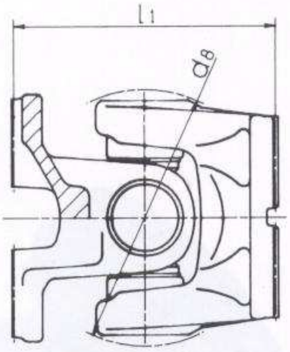

Function torque capacity	M_{FG}	Nm	**14000**	**14000**	**15000**	**17000**	**17000**	**20250**	**24750**
Type and size			**001 490**	**001 490**	**001 491**	**001 590**	**001 590**	**001 600**	**001 610**
Swing-∅	d_8	mm	158	158	156	172	172	168	168
Max. deflection angle	ß	degree	25°	44°	35°	25°	44°	35°	35°
Joint lenght	l_1	mm	164	204	190	170	216	200	200
Joint load rating	T	Nm	2800	2800	3040	3490	3490	4120	4120
Weight	G	kg	10,3.	12,0	13,5	13,5	15,3	14,2	20,0
Mass moment of inertia	J_m	kgm^2	0,0300	0,0349	0,0493	0,0537	0,0442	0,0657	0,1007

For flange types see tables on pages 61-69.

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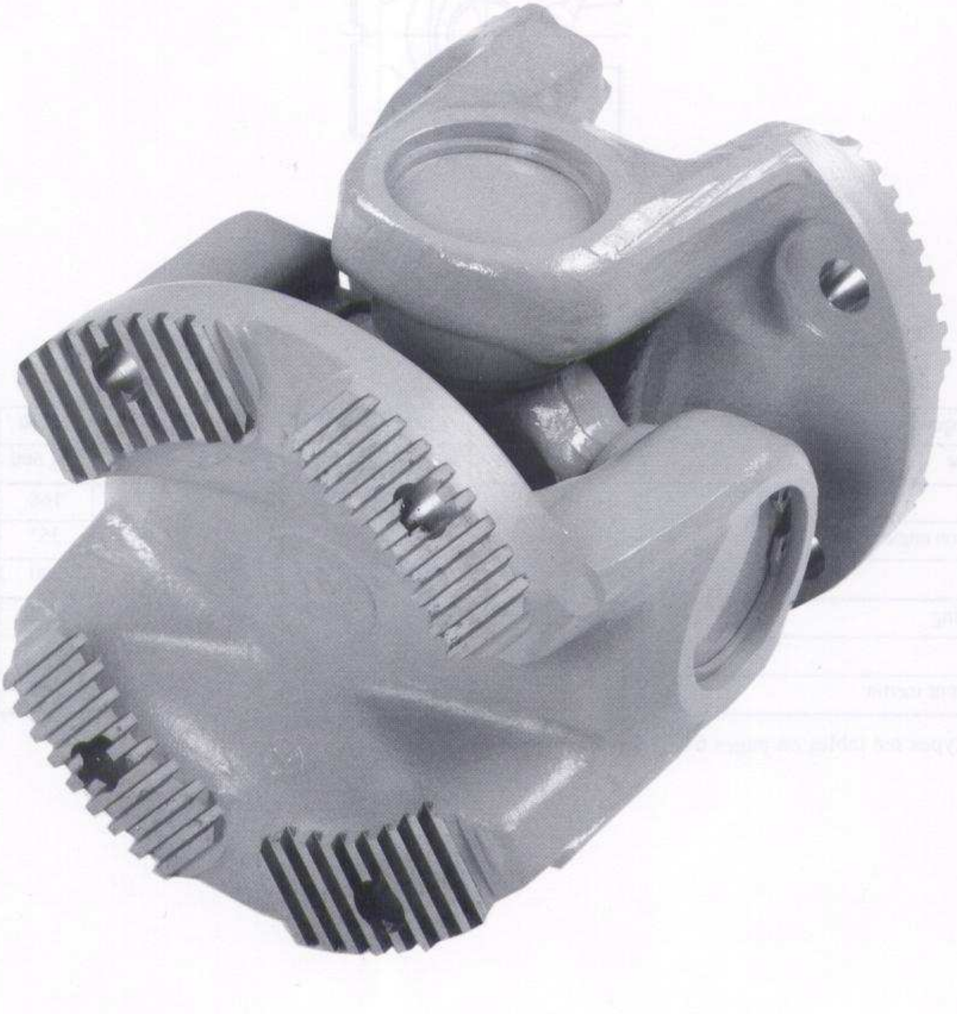
Double flanged joint assemblies

Data sheet
Type 001



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Double flanged joint assemblies

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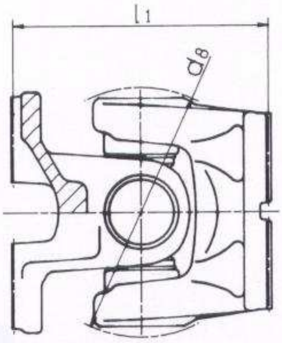

Function torque capacity	M_{FG}	**Nm**	**25000**	**30000**	**35000**	**45000**			
Type and size			**001 620**	**001 680**	**001 700**	**001 710**			
Swing-∅	d_8	mm	178	196	200	200			
Max. deflection angle	ß	degree	25°	28°	28°	30°			
Joint lenght	l_1	mm	184	200	200	200			
Joint load rating	T	Nm	4435	5100	6850	6850			
Weight	G	kg	14,9	17,8	20,8	24,0			
Mass moment of inertia	J_m	kgm^2	0,0529	0,0706	0,0836	0,1243			

For flange types see tables on pages 61-69.

Fixed length propeller shafts

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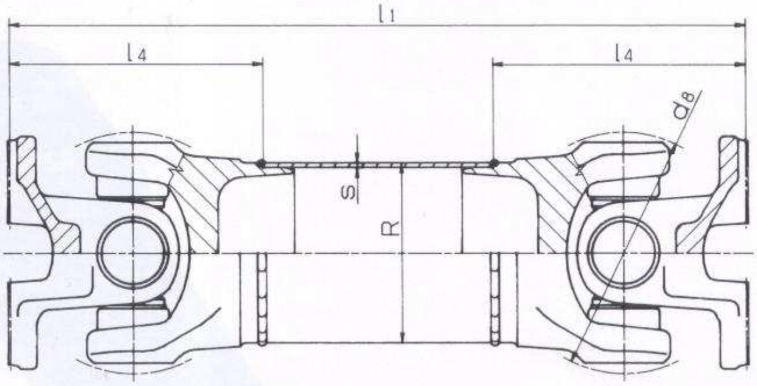
Fixed length propeller shafts

Data sheet
Type 008



Function torque capacity	M_{FG}	Nm	2700	5500	5500	6000	10200	10200	11550
Type and size			**008 200**	**008 195**	**008 196**	**008 253**	**008 375**	**008 376**	**008 411**
Swing-∅	d_8	mm	125	125	104	125	138	138	156
Tube-∅	RxS	mm	52 x4	98 x 2	98 x 2	80 x 3,5	85 x 5	85 x 5	88 x 4,5
Max. deflection angle	ß	degree	15°	35°	35°	35°	35°	35°	35°
Min. length	l_1	mm	300	405	405	420	440	440	470
Fixed joint length	l_4	mm	118	170	170	159	171	171	184
Joint load rating	T	Nm	1110	1460	1460	1675	2260	2260	3040
Weight at l_1 = 1000 mm	G	kg	9,9	13,5	12,5	15,5	22,1	23,5	27,3
Weight of 100 mm tube	G_R	kg	0,473	0,4735	0,4735	0,660	0,987	0,987	0,927
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,0202	0,0239	0,0243	0,0236	0,0420	0,0448	0,0622
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,00027	0,00109	0,00109	0,00097	0,00158	0,00158	0,00162

For flange types see tables on pages 61-69.

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Fixed length propeller shafts

Data sheet
Type 008

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Fixed length propeller shafts

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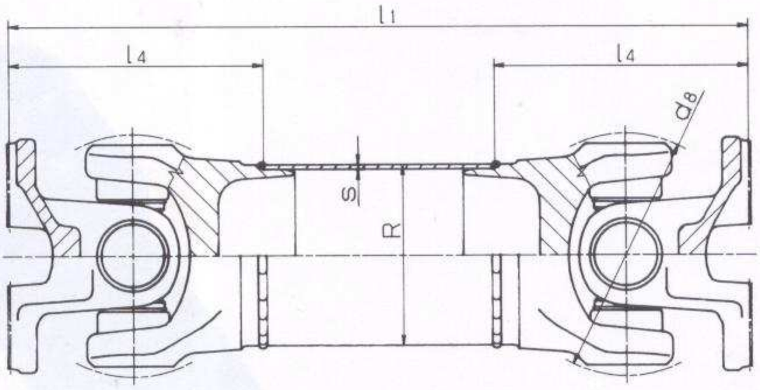

Function torque capacity	M_{FG}	Nm	14000	14000	15000	17000	17000	20250	24750
Type and size			**008 490**	**008 490**	**008 491**	**008 590**	**008 590**	**008 600**	**008 610**
Swing-∅	d_8	mm	158	158	156	172	172	168	168
Tube-∅	RxS	mm	120x3	100x4,5	90x5,5	120X4	120x4	100x6	100x6
Max. deflection angle	ß	degree	25°	44°	35°	25°	44°	35°	35°
Min. length	l_1	mm	387	454	470	430	498	500	500
Fixed joint length	l_4	mm	169	202	184	182	216	203	203
Joint load rating	T	Nm	2800	2800	3040	3490	3490	4120	4120
Weight at $l_1 = 1000$ mm	G	kg	25,7	27,9	31,0	30,3	32,5	35,7	43,9
Weight of 100 mm tube	G_R	kg	0,865	1,060	1,146	1,144	1,144	1,391	1,391
Mass moment of inertia at $l_1 = 1000$ mm	J_m	kgm^2	0,0759	0,0758	0.0844	0,1075	0,1242	0,1127	0,1555
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,0029	0,00242	0,00205	0,0038	0,0038	0,00308	0,00308

For flange types see tables on pages 61-69.

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Fixed length propeller shafts

Data sheet
Type 008

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Fixed length propeller shafts

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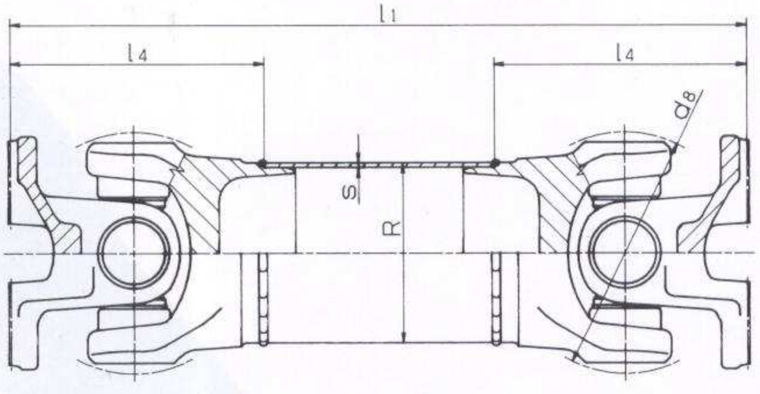
Type 008



Function torque capacity	M_{FG}	Nm	25000	30000	35000	45000			
Type and size			**008 620**	**008 680**	**008 700**	**008 710**			
Swing-∅	d_8	mm	178	204	204	204			
Tube-∅	RxS	mm	120x6	140x5	140x5	140x5			
Max. deflection angle	ß	degree	25°	28°	28°	30°			
Min. length	l_1	mm	433	550	550	550			
Fixed joint length	l_4	mm	192	220	225	225			
Joint load rating	T	Nm	4435	5100	6810	6810			
Weight at l_1 = 1000 mm	G	kg	40,4	39,3	54,4	57,5			
Weight of 100 mm tube	G_R	kg	1,687	1,665	1,665	1,665			
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,1310	0,1649	0,1796	0,2604			
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,0054	0,0076	0,0076	0,0076			

For flange types see tables on pages 61-69.

Coupling shafts

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Coupling shafts

Data sheet
Type 026

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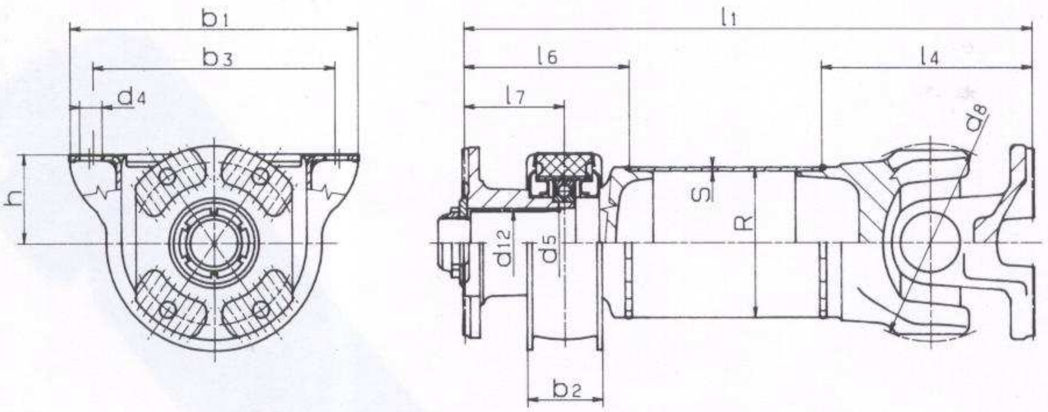
Coupling shafts

Data sheet
Type 026



Function torque capacity	M_{FG}	Nm	6000	10200	10200	14000	15000	17000	20250
Type and size			**026 253**	**026 375**	**026 376**	**026 490**	**026 491**	**026 590**	**026 600**
Swing-∅	d_8	mm	125	138	138	158	156	172	168
Tube-∅	RxS	mm	80x3,5	85x5	85 x 5	120 x 3	90x5,5	120 x 4	100x6
Max. deflection angle	ß	degree	35°	35°	35°	25°	35°	25°	35°
Min. length	l_1	mm	390	410	410	400	425	415	460
Fixed joint length	l_4	mm	159	171	171	169	184	182	203
Fixed centre bearing assembly length	l_6	mm	130	141	141	132	141	132	157
Coupling flange to bearing	l_7	mm	85	95	95	80	95	80	100
Bearing internal-∅	d_5	mm	45	55	65	65	55	65	60
Hight	h	mm	71,5	71,5	71,5	71,5	71,5	71,5	80
Housing length	b_1	mm	230	230	230	230	230	230	255
Housing width	b_2	mm	57	57	60	60	57	60	60
Bolt hole-∅	d_4	mm	15	15	15	15	15	15	15
Bolt hole centres	b_3	mm	200	200	200	193,5	200	200	200
Spline DIN 5480	d_{12}	mm	45x2,5	55x2,5	55x2,5	55x2,5	55x2,5	55x2,5	60x2,5
Joint load rating	T	Nm	1675	2260	2260	2800	3040	3490	4120
Weight at l_1 = 1000 mm	G	kg	13,8	18,8	24,0	26,0	250	32,0	25,0
Weight of 100 mm tube	G_R	kg	1,660	0,987	0,987	0,865	1,146	1,144	1,391
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,0165	0,0281	0,0472	0,0706	0,0405	0,0949	0,11
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,00097	0,00158	0,00158	0,0029	0,00205	0,0038	0,00308

For flange types see tables on pages 61 - 69 for fixed joints and pages 73 -75 for centre bearing assemblies.

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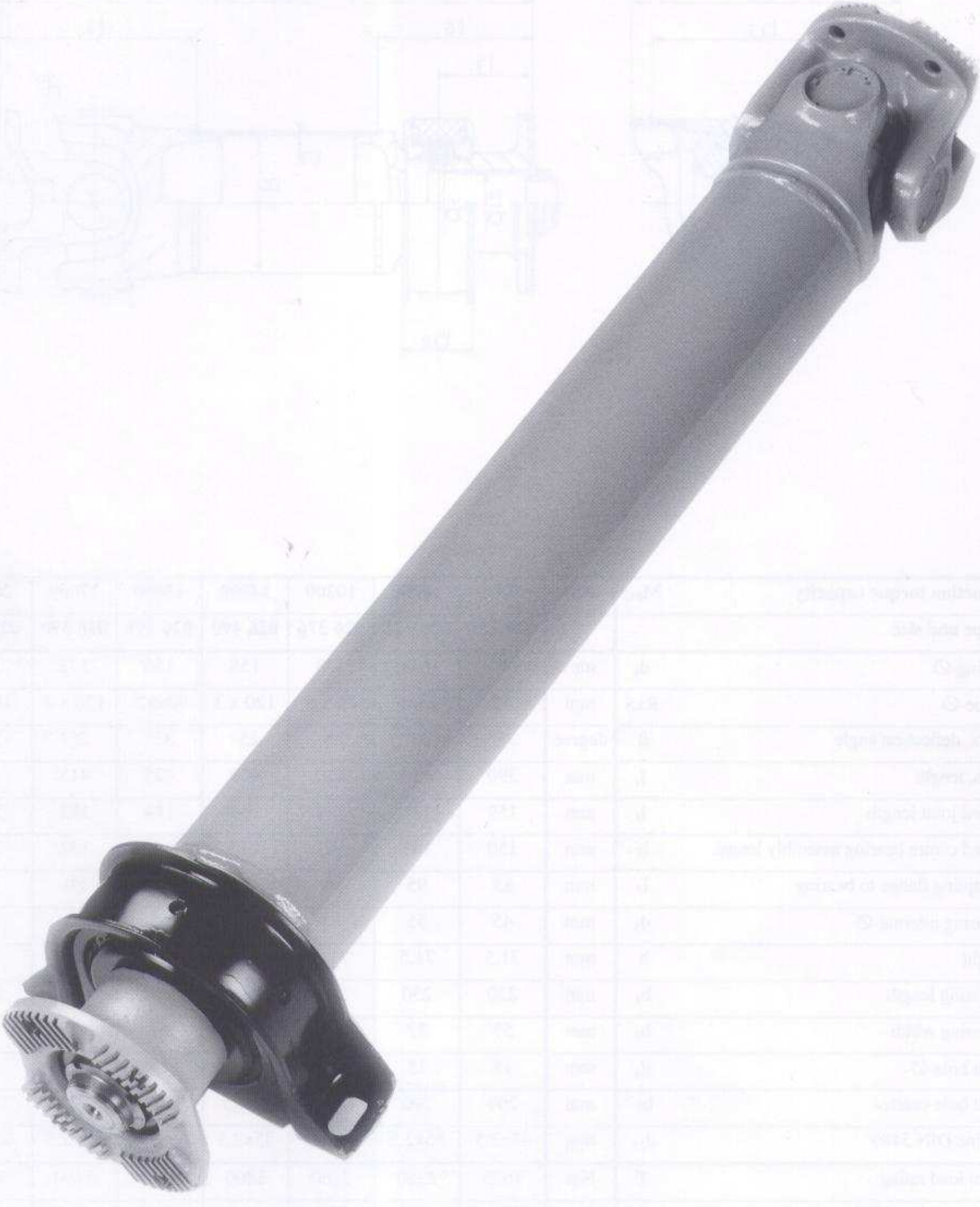
Coupling shafts

Data sheet
Type 026



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Coupling shafts

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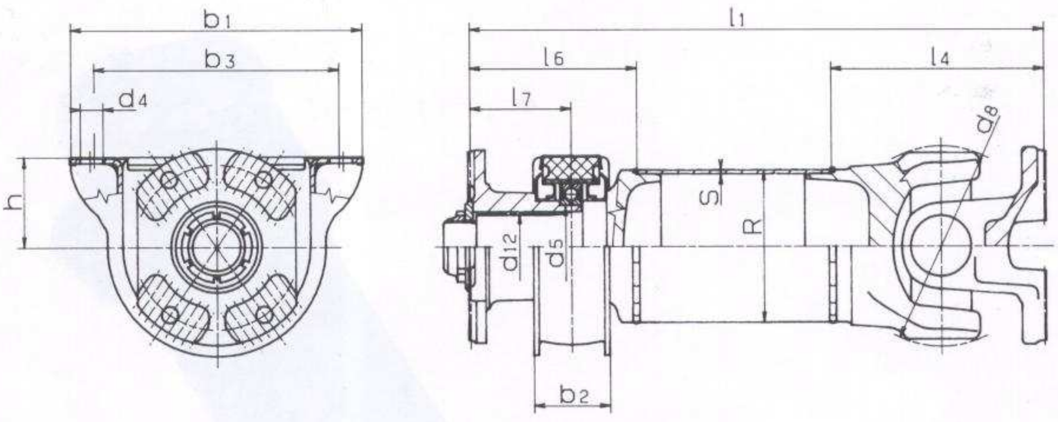

Function torque capacity	M_{FG}	**Nm**	**25000**	**30000**	**35000**				
Type and size			**026 620**	**026 680**	**026 700**				
Swing-∅	d_8	mm	178	204	204				
Tube-∅	RxS	mm	120 x 6	140 x 5	140 x 5				
Max. deflection angle	ß	degree	25°	28°	28°				
Min. length	l_1	mm	475	475	500				
Fixed joint length	l_4	mm	192	220	225				
Fixed centre bearing assembly length	l_6	mm	182	165	181				
Coupling flange to bearing	l_7	mm	107	107	107				
Bearing internal-∅	d_5	mm	75	60	70				
Hight	h	mm	85,5	88	88				
Housing length	b_1	mm	255	255	255				
Housing width	b_2	mm	60	65	65				
Bolt hole-∅	d_4	mm	15	15	15				
Bolt hole centres	b_3	mm	220	220	220				
Spline DIN 5480	d_{12}	mm	60x2,5	60x2,5	70x2,5				
Joint load rating	T	Nm	4435	5100	6850				
Weight at l_1 = 1000 mm	G	kg	40,4	44,1	52,3				
Weight of 100 mm tube	G_R	kg	1,687	1,665	1,665				
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,1214	0,1718	0,1879				
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,0054	0,0076	0,0076				

For flange types see tables on pages 61 - 69 for fixed joints and pages 73 -75 for centre bearing assemblies.

Propeller shafts

with length extension, with tube

KLEIN

Propeller shafts *with lenght extension*

Data sheet
Type 052

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Propeller shafts *with lenght extension*

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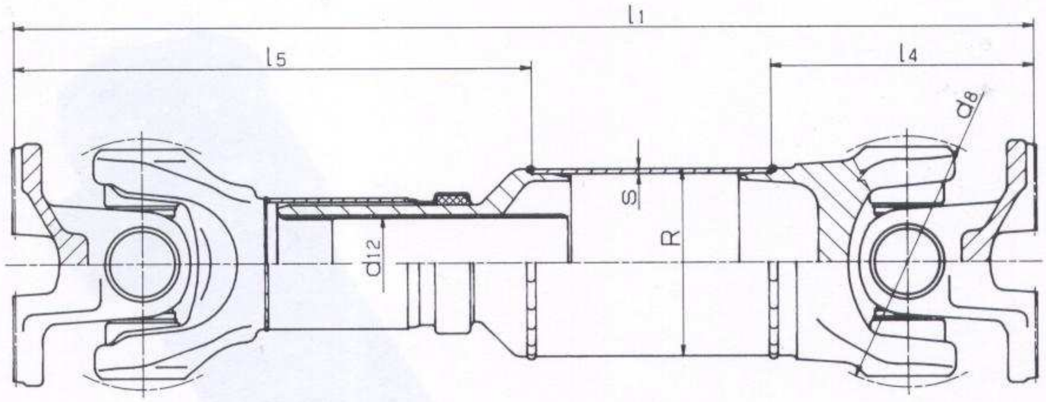
Type 052



Function torque capacity	M_{FG}	Nm	2700	5500	5500	6000	10200	10200	11500
Type and size			**052 200**	**052 195**	**052 196**	**052 253**	**052 375**	**052 376**	**052 411**
Swing-∅	d_8	mm	104	125	125	125	138	138	156
Tube-∅	RxS	mm	52x4	98x2	98x2	80x3,5	85x5	85x5	88x4,5
Max. deflection angle	ß	degree	15°	35°	35°	35°	35°	35°	35°
Min. length	l_1	mm	450	680	680	630	670	670	700
Extension length	l_2	mm	90	110	110	110	110	110	110
Fixed joint length	l_4	mm	118	170	170	159	171	171	184
Sliding joint length	l_5	mm	285	445	445	374	398	398	420
Slip spline DIN 5480	d_{12}	mm	38x2	90x2,5	90x2,5	52x2,5	55x2,5	55x2,5	65x2,5
Joint load rating	T	Nm	1100	1460	1460	1675	2260	2260	3040
Weight at l_1 = 1000 mm	G	kg	11,8	15,3	17,2	20,2	28,1	28,7	37,3
Weight of 100 mm tube	G_R	kg	0,473	0,4735	0,4735	0,660	0,987	0,987	0,927
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,0083	0,0257	0,0297	0,0264	0,0442	0,0474	0,0754
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,00027	0,00109	0,00109	0,00097	0,00158	0,00158	0,00162

For flange types see tables on pages 61-69.

KLEIN

Propeller shafts *with lenght extension*

Data sheet
Type 052

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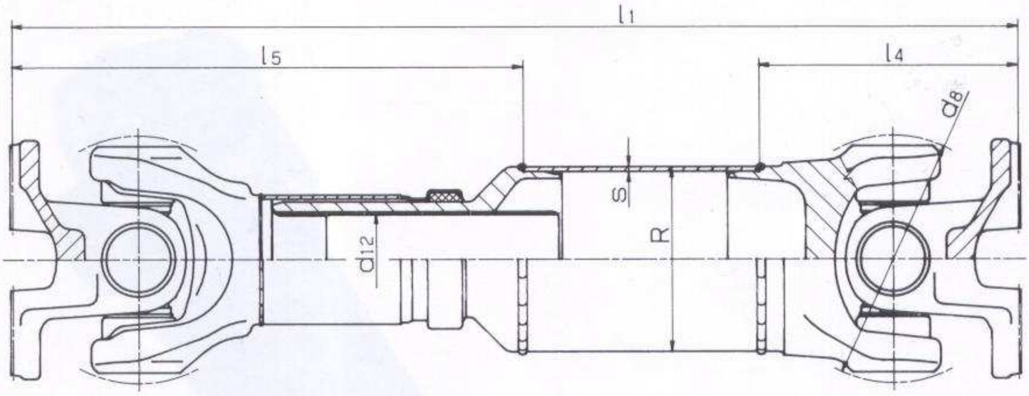
Propeller shafts *with lenght extension*

Data sheet
Type 052



Function torque capacity	M_{FG}	Nm	14000	14000	15000	17000	17000	20250	24750
Type and size			**052 490**	**052 490**	**052 491**	**052 590**	**052 590**	**052 600**	**052 610**
Swing-∅	d_8	mm	158	158	156	172	172	168	168
Tube-∅	RxS	mm	120x3	100x4,5	90x5,5	120x4	120x4	100x6	100x6
Max. deflection angle	ß	degree	25°	44°	35°	25°	44°	35°	35°
Min. length	l_1	mm	550	716	700	600	716	750	750
Extension length	l_2	mm	110	180	110	110	180	110	110
Fixed joint length	l_4	mm	169	202	184	182	216	203	203
Sliding joint length	l_5	mm	332	466	420	352	434	450	450
Slip spline DIN 5480	d_{12}	mm	62x2	62x2	65x2,5	95x2	95x2	75x2,5	75x2,5
Joint load rating	T	Nm	2800	2800	3040	3490	3490	4120	4120
Weight at l_1 = 1000 mm	G	kg	30,3	35,5	40,4	35,8	43,6	50,7	58,2
Weight of 100 mm tube	G_R	kg	0,865	1,060	1,146	1,144	1,144	1,391	1,391
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,0720	0,0774	0,0930	0,1115	0,1290	0,0976	0,0976
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,0029	0,00242	0,00205	0,0038	0,0038	0,00308	0,00308

For flange types see tables on pages 61-69.

KLEIN

Propeller shafts *with lenght extension*

Data sheet
Type 052

KLEIN

Propeller shafts *with lenght extension*

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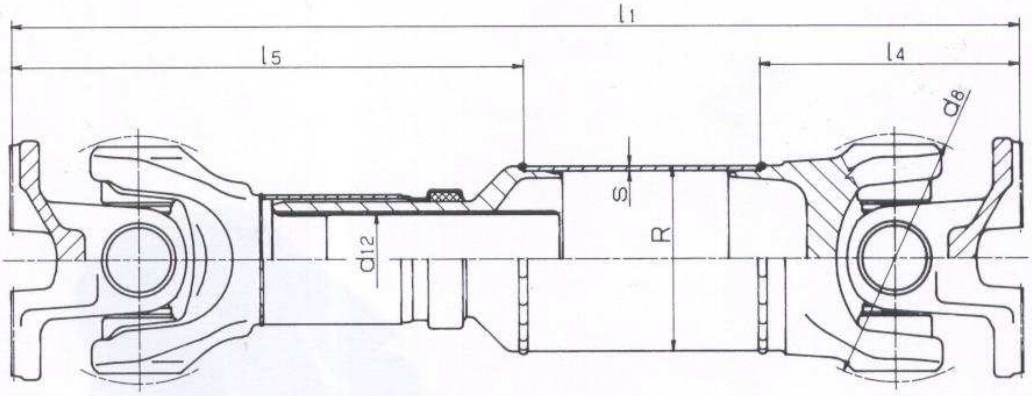
Type 052



Function torque capacity	M_{FG}	Nm	**25000**	**30000**	**35000**	**45000**			
Type and size			**052 620**	**052 680**	**052 700**	**052 710**			
Swing-∅	d_8	mm	178	196	204	204			
Tube-∅	RxS	mm	120x6	140x5	140x5	140x5			
Max. deflection angle	ß	degree	25°	28°	28°	30°			
Min. length	l_1	mm	620	650	800	850			
Extension length	l_2	mm	110	110	150	150			
Fixed joint length	l_4	mm	192	220	225	225			
Sliding joint length	l_5	mm	379	465	525	525			
Slip spline DIN 5480	d_{12}	mm	95x2	75x2,5	90x2,5	90x2,5			
Joint load rating	T	Nm	4435	5100	6850	6850			
Weight at l_1 = 1000 mm	G	kg	45,7	60,2	69,9	77,5			
Weight of 100 mm tube	G_R	kg	1,687	1,665	1,665	1,665			
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,1346	0,1688	0,2239	0,2791			
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,0054	0,0076	0,0076	0,0076			

For flange types see tables on pages 61-69.

Short couple shafts

KLEIN

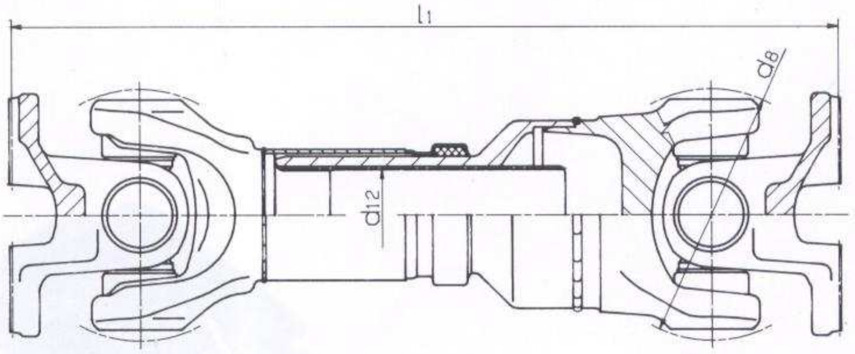
Short couple shafts

Data sheet
Type 055

KLEIN

Short couple shafts

Data sheet
Type 055



Function torque capacity	M_{FG}	Nm	2700	6000	10200	10200	11550	14000	14000
Type and size			**055 200**	**055 253**	**055 375**	**055 376**	**055 411**	**055 490**	**055 490**
Swing-∅	d_8	mm	104	125	138	138	156	158	158
Max. deflection angle	ß	degree	15°	35°	35°	35°	35°	25°	44°
Min. length	l_1	mm	360	440	490	490	505	453	560
Max. length	l_1	mm	410	534	578	578	615	524	680
Min. extension length	l_2	mm	30	40	40	40	40	40	180
Max. extension length	l_2	mm	90	110	110	110	110	110	45
Slip spline DIN 5480	d_{12}	mm	38x2	52x2,5	55x2,5	55x2,5	65x2,5	62x2	62x2
Joint load rating	T	Nm	1110	1675	2260	2260	3040	2800	2800
Weight at max. length l_1	G	kg	12,5	17,1	23,8	24,6	33,6	26,0	34,0
Mass moment of inertia at max. length l_1	J_m	kgm^2	0,0020	0,0219	0,2791	0,0406	0,0690	0,0576	0,0694

For flange types see tables on pages 61- 69.

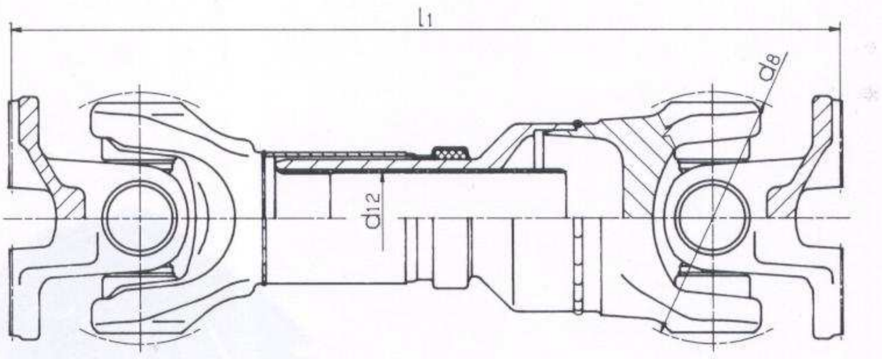
KLEIN

Short couple shafts

Data sheet
Type 055

Short couple shafts

Data sheet
Type 055



Function torque capacity	M_{FG}	Nm	15000	17000	17000	20250	24750	25000	30000
Type and size			**055 491**	**055 590**	**055 590**	**055 600**	**055 610**	**055 620**	**055 680**
Swing-∅	d_8	mm	156	158	158	168	168	178	196
Max. deflection angle	ß	degree	35°	25°	44°	35°	35°	25°	28°
Min. length	l_1	mm	505	516	580	570	570	553	540
Max. length	l_1	mm	615	620	700	660	660	657	700
Min. extension length	l_2	mm	40	50	50	40	40	50	60
Max. extension length	l_2	mm	110	110	180	110	110	110	140
Slip spline DIN 5480	d_{12}	mm	55x2,5	95x2,5	95x2,5	75x2,5	75x2,5	95x2	75x2,5
Joint load rating	T	Nm	3040	3490	3490	4120	4120	4435	5100
Weight at max. length l_1	G	kg	35	30,5	40,0	45,8	51,6	38,5	55,0
Mass moment of inertia at max. length l_1	J_m	kgm^2	0,0849	0,0943	0,1170	0,0990	0,1340	0,1115	0,1441

For flange types see tables on pages 61-69.

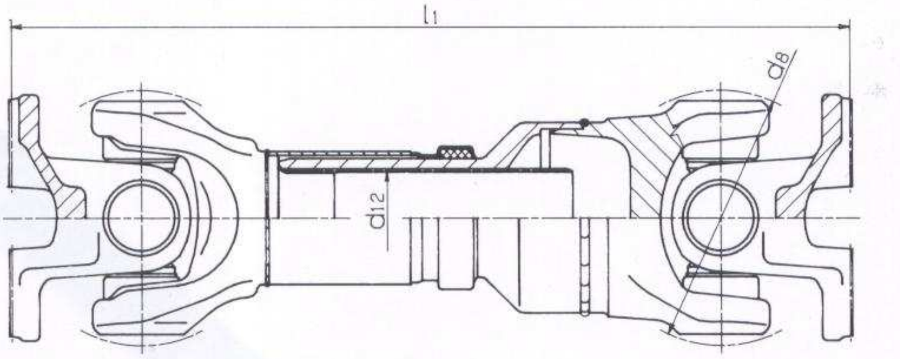
KLEIN

Short couple shafts

Data sheet
Type 055

Short couple shafts

Data sheet
Type 055



Function torque capacity	M_{FG}	Nm	35000	45000					
Type and size			**055 700**	**055 710**					
Swing-∅	d_8	mm	204	204					
Max. deflection angle	ß	Grad	28°	30°					
Min. length	l_1	mm	595	590					
Max. length	l_1	mm	665	695					
Min. extension length	l_2	mm	60	60					
Max. extension length	l_2	mm	140	140					
Slip spline DIN 5480	d_{12}	mm	90x2,5	90x2,5					
Joint load rating	T	Nm	6850	6850					
Weight at max. length l_1	G	kg	71,6	71,5					
Mass moment of inertia at max. length l_1	J_m	kgm^2	0,2049	0,2597					

For flange types see tables on pages 61-69.

Double jointed shafts for driven steering axles

KLEIN	*Double jointed shafts*	Data sheet Type 071

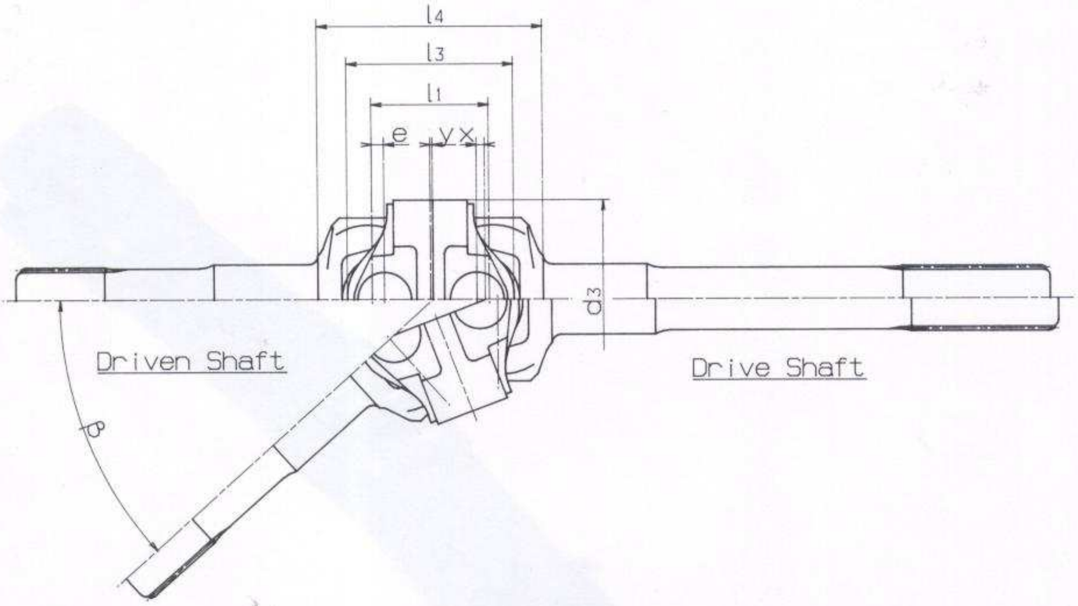
Internet: http//klein-gelenkwellen.de

Eugen Klein GmbH, D-73734 Esslingen, Parkstraße 27-29, Tel. + 49 711/3 80 05-12, Fax + 49 711/3 80 05-49

KLEIN

Double jointed shafts

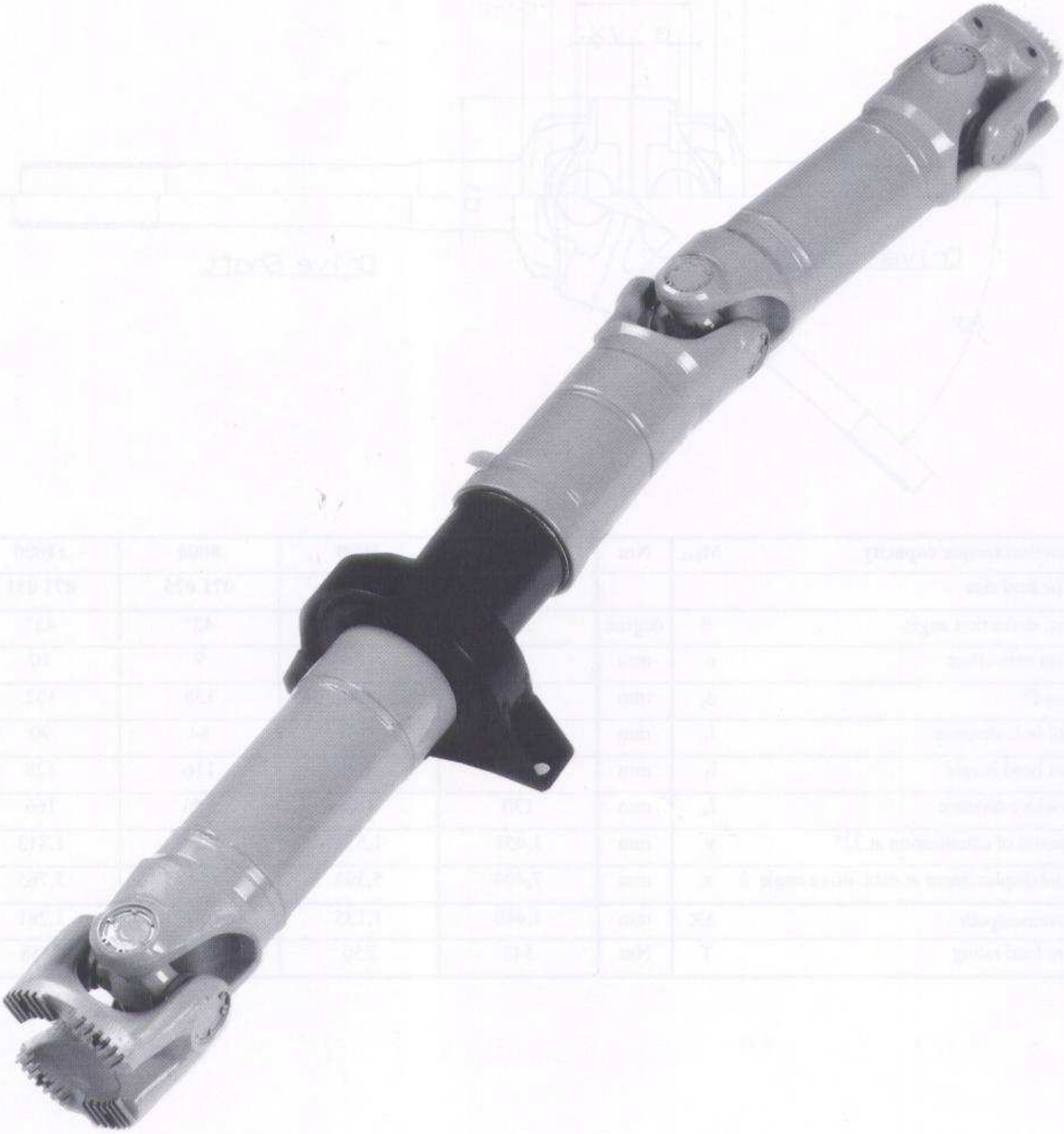
Data sheet
Type 071



Function torque capacity	M_{FG}	Nm	4000	6000	8000	11000
Type and size			071 019	071 023	071 025	071 031
Max. deflection angle	ß	degree	50°	42°	42°	42°
Cross axis offset	e	mm	7	8	9	10
Joint-∅	d_3	mm	112	128	138	152
Fork hole distance	l_1	mm	72	76	84	90
Fork head height	l_3	mm	101	108	116	128
Shoulder distance	l_4	mm	130	144	156	166
Amount of equalisation at 32°	y	mm	1,451	1,531	1,693	1,813
Axial displacement at max. drive angle ß	x	mm	7,404	5,393	5,961	5,765
Movementpath	ΔX	mm	1,440	1,135	1,277	1,281
Joint load rating	T	Nm	543	856	1190	2158

Two piece driveline assemblies

KLEIN	*Two piece driveline assemblies*	Data sheet Type 099



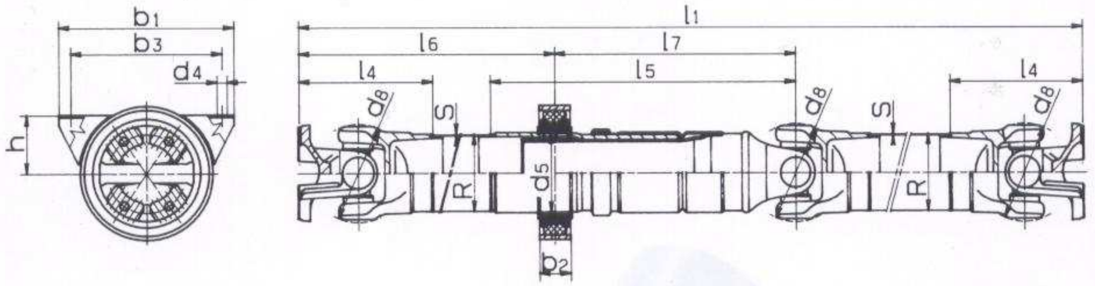
Internet: http//klein-gelenkwellen.de

Eugen Klein GmbH, D-73734 Esslingen, Parkstraße 27-29, Tel. + 49 711/3 80 05-12, Fax + 49 711/3 80 05-49

KLEIN

Two piece driveline assemblies

Data sheet
Type 099



Function torque capacity	M_{FG}	Nm	**5500**						
Type and size			**099 196**						
Swing-∅	d_8	mm	125						
Tube-∅	RxS	mm	98x2						
Max. deflection angle	ß	degree	35°						
Min. length	l_1	mm	1000						
Extension length	l_2	mm	110						
Fixed joint length	l_4	mm	170						
Sliding joint length	l_5	mm	370						
Min. length	l_6	mm	300						
Bearing joint centre	l_7	mm	338						
Bearing internal-∅	d_5	mm	100						
Hight	h	mm	68						
Housing length	b_1	mm	224						
Housing width	b_2	mm	40						
Bolt hole-∅	d_4	mm	13						
Bolt hole centres	b_3	mm	193,5						
Spline DIN 5480	d_{12}	mm	90x2,5						
Joint load rating	T	Nm	1460						
Weight at l_1 = 1000 mm	G	kg	22,5						
Weight of 100 mm tube	G_R	kg	0,4745						
Mass moment of inertia at l_1 = 1000 mm	J_m	kgm^2	0,045						
Mass moment of inertia of 100 mm tube	J_{mR}	kgm^2	0,00109						

For flange types see tables on pages 61 und 65.

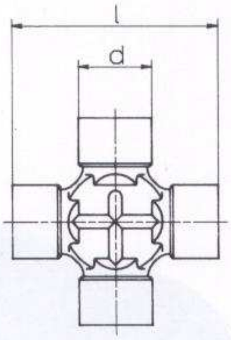
Universal joints

Universal joints

KLEIN

Universal joints

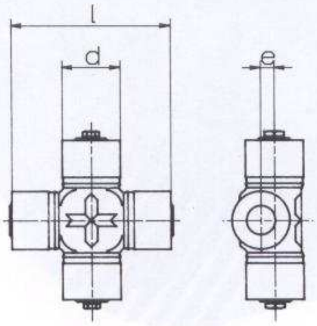
Data sheet
Group 103



For types 001, 008, 026, 052, 055, 099 (size 200 lubricated for life)

Type and size			103 197	103 200	103 253	103 375	103 400	103 490	103 590
Joint load rating	T	Nm	1460	1110	1685	2330	3070	2800	3490
Length	l	mm	110	89	104	116	133	135	147
Bush-∅	d	mm	38	38	42	48	52	48	52

Type and size			103 600	103 650	103 680	103 700			
Joint load rating	T	Nm	4120	4420	5155	6890			
Length	l	mm	144	152	172	172			
Bush-∅	d	mm	57	57	57	65			

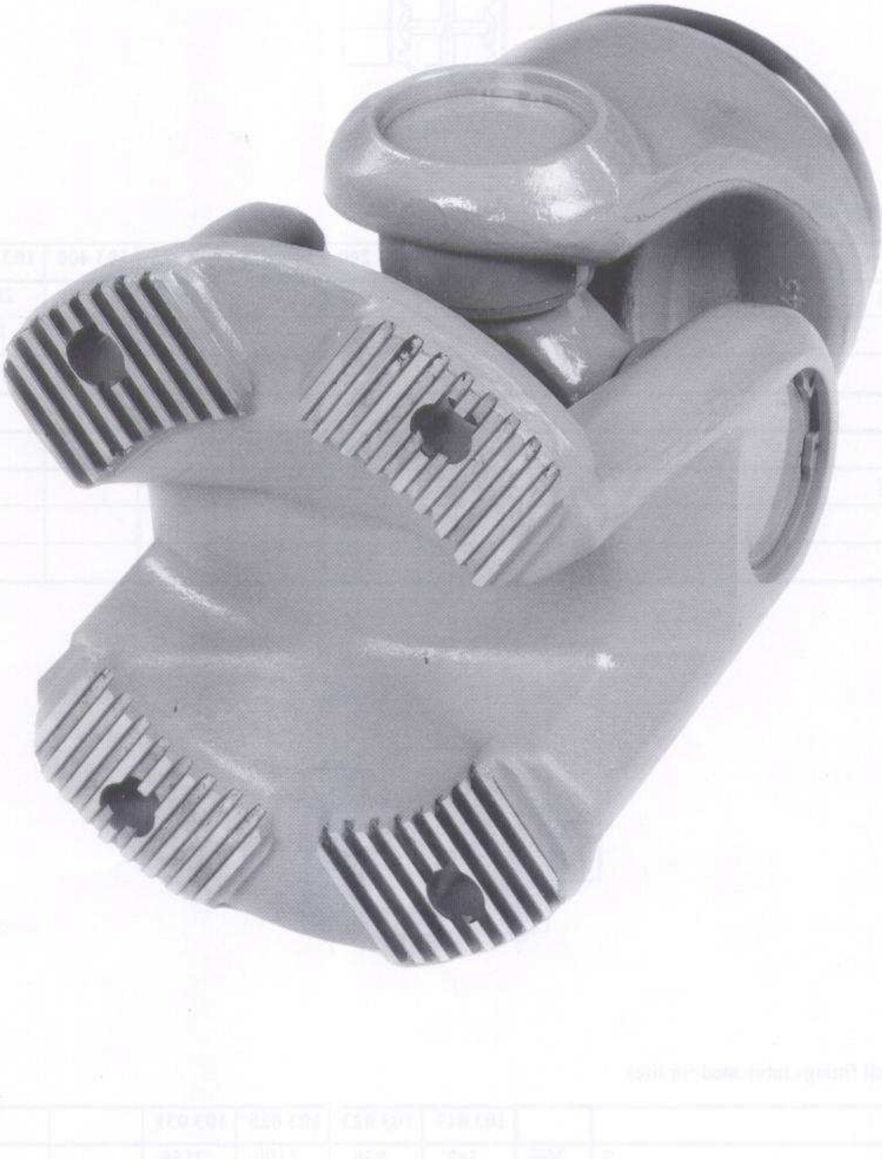


For type 071 (all fittings lubricated for life)

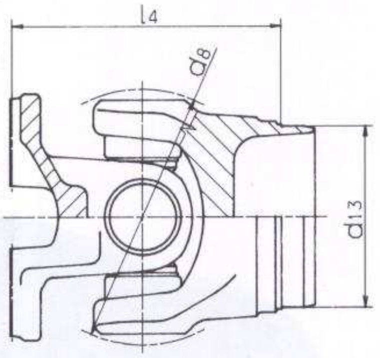
Type and size			103 019	103 023	103 025	103 031			
Joint load rating	T	Nm	543	856	1190	2158			
Length	l	mm	82	96	104	114			
Bush-∅	d	mm	32	35	38	45,5			
Cross axis offset	e	mm	7	8	9	10			

Fixed joints

KLEIN	Fixed joints	Data sheet Group 108



Fixed joints

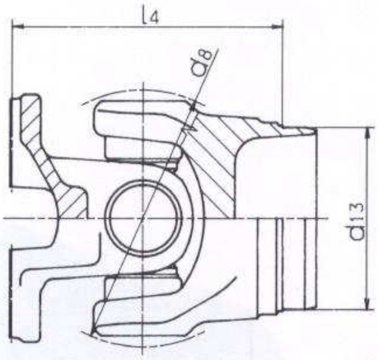


Function torque capacity	M_{FG}	Nm	2700	5500	5500	6000	10200	10200	11550
Type and size			**108 200**	**108 195**	**108 196**	**108 253**	**108 375**	**108 376**	**108 411**
Swing-∅	d_8	mm	104	125	125	125	138	138	156
Max. deflection angle	ß	degree	15°	35°	35°	35°	35°	35°	35°
Fixed joint length	l_4	mm	118	170	170	159	171	171	184
Tube location-∅	d_{13}	mm	44,4	94,2	94,2	73,4	75,4	75,4	794
Joint load rating	T	Nm	1110	1460	1460	1675	2260	2260	3040
Weight	G	kg	3,07	4,7	5,2	5,5	7,8	8,2	10,7
Mass moment of inertia	J_m	kgm^2	0,00325	0,0084	0,0086	0,0085	0,0158	0,0172	0,0260

For flange types see tables on pages 61-69.

Fixed joints

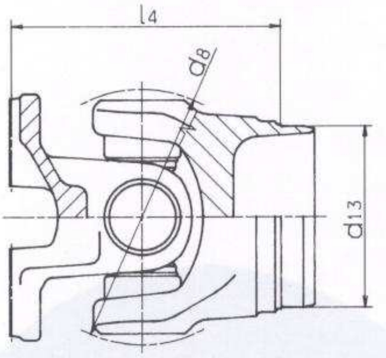
Fixed joints



Function torque capacity	M_{FG}	Nm	14000	14000	15000	17000	17000	20250	24750
Type and size			**108 490**	**108 490**	**108 491**	**108 590**	**108 590**	**108 600**	**108 610**
Swing-∅	d_8	mm	158	158	156	172	172	168	168
Max. deflection angle	ß	Grad	25°	44°	35°	25°	44°	35°	35°
Fixed joint length	l_4	mm	169	202	184	182	216	203	203
Tube location-∅	d_{13}	mm	114,4	91,4	79,4	112,4	112,4	88,4	88,4
Joint load rating	T	Nm	2800	2800	3040	3490	3490	3910	3910
Weight	G	kg	10,0	10,8	11,9	11,5	13,0	13,7	16,6
Mass moment of inertia	J_m	kgm^2	0,0284	0,0307	0,0357	0,0417	0,0472	0,0407	0,0647

For flange types see tables on pages 61-69.

Fixed joints



Function torque capacity	M_{FG}	Nm	25000	30000	35000	45000			
Type and size			**108 620**	**108 680**	**108 700**	**108 710**			
Swing-∅	d_8	mm	178	196	200	200			
Max. deflection angle	ß	Grad	25°	28°	28°	30°			
Fixed joint length	l_4	mm	192	220	225	225			
Tube location-∅	d_{13}	mm	108,4	130,4	130,4	130,4			
Joint load rating	T	Nm	4435	5100	6850	6850			
Weight	G	kg	15,0	15,0	22,6	23,5			
Mass moment of inertia	J_m	kgm^2	0,0489	0,0727	0,0612	0,1089			

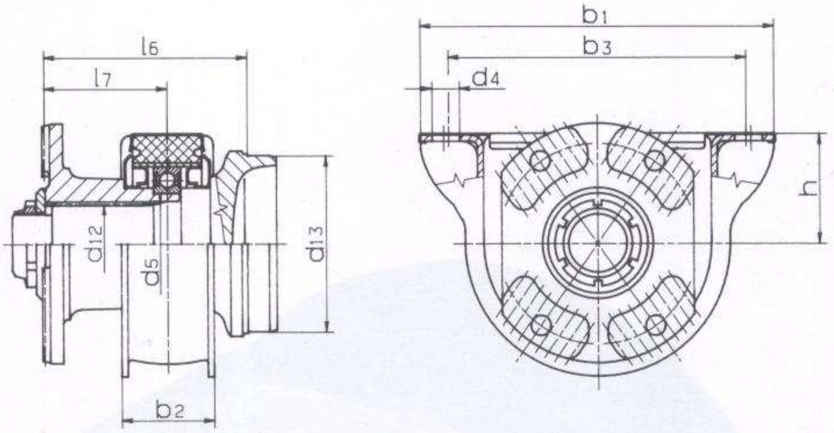
For flange types see tables on pages 61-69.

Centre bearing assemblies

Centre bearing assemblies

Centre bearing assemblies

Data sheet
Group 125



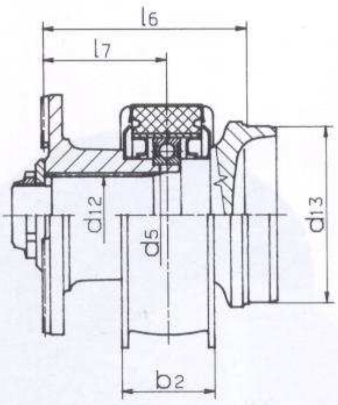
Funktion torque capacity	M_{FG}	Nm	6000	10200	10200	14000	15000	17000	20250
Type and size			125 253	125 375	125 376	125 490	125 491	125 590	125 600
Flange face to tube location	l_6	mm	130	141	141	132	141	132	157
Flange face to bearing centre	l_7	mm	85	95	95	80	95	80	100
Bearing internal-∅	d_5	mm	45	55	65	65	55	65	60
Tube location-∅	d_{13}	mm	73,4	75,4	75,4	114,4	79,4	112,4	88,4
Height	h	mm	71,5	71,5	71,5	71,5	71,5	71,5	80
Housing length	b_1	mm	230	230	230	230	230	230	255
Housing width	b_2	mm	57	57	60	60	57	60	60
Bolt hole-∅	d_4	mm	15	15	15	15	15	15	15
Bolt hole centres	b_3	mm	200	200	200	193,5	200	200	200
Spline DIN 5480	d_{12}	mm	45x2,5	55x2,5	55x2,5	55x2,5	55x2,5	55x2,5	60x2,5
Weight	G	kg	4,3	9,4	9,7	11,0	9,2	9,9	12,0
Mass moment of inertia	J_m	kgm^2	0,016	0,018	0,0192	0,0220	0,02	0,0277	0,03

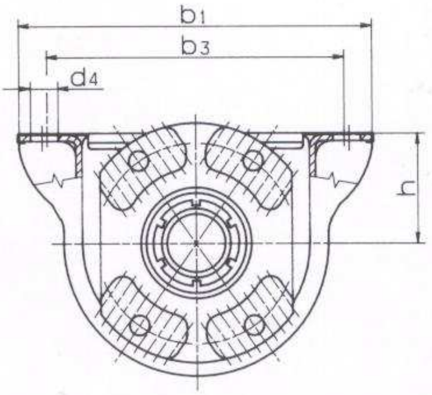
For flange types see tables on pages 73-75.

KLEIN

Centre bearing assemblies

Data sheet
Group 125



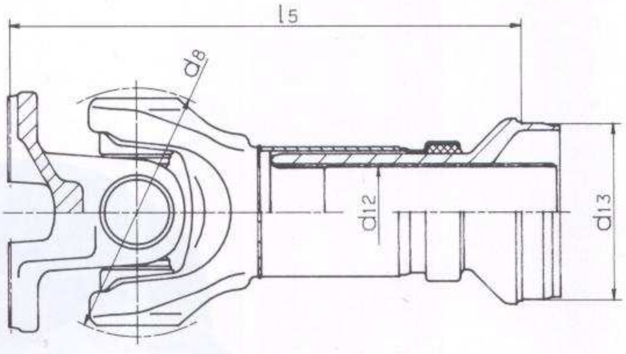


Funktion torque capacity	M_{FG}	**Nm**	**25000**	**30000**	**35000**				
Type and size			**125 620**	**125 680**	**125 700**				
Flange face to tube location	l_6	mm	182	165	181				
Flange face to bearing centre	l_7	mm	107	107	107				
Bearing internal-∅	d_5	mm	75	60	70				
Tube location-∅	d_{13}	mm	108,4	130,4	130,4				
Height	h	mm	85,5	88	88				
Housing length	b_1	mm	255	255	255				
Housing width	b_2	mm	60	65	65				
Bolt hole-∅	d_4	mm	15	15	15				
Bolt hole centres	b_3	mm	220	220	220				
Spline DIN 5480	d_{12}	mm	60x2,5	60x2,5	70x2,5				
Weight	G	kg	15,0	16,5	21,8				
Mass moment of inertia	J_m	kgm^2	0,0387	0,0639	0,0701				

For flange types see tables on pages 73-75.

Sliding joint assemblies

Sliding joint assemblies



Function torque capacity	M_{FG}	Nm	2700	5500	5500	6000	10200	10200	11550
Type and size			**152 200**	**152 195**	**152 196**	**152 253**	**152 375**	**152 376**	**152 411**
Swing-∅	d_8	mm	104	125	125	125	138	138	156
Max. deflection angle	ß	degree	15°	35°	35°	35°	35°	35°	35°
Sliding joint length	l_5	mm	285	445	445	374	398	398	420
Extension length	l_2	mm	90	110	110	110	110	110	110
Slip spline DIN 5480	d_{12}	mm	38x2	90x2,5	90x2,5	52x2,5	55x2,5	55x2,5	65x2,5
Tube location-∅	d_{13}	mm	44,4	94,2	94,2	73,4	75,4	75,4	794
Joint load rating	T	Nm	1110	1460	1460	1675	2260	2260	3040
Weight	G	kg	5,6	9,7	9,3	11,4	16,6	16,5	22,9
Mass moment of inertia	J_m	kgm^2	0,0034	0,0131	0,0169	0,0134	0,0216	0,0234	0,0430

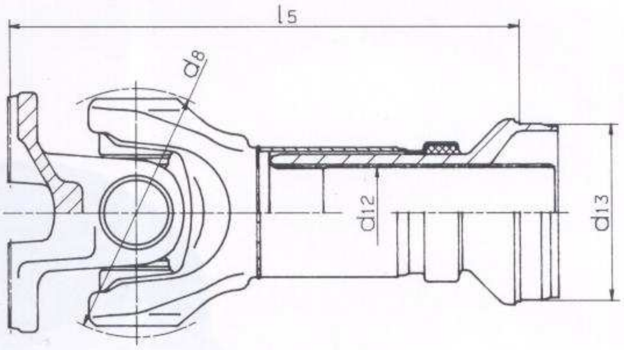
For flange types see tables on pages 61-69.

KLEIN

Sliding joint assemblies

Data sheet
Group 152

Sliding joint assemblies



Function torque capacity	M_{FG}	Nm	14000	14000	15000	17000	17000	20250	24750
Type and size			**152 490**	**152 490**	**152 491**	**152 590**	**152 590**	**152 600**	**152 610**
Swing-∅	d_8	mm	158	158	156	172	172	168	168
Max. deflection angle	ß	degree	25°	44°	35°	25°	44°	35°	35°
Sliding joint length	l_5	mm	332	466	420	352	468	450	450
Extension length	l_2	mm	110	180	110	110	180	110	110
Slip spline DIN 5480	d_{12}	mm	62x2	62x2	65x2,5	95x2	95x2	75x2,5	75x2,5
Tube location-∅	d_{13}	mm	114,4	91,4	79,4	112,4	112,4	88,4	88,4
Joint load rating	T	Nm	2800	2800	3040	3490	3490	3910	3910
Weight	G	kg	16,0	21,2	11,9	19,0	27,0	13,7	16,6
Mass moment of inertia	J_m	kgm^2	0,0292	0,0387	0,0357	0,0526	0,0698	0,0407	0,0647

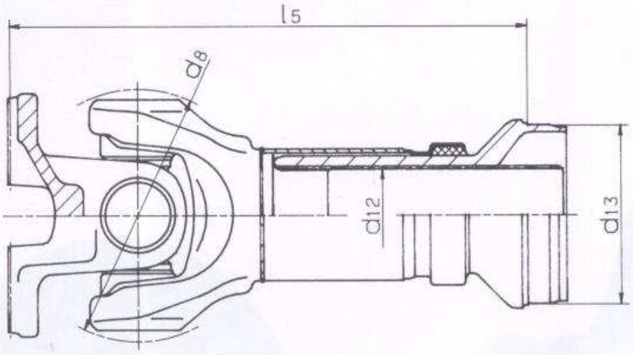
For flange types see tables on pages 61-69.

Sliding joint assemblies

KLEIN

Sliding joint assemblies

Data sheet
Group 152



Function torque capacity	M_{FG}	Nm	25000	30000	35000	45000			
Type and size			**152 620**	**152 680**	**152 700**	**152 710**			
Swing-∅	d_8	mm	178	196	200	200			
Max. deflection angle	ß	degree	25°	28°	28°	30°			
Sliding joint length	l_5	mm	379	455	525	525			
Extension length	l_2	mm	110	110	150	150			
Slip spline DIN 5480	d_{12}	mm	95x2	75x2,5	90x2,5	90x2,5			
Tube location-∅	d_{13}	mm	108,4	130,4	130,4	130,4			
Joint load rating	T	Nm	4435	5100	6850	6850			
Weight	G	kg	23,5	40,0	47,3	49,0			
Mass moment of inertia	J_m	kgm^2	0,0626	0,0829	0,1322	0,1089			

For flange types see tables on pages 61-69.

Flanges

- *cross toothed connection to ISO 12667*
- *for "DIN" connection to ISO 7646*
- *for "SAE" connection to ISO 7647*

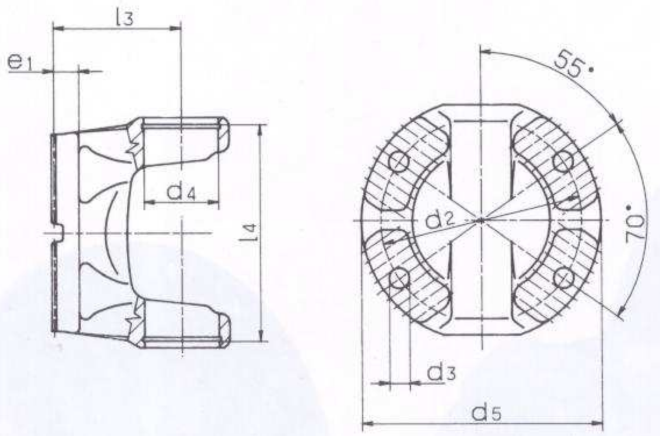
Flanges

Data sheet
Part type 201

KLEIN

Flanges *cross toothed connection to ISO 12667*

Data sheet
Part type 201



Size		196	376	376	490	490	490	491
Flange-∅	d_5	120	120	152	150	180	152	180
Max. deflection angle	ß	35°	25°	35°	25°	25°	44°	35°
Flange face to joint centre line	l_3	75	75	86	82	82	102	95
Thickness	e_1	13	14	16	16	18	16	18
Bolt hole pitch circle-∅	d_2	100	100	130	130	150	130	150
Bolt hole-∅	d_3	11,1	11	13,0	13,0	15,0	13	15,0
Bush-∅	d_4	38	48	48	48	48	48	52
Across circlips	l_4	110	116	116	133	133	133	133

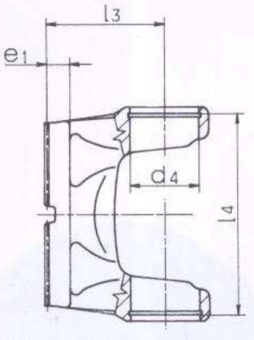
All dimensions in mm.

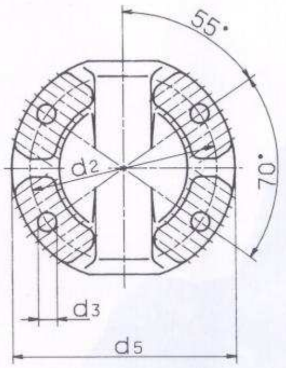
KLEIN	*Flanges*	**Data sheet** **Part type 201**

KLEIN

Flanges *cross toothed connection to ISO 12667*

Data sheet
Part type 201





Size		590	590	590	600	600	620	680
Flange-∅	d_5	150	180	180	150	180	180	180
Max. deflection angle	ß	25°	25°	44°	35°	35°	25°	28°
Flange face to joint centre line	l_3	85	85	108	100	100	92	100
Thickness	e_1	16	18	18	16	18	18	18
Bolt hole pitch circle-∅	d_2	130	150	150	130	150	150	150
Bolt hole-∅	d_3	13,0	15,0	15,0	13,0	15,0	15,0	15,0
Bush-∅	d_4	52	52	52	52	57	57	57
Across circlips	l_4	147	147	147	144	144	152	172

All dimensions in mm.

KLEIN

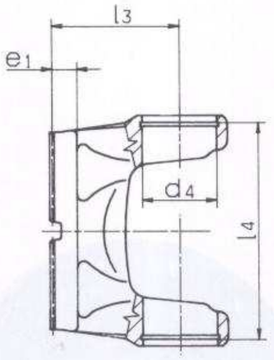
Flanges

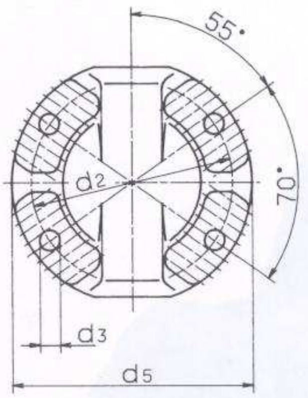
Data sheet
Part type 201

KLEIN

Flanges *cross toothed connection to ISO 12667*

Data sheet
Part type 201





Size		700						
Flange-∅	d_5	180						
Max. deflection angle	ß	28°						
Flange face to joint centre line	l_3	100						
Thickness	e_1	18						
Bolt hole pitch circle-∅	d_2	150						
Bolt hole-∅	d_3	15,0						
Bush-∅	d_4	65						
Across circlips	l_4	172						

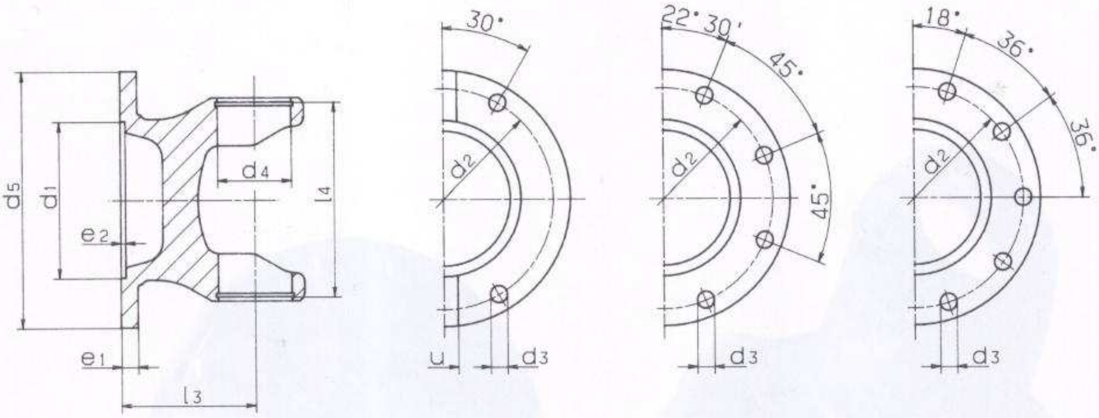
All dimensions in mm.

KLEIN	Flanges	Data sheet Part type 201

KLEIN

Flanges *DIN connection to ISO 7646*

Data sheet
Part type 201



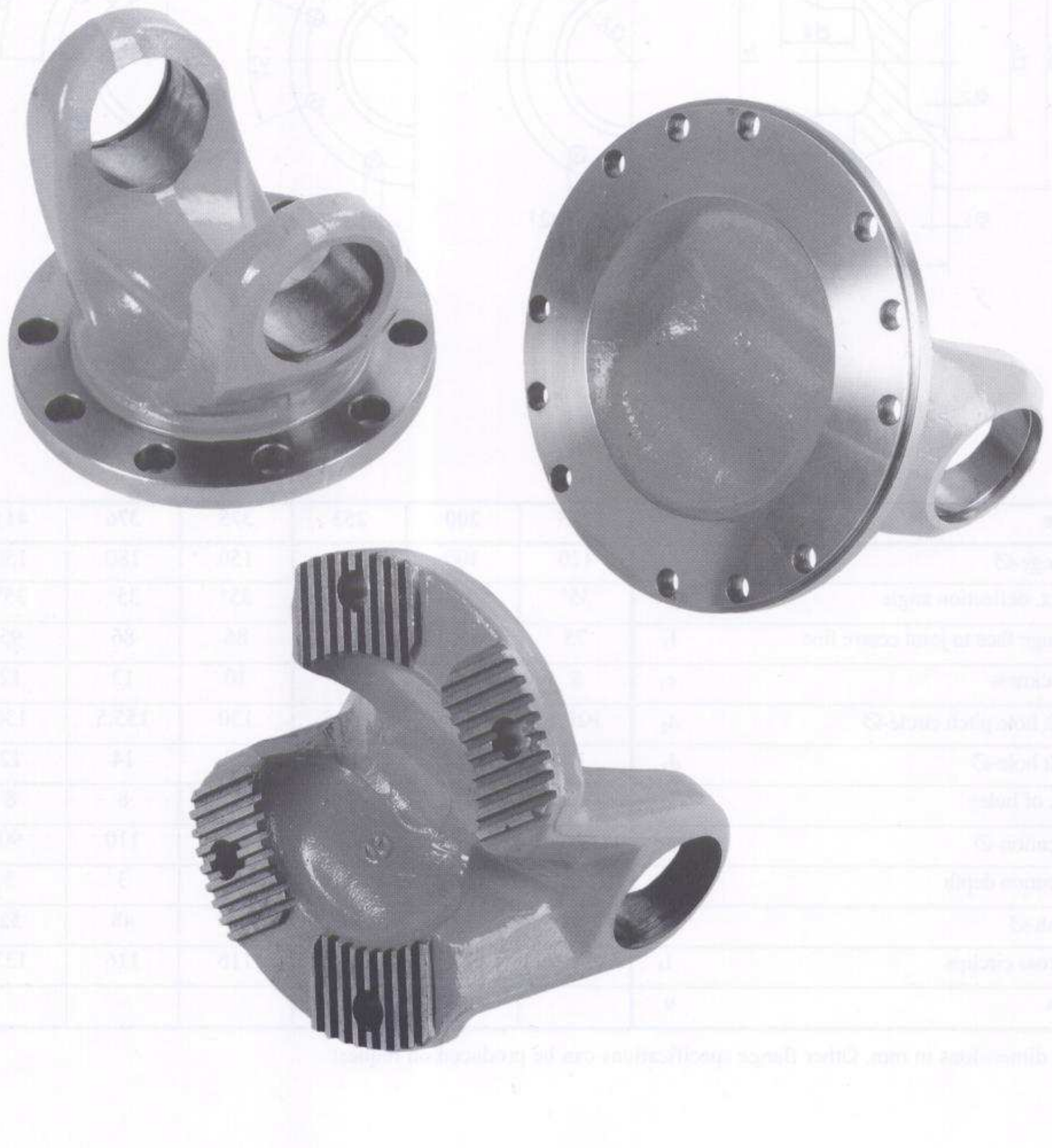
Size		195	200	253	375	376	411
Flange-∅	d_5	120	100	120	150	180	150
Max. deflection angle	ß	35°	15	35°	35°	35°	35°
Flange face to joint centre line	l_3	75	48	75	86	86	95
Thickness	e_1	8	9	8	10	12	12
Bolt hole pitch circle-∅	d_2	101,5	80	101,5	130	155,5	130
Bolt hole-∅	d_3	10	10,5	10	10	14	12
No. of holes	z	8	4	8	8	8	8
Location-∅	d_1	75	50	75	90	110	90
Location depth	e_2	2,5	2,5	2,5	3	3	3
Bush-∅	d_4	38	38	42	48	48	52
Across circlips	l_4	110	98	104	116	116	133
Slot	u		8				

All dimensions in mm. Other flange specifications can be produced on request.

KLEIN

Flanges

Data sheet
Part type 201



KLEIN

Flanges *DIN connection to ISO 7646*

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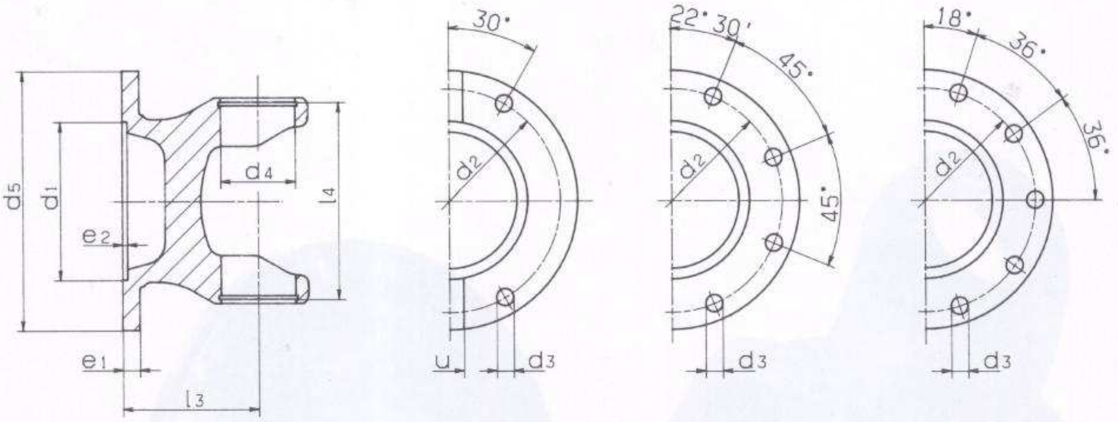


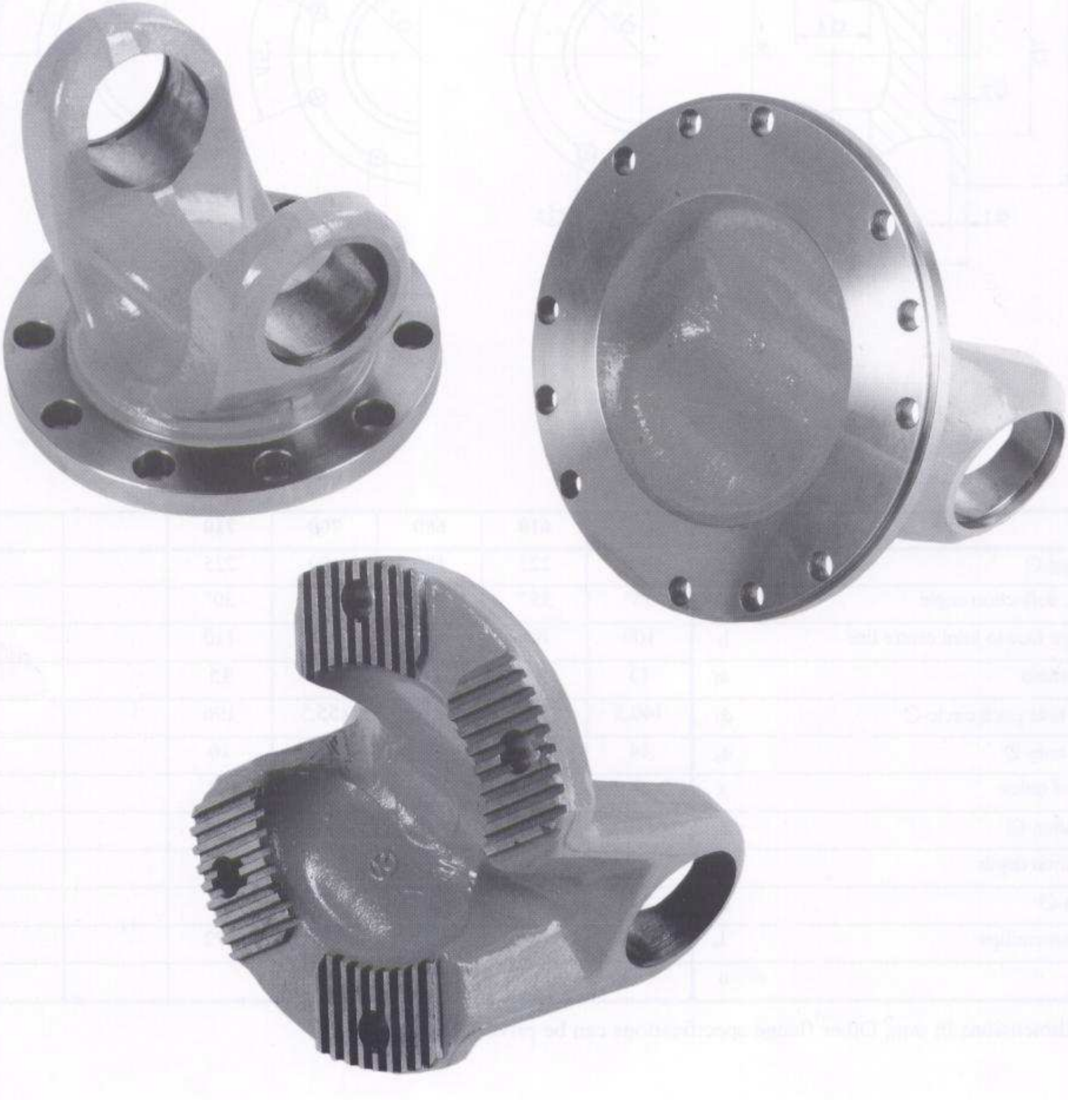
Size		**600**	**610**	**680**	**700**	**710**		
Flange-∅	d_5	180	225	180	180	225		
Max. deflection angle	ß	35°	35 °	25°	30°	30°		
Flange face to joint centre line	l_3	100	100	110	110	110		
Thickness	e_1	13	15	14	15	15		
Bolt hole pitch circle-∅	d_2	140,5	196	155,5	155,5	196		
Bolt hole-∅	d_3	14	16	16	16	16		
No. of holes	z	8	8	10	10	10		
Location-∅	d_1	110	140	110	110	140		
Location depth	e_2	3	5	3	3	5		
Bush-∅	d_4	57	57	57	65	65		
Across circlips	l_4	144	144	172	172	172		
Slot	u							

All dimensions in mm. Other flange specifications can be produced on request.

KLEIN

Flanges

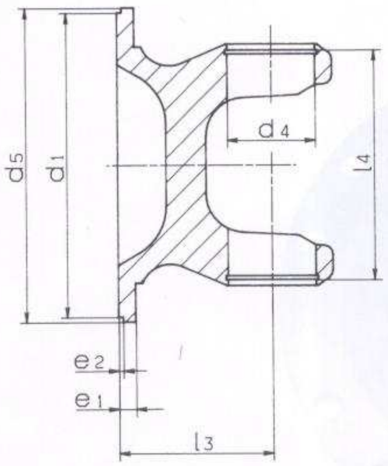
Data sheet
Part type 201

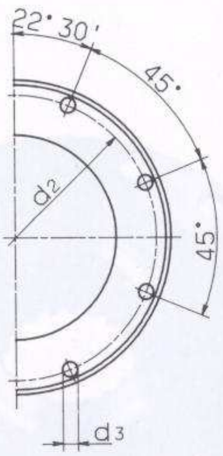


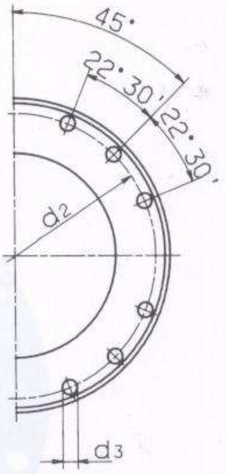
KLEIN

Flanges *SAE connection to ISO 7647*

Data sheet
Part type 201







Size		**253**	**376**	**491**	**610**	**600**	**700**	
„SAE“- specification		**1510**	**1600**	**1700**	**1700**	**1800**	**1800**	
Flange-∅	d_5	146	174,6	203,2	203,2	203,2	203,2	
Max. deflection angle	ß	35	35°	35°	35°	35°	30°	
Flange face to joint centre line	l_3	80	86	95	100	100	110	
Thickness	e_1	9	9,5	9,5	11	11	11	
Bolt hole pitch circle-∅	d_2	120,65	155,57	184,15	184,15	184,15	184,15	
Bolt hole-∅	d_3	12	10	10	10	10	12	
No. of holes	z	4	8	8	8	12	12	
Location-∅	d_1	95,25	168,22	196,82	196,82	196,82	196,82	
Location depth	e_2	1,6	3	3	3	3	3	
Bush-∅	d_4	42	48	52	57	57	65	
Across circlips	l_4	104	116	133	144	144	172	

All dimensions in mm. Other flange specifications can be produced on request.

Coupling flanges

- *cross toothed connection to ISO 8667*
- *"DIN" connection to ISO 7646*
- *"SAE" connection to ISO 7647*

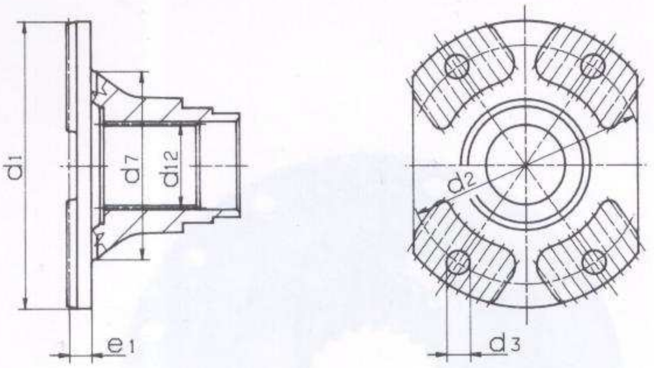
Coupling flanges

Data sheet
Part type 224

KLEIN

Coupling flanges *cross toothed con. to ISO 8667*

Data sheet
Part type 224



Size		376	490	590	620	680	700	
Flange-∅	d_1	152	152	180	180	180	180	
Thickness	e_1	12	12	14	14	14	14	
Bolt hole pitch circle-∅	d_2	130	130	150	150	150	150	
Bolt hole-∅	d_3	13	13	15	15	15	15	
Clearance	d_7	98	80	118	118	118	118	
Spline DIN 5480	d_{12}	55x2,5	55x2,5	55x2,5	60x2,5	60x2,5	70x2,5	

All dimensions in mm.

KLEIN

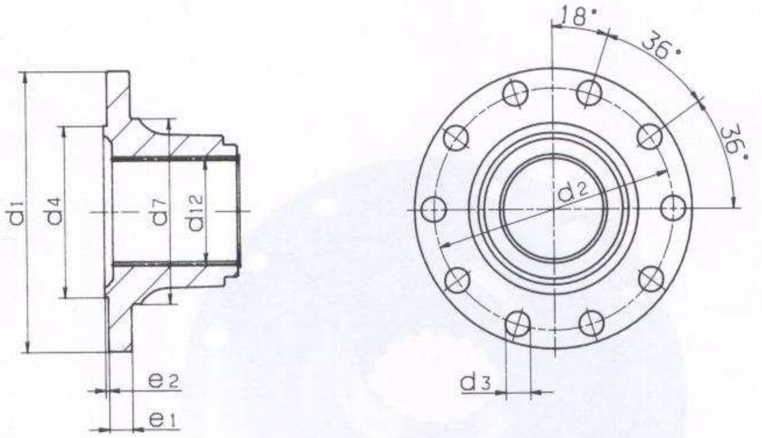
Coupling flanges

Data sheet
Part type 224

KLEIN

Coupling flanges *DIN connection to ISO 7646*

Data sheet
Part type 224



Size		253	375	491	600	680	700	
Flange-∅	d_1	120	150	180	180	180	180	
Thickness	e_1	8	10	12	12	15	15	
Bolt hole pitch circle-∅	d_2	101,5	130	155,5	155,5	155,5	155,5	
Bolt hole-∅	d_3	10	12	16	16	16	16	
No. of holes	z	8	8	8	8	10	10	
Location-∅	d_4	75	90	110	110	110	110	
Location depth	e_2	2,3	2,3	2,3	2,3	2,3	2,3	
Clearance	d_7	80	106	119	119	118	119	
Spline DIN 5480	d_{12}	45x2,5	55x2,5	55x2,5	60x2,5	60x2,5	70x2,5	

All dimensions in mm. Other flange specifications can be produced on request.

KLEIN

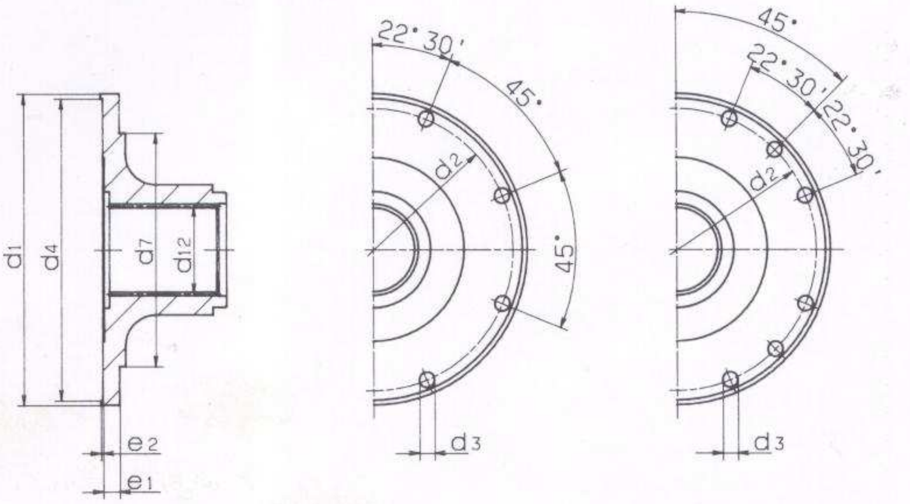
Coupling flanges

Data sheet
Part type 224

KLEIN

Coupling flanges *SAE connection to ISO 7647*

Data sheet
Part type 224



Size		**253**	**375**	**491**	**600**	**600**	**700**	
„SAE“-Ausführung		**1510**	**1600**	**1700**	**1700**	**1700**	**1800**	
Flange-∅	d_1	146	174,6	203,2	203,2	203,2	203,2	
Thickness	e_1	9	11	11	12,5	12,5	12,5	
Bolt hole pitch circle-∅	d_2	120,65	155,57	184,15	184,15	184,15	184,15	
Bolt hole-∅	d_3	12	10	10	10	10	12	
No. of holes	z	4	8	8	8	12	12	
Location-∅	d_4	90,25	168,22	196,82	196,82	196,82	196,82	
Location height	e_2	2,3	1,5	1,5	1,5	1,5	1,5	
Clearance	d_7	101,6	138,5	167	167	167	167	
Spline DIN 5480	d_{12}	45x2,5	55x2,5	55x2,5	60x2,5	60x2,5	70x2,5	

Alle dimensions in mm.. Other flange specifications can be produced on request.

Technical supplement

Technical Appendix

1. Application Notes

⚠ Where rotating propeller shafts constitute a hazard, the operator must take suitable safety precautions.

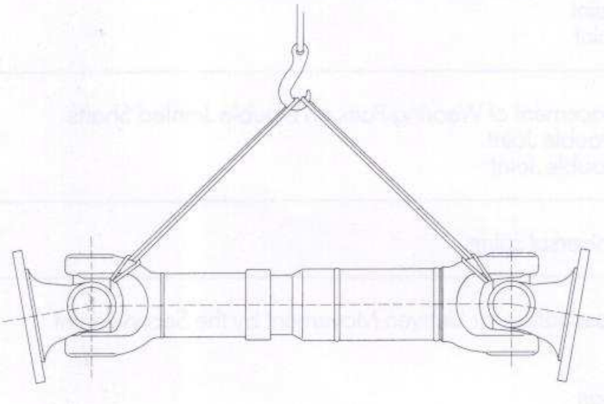
The propeller shafts supplied as complete assemblies have been carefully balanced; they correspond to quality class G16 to DIN ISO 1940, in exceptional cases G40.

1.1 Transport and Storage of Propeller Shafts

⚠ The shafts should be transported and stored such that no rough impacts or collisions affect the cardan shaft and the tube is not damaged. This would reduce the balance quality.

⚠ The shafts are best transported in horizontal position (Fig. 1). When transporting vertically, appropriate security must be supplied to ensure that the joint halves do not come apart.

Fig. 1:



⚠ There is a risk of injury during transport and tilting of the joints. For crane transport, we recommend the use of plastic ropes or belts mounted as shown.

Do not turn propeller shafts in the joint using mounting levers else the bearing seals can be damaged and the lubricating nipples broken off.

The original KLEIN packing is intended only for dispatch and short term storage. The parts must be stored in the dry, protected from the weather.

Propeller shafts should preferably be stored in the horizontal position as this prevents the shafts tilting and avoids any damage. Do not place propeller shafts directly on the ground but where possible on wooden shelves. For long term storage, bright metal parts should be checked for corrosion and where applicable treated with corrosion protection oil.

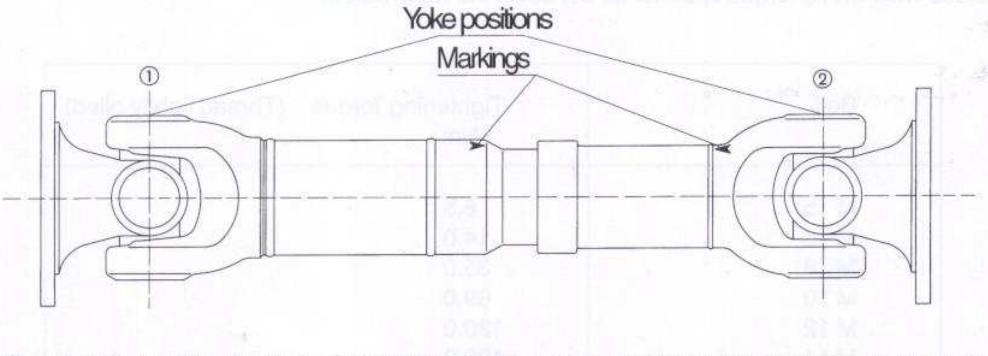
1.2 Installation of Propeller Shafts

⚠ Before the propeller shaft is fitted, all flange surfaces must be thoroughly cleaned of corrosion-inhibiting oil, dirt and grease in order to ensure the necessary static friction coefficient for torque transmission.

⚠ On no account may the welded balance plates be removed. Since the propshaft is always balanced with the tube and joints together as an integrated whole, the joints of different shafts may not be interchanged.

The yokes 1 and 2 (Fig. 2) must be located in specific positions with the respect to each other so that the uneven rotation induced by the first is cancelled out by the second. The yokes must be in one plane, and only in very rare applications are they offset relative to one another by the precisely defined angle. The correct position in any one instance is shown by the arrow markings on the shaft tube. The shaft should always be assembled in such a way that the arrows point to each other. If it is incorrectly assembled, the second joint will compound the uneveness of the first, and the shaft will run noisily and with increased wear.

Fig. 2:



The propeller shafts should be fitted with the spline protected from dirt and moisture as much as possible. As a rule, this means fitting them in the position shown in Figure 3 with the spline seal pointing downwards so that any splashed water runs away from the splined section.

Fig. 3:

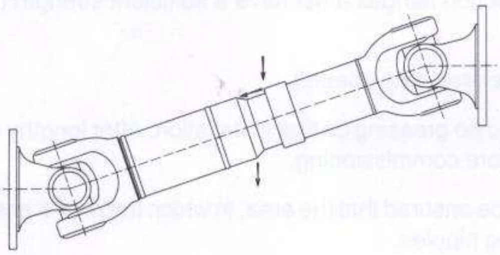
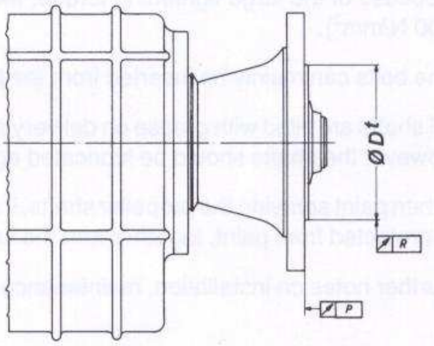


Fig. 4:



The high standard of balance of the shaft is only of advantage if the two connecting flanges to which the propeller shaft is fitted run truly flat and concentrically. In addition, the radial bearing clearance and the clearance between the centring boss of the connecting flange and the flange fitting should be small.

Guide values for permissible flatness and concentricity runout and fit sizes for connecting flanges and their centring bosses of diameter D (Fig. 4).

Shaft speed n = rpm	Flattness runout P = mm	Concentricity runout R = mm	Fit size t
500	0.1	0.1	h 8
1.500	0.07	0.07	h 7
3.000	0.05	0.05	h 6
5.000	0.03	0.03	j 6

A high precision measuring flange may be used to test cross-toothed flanges.

To avoid difficulties when fitting the propeller shafts, the following tolerances must be observed as regards the bolt holres in the flanges:

Hole circle	±0,1 mm
Hole circle pitch	±0,05 mm
Hole diameter	C 12

The torque is transmitted by friction, by titled keys, or by toothing. The positive connections mean, that the flange diameters can be smaller.

In order to keep the coefficient of friction as high as possible with friction connections, the flanges must be clean and free from grease. The surface quality should not exceed a peak-to-valley heigh of 25 μm.

For the bolted joint the bolts must be of strength class 10.9 and the nuts 10. They must be tightened up even cross-wise with a torque spanner as set out in the table below.

Bolt	Tightening Torque (Thread lightly oiled) Nm
M 5	8.5
M 6	14.0
M 8	35.0
M 10	69.0
M 12	120.0
M 14	190.0
M 16	295.0

Because of the large tightening torque, the connection flanges must have a sufficient strength (at least 700 N/mm^2).

The bolts can mainly be inserted from the joint side (see data sheets).

All shafts are filled with grease on delivery and need no greasing on first installation. After lengthy storage however the shafts should be lubricated again before commissioning.

When paint spraying the propeller shafts, it should be ensured that the area, in which the profile or seal lies is protected from paint, together with the lubricating nipples.

Further notes on installation, maintenance, transport etc. are given in our leaflet TB 486.

1.3 Transport and Storage of Double Jointed Shafts

Transport and storage should always be done in such a manner, that the input and output shafts, the yokes and the universal joints are not subjected to any severe knocks or blows.

⚠ The shafts are best transported on pallets or in crates. If the input or output shafts are tilted, there is a danger of injuries due to crushing. The original KLEIN-packing is only intended for shipping and for short term storage. Storage must be in rooms protected from the weather.

Double jointed shafts are best stored horizontally, as this prevents the shafts from tilting and from being damaged from the outset. Shafts should never be stored directly on the floor, but on wooden shelving. If storage is for prolonged period, the bright metal parts should be inspected for corrosion and treated with corrosion-inhibiting oil.

1.4 Installation of Double Jointed Shafts

Before the double jointed shaft is fitted into the axle, any protective layer applied for transport purposes or any protective caps on the input and output shafts must be removed.

Clean the double jointed shaft of corrosion-inhibiting oil, dirt and grease.

The splines on the input and output shafts must be checked for cleanliness and to ensure that they are not damaged. The bearing and sealing surfaces must be similarly checked.

The position and location of the double jointed shaft in the axle is determined by the vehicle design.

All double jointed shafts are lubricated before despatch and do not need to be lubricated when fitted for the first time. After prolonged storage, however, it is recommended to relubricate the spider bearings if provision is made for this.

When spray painting the joint, make sure that the grease nipple is protected against paint.

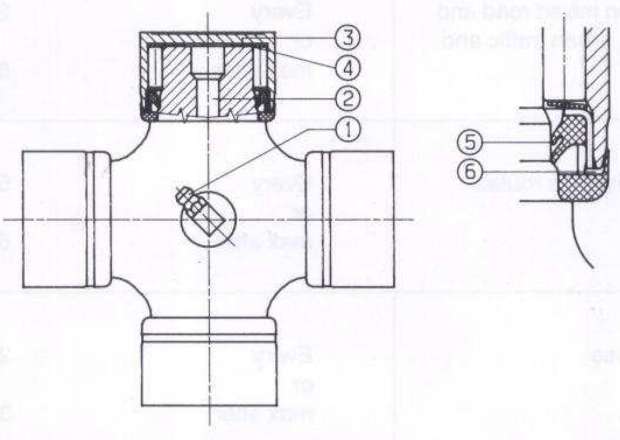
2. Maintenance of Propeller Shafts and Double Jointed Shafts

Propeller shafts are supplied maintenance-free or suitable for lubrication.

In the lubrication design (Fig. 5), the four bearings of a joint are lubricated via a tapered lubricating nipple to DIN 71412 in the centre of the joint. In special designs, the lubricating nipple may be placed on the base of the bearing bush.

The lubricating nipples must be cleaned before lubricating.

Fig. 5:



The grease is forced into the distribution channel 2 via the tapered lubricating nipple 1 and transferred to the universal joint bushes. The grease penetrates between the roller bodies via the channels 3 of the pressure plate and edge 4 of the universal joint pin. When further grease is added, the grease penetrates through the valve-like opening gap of the seal lips 5 and the labyrinth. Excess grease emerges from gap 6 of the labyrinth.

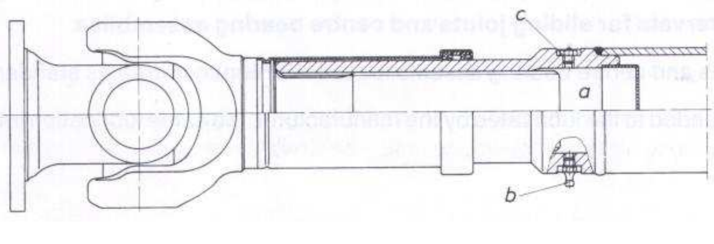
Apply lubrication until grease is exuded from all four bearing bushes.

If it is not possible to lubricate all four bearings fully, the shaft must be dismantled.

In standard designs, the length extension is maintenance-free as shown in the drawings in the table part.

For special lubrication designs, the sliding profile (Fig. 6) is greased from a storage chamber (a) which is filled via pressure lubricating head (b). The storage chamber (a) should preferably be lubricated with the shaft retracted (vehicle loaded) so that an air cushion can form when the shaft is extended. To prevent damage to the cardan shaft or bearings of attached assemblies due to incorrect excess greasing (a) when the springs are compressed, if requested an excess presure valve (c) can be installed which prevents an unacceptable pressure rise in this chamber.

Fig. 6:



2.1. Lubrication Intervals

Unless specified particularly by the vehicle or system manufacturer, we recommend the following maintenance intervals. The data in the tables refers to European and comparable conditions.

⚠ Other operating conditions may require lubrication at shorter intervals. If propeller shafts are cleaned with pressurised water or vapour jets, lubrication must be applied after every cleaning.

Lubricating Interval for Joints

Usage	Lubricating Interval
Goods vehicles in long distance travel and similar vehicles	Every 50.000 km or max after 1 year
Goods vehicles in mixed road and private land use, urban traffic and similar vehicles	Every 25.000 km or max after 6 months
Buses on long distance routes	Every 50.000 km or max after 6 months
Buses in urban use	Every 25.000 km or max after 3 months
Goods vehicles in site use, community service vehicles, building machines, crane vehicles, forestry and agricultural tractors, military vehicles * and similar vehicles	Every 12.500 km or max after 3 months
Industrial plant	Every month but at the latest after 500 operating hours

* After travelling through water, shorter lubricating intervals are required.

Lubricating Intervals for sliding joints and centre bearing assemblies

The sliding joints and centre bearing assemblies are maintenance-free as standard.

For versions intended to the lubricated by the manufacturer, the same lubrication intervals apply as for universal joints.

2.2 Lubricating Grease

The recommended lubricants are lithium complex greased with a consistency to NLGI-class 2 to DIN 51818.

In particular we recommend the products listed in our leaflet TM 150.

⚠ It must be ensured that greases with a different type of saponification are never used, because lithium and sodium greased for example are incompatible.

KLEIN-propeller shafts in normal design are suitable for operating use at ambient temperatures from −35°C to + 60°C (for short periods and only occasionally, up to + 80°C).

⚠ If Propeller shafts are to be used outside this temperature range or in ambient conditions deviating from the norm, please contact us.

2.3 Timelimits for checkups

CAUTION!

These timelimits and contents for checkups can be found in the technical appendix on our homepage:

www.klein-gelenkwellen.de

3. Repair and Replacement of Wearing Parts on Propeller Shafts

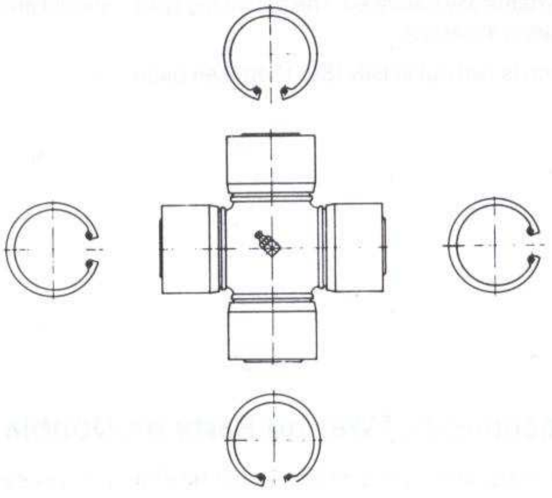
All joints are fully dismantable and designed for dismantling without special tools.

⚠ However for safety reasons, the following work should be carried out only by competent work shops. In case of doubt please ask us.

When dismantling a propeller shaft, first check whether the positions of forks 1 and 2 are marked by arrows (see Fig. 2); if the marking is covered with paint, these sliding parts should be clearly marked together.

We strongly recommend not replacing damaged bearings individually as in most cases the pins on the universal joint will also be damaged. It is therefore advisable to replace only complete universal joint fittings (Fig. 7). In the case of wear in the sliding profile, splined shafts and hubs should always be replaced together. The wear limit for fast running shafts is achieved when play is perceptible in the installed position.

Fig. 7:



3.1 Dismantling a Joint

1. Remove all four circlips with circlip pliers.
2. Push the universal joint and bushes to one side using a press (see. Fig. 8a).
3. Clamp the projecting bush in a screw vice and withdraw the bush with light hammer blows on the fork (Fig. 8b). Do not reuse bearing bushes with thin walls.

Fig. 8a:

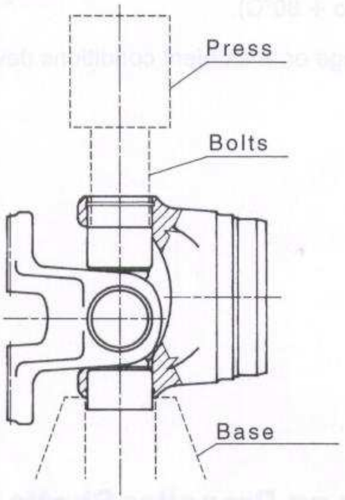
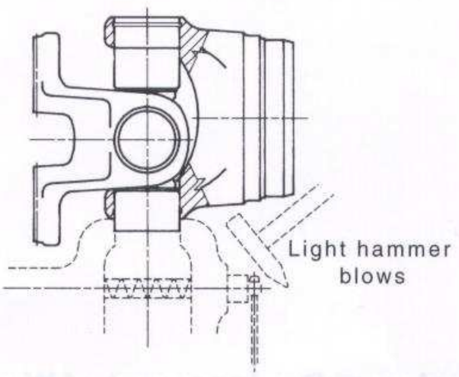


Fig. 8b:



3.2 Assembling a Joint

1. Press in the bearing bushes exactly in line with their centrelines, without tilting them.
2. Fit circlips so that the universal joint can be easily moved. To achieve this, circlips of various thickness are used and if absolutely necessary a thicker circlip can be ground to the required dimension. The clearence at the ends of the pins should be adjusted so that the bending moment of the flange in both axes does not exceed 4 Nm, without letting the flange drop down on his own accord.
3. Check that the joint runs true. To do this, mount the propeller shaft on the flange fitting and check the tube with a dial gauge. Maximum permissible runout is 0,1 mm. For running speeds under 1500 rpm this check will in most cases avoid the need for balancing and for speeds above 1500 rpm it considerably shortens the balancing process.

   In the case of motor vehicles, the running speed is generally above 1500 rpm. Propeller shafts for this application must be dynamically balanced. The balancing speed should always be 10 – 15 % above the maximum speed occuring in service.

   The acceptable balance is laid out in DIN ISO 1940 (see page 98).

4. Repair and Replacement of Waring Parts on Double Jointed Shafts

Repairs to double cardan shafts should be considered only in emergency cases when it is not possible to obtain replacement shafts.

⚠ For safety reasons, repairs should be carried out only by authorized workshops.

4.1 Dismantling a Double Joint

We strongly advise that individual damaged bearings should not be replaced, since in most instances the pin on the spider is damaged. For this reason, it is advisable only to replace complete double jointed shafts.

If the double jointed shaft is designed with forked shafts, the dismantling of the spider can be carried out as described under 3.2. The following description is usual for fist-designed shafts.

Remove the circlips from the outer drive ring, and press the spider, complete with the bushes, up against the drive ring. Take out the bush protruding from the drive ring. Remove the opposite bush in a similar manner and twist the shaft complete with spider out of the drive ring.

Remove circlips from the spider and withdraw both bushes from the spider. Press out the spider pin out of the shaft and spide, having first unscrewed the retaining screw for the spider pin.

4.2 Assembling a Double Joint

Place the larger opening of the spider on the shaft and press in the new spider pin. Make sure that the spider pin is centred in the shaft boss. This is checked between centres or on prism blocks. The permissible tolerance is ± 0.1 mm. Screw the retaining screw for the spider pin.

Insert the bushes in the joint and press them in. Secure them in a centred position with circlips, preferably without any clearance. Permissible tolerance ± 0.1 mm

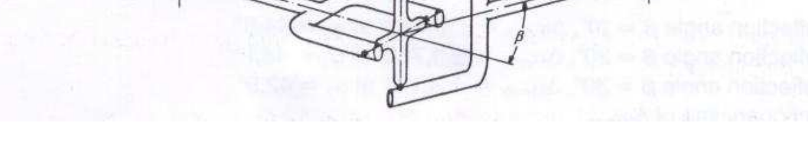
Introduce the assembled shaft into the drive ring. Position the bushes in the drive ring and press them in. Secure them in a centred position with circlips. Permissible tolerance ± 0.1 mm.

Pack the double jointed shafts with grease through the grease nipple until grease comes out at the bearings.

5. Kinematics of Universal Joints

If two shafts bent at angles to each other are connected with an universal joint (Fig. 9) and the drive shaft moves at constant angular velocity ω_1, the driven shaft runs with uneven angular velocity ω_2, ie. the twist angle α_2 of the driven shaft does not at any point agree with the twist angle α_1 of the drive shaft. The difference angle $\Delta\alpha$ and hence the degree of unevenness u depends on the deflection angle of the joint.

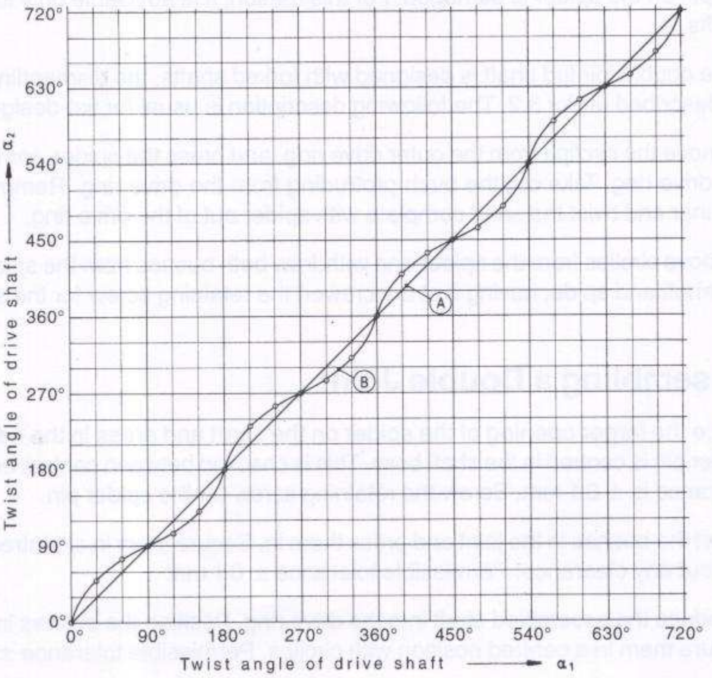
Fig. 9:



The correlations are shown in the following figures 10 to 13.

Fig. 10:

$$\alpha_2 = \arc\tan \frac{\tan \alpha_1}{\cos \beta}$$

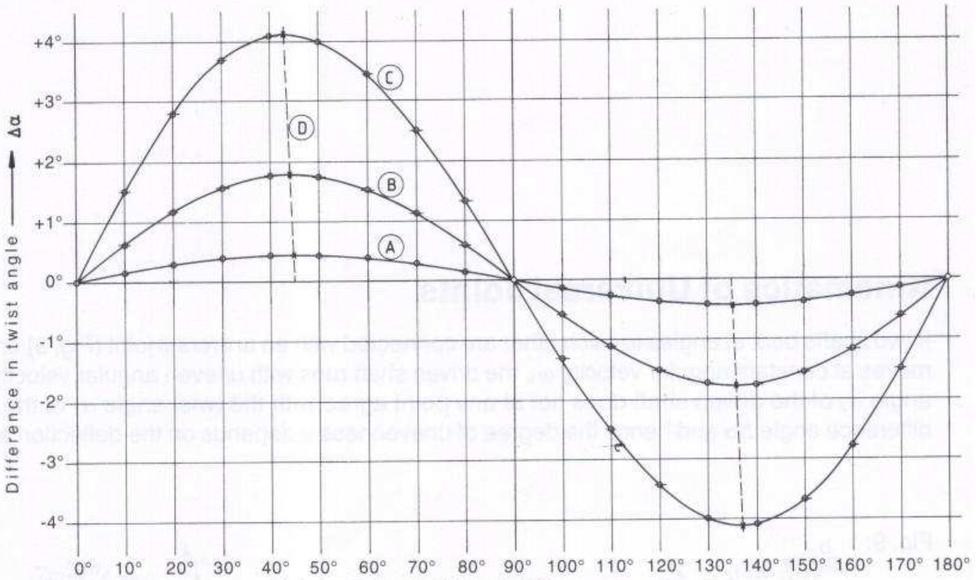


Curve A: $\alpha_2 = \alpha_1$ at $\beta = 0°$ (synchronous line)
Curve B: $\alpha_2 = f(\alpha_1; \beta \neq 0°)$

Difference in twist angle (cardan fault)

$$\Delta\alpha = \alpha_2 - \alpha_1$$

Fig. 11:

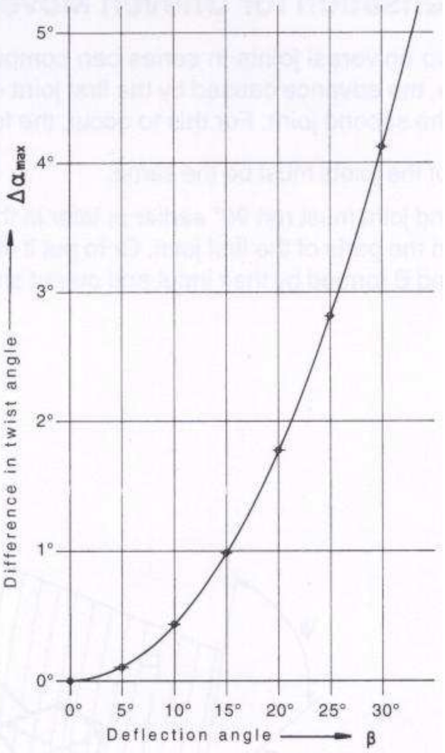


Curve A: Deflection angle $\beta = 10°$, $\Delta\alpha_{\max} = \pm 0{,}438°$ at $\alpha_1 = 44{,}8°$
Curve B: Deflection angle $\beta = 20°$, $\Delta\alpha_{\max} = \pm 1{,}782°$ at $\alpha_1 = 44{,}1°$
Curve C: Deflection angle $\beta = 30°$, $\Delta\alpha_{\max} = \pm 4{,}117°$ at $\alpha_1 = 42{,}9°$
Curve D: Stationary line of $\Delta\alpha_{\max}$

Max. difference in twist angle

$$\Delta\alpha_{max} = \arctan \frac{1-\cos\beta}{2\sqrt{\cos\beta}}$$

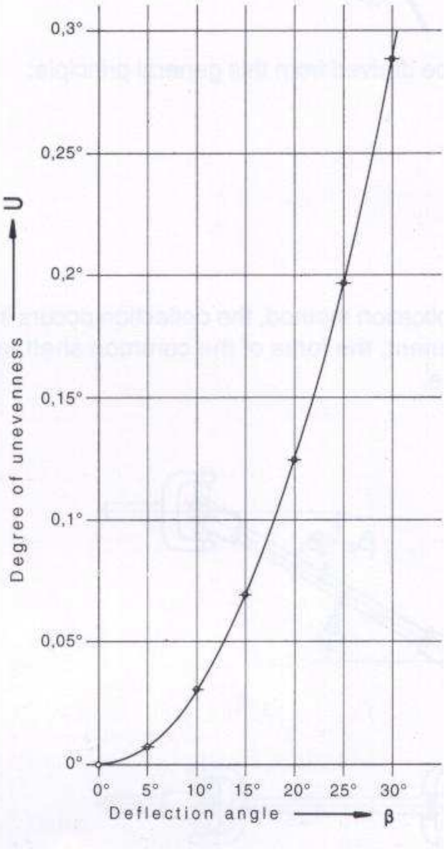
Fig. 12:



Degree of unevenness

$$u = \frac{\omega_{2max} - \omega_{2min}}{\omega_1} = \tan\beta \cdot \sin\beta$$

Fig. 13:

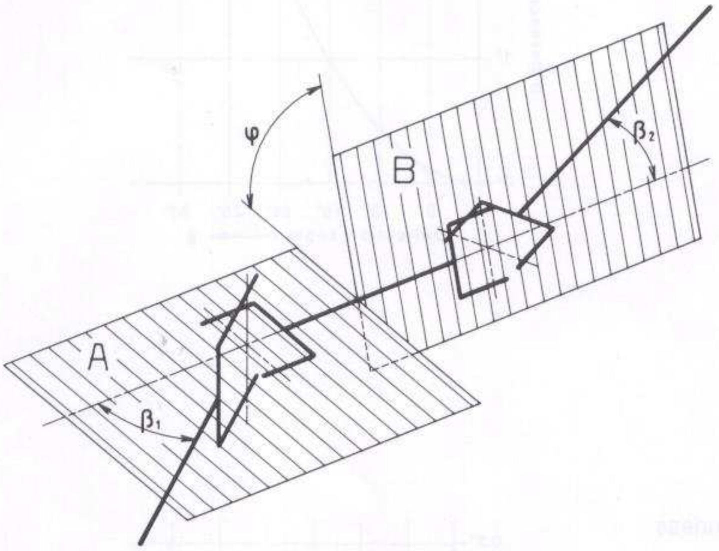


6. Complete Compensation for Uneven Movement by the Second Joint

Proper connection of two universal joints in series can compensate fully for the unevenness of the movement. For example, the advance caused by the first joint $+\Delta\alpha$ is compensated by a retard of the same order $-\Delta\alpha$ from the second joint. For this to occur, the following must be fulfilled:

1. The deflection angle of the joints must be the same.
2. The parts of the second joint must run 90° earlier or later in their deflection plane formed by the input and output shafts than the parts of the first joint. Or to put it more clearly: the forks of the centre shaft must lie in planes A and B formed by their input and output shafts at the same time (Fig. 14).

Fig. 14:

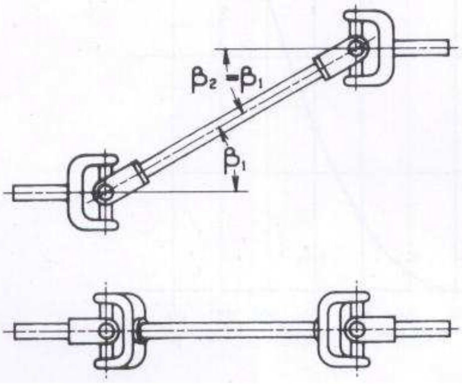


Two common applications can be derived from this general principle:

6.1 Z-Deflection

In this most common application method, the deflection occurs in one plane only (Fig. 15). For complete compensation for movement, the forks of the common shaft must lie in one plane and the deflection angles must be the same.

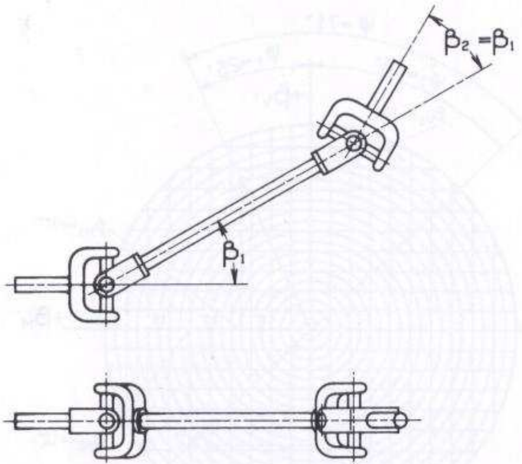
Fig. 15:



6.2 W-Deflection

Here the same applies as for the Z-deflection.

Fig. 16:

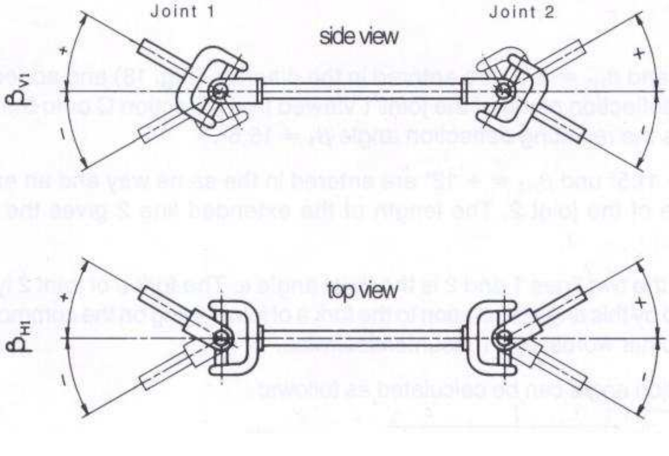


6.3 Physical Deflection

If the two shaft projections viewed from the side show a Z-deflection and from the top a W-deflection or vice versa, there is a physical deflection as shown in Fig. 14.

The resulting deflection angles β_1 and β_2 and the twist angle of the deflection planes can be determined from the deflection angles β_1, β_2, β_{H1}, β_{H2} of the projections in Figs. 17 and 18.

Fig. 17:



Example (graphic process):

An arrangement as shown in Fig. 19 is used. The size and direction of the twist angle φ must be determined.

Fig. 18:

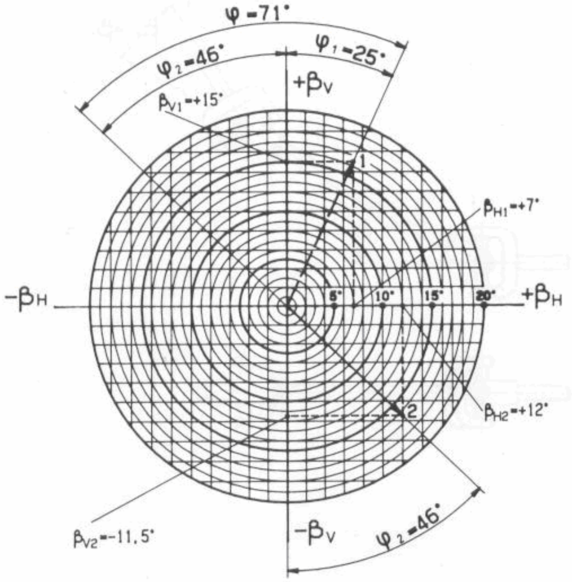
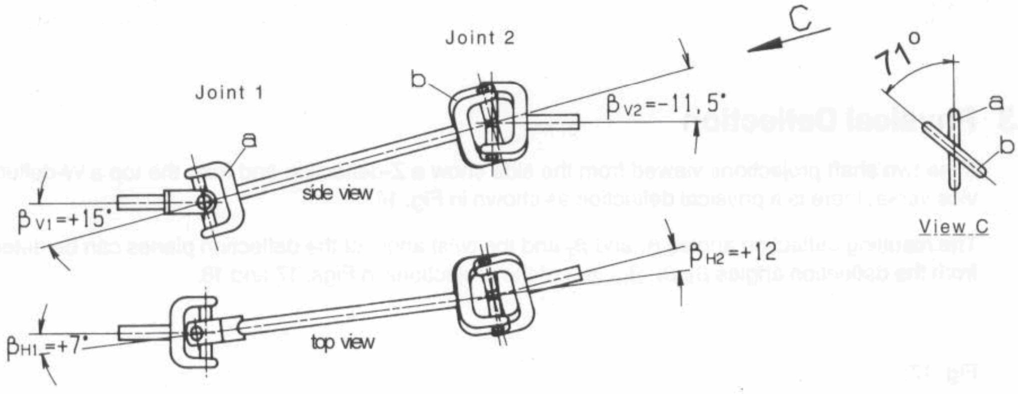


Fig. 19



Values $\beta_{V1} = +15°$ and $\beta_{H1} = +7°$ are entered in the diagram (Fig. 18) and added geometrically. The dotted line 1 is the deflection plane of the joint 1 viewed from direction C onto the shaft. The length of the dotted line gives the resulting deflection angle $\beta_1 = 16{,}5°$.

The angles $\beta_{V2} = -11.5°$ und $\beta_{H2} = +12°$ are entered in the same way and an extended line 2 gives the deflection plane of the joint 2. The length of the extended line 2 gives the resulting deflection angle β_2.

The angle between the two lines 1 and 2 is the tiwst angle φ. The fork b of joint 2 lying on the common shaft must be twisted by this angle in relation to the fork a of joint 1 lying on the common shaft when viewed from direction C. In other words, by 71° counterclockwise.

The resulting deflection angle can be calculated as follows:

$$\tan\beta_1 = \sqrt{\tan^2\beta_{H1} + \tan^2\beta_{V1}}$$

$$\tan\beta_2 = \sqrt{\tan^2\beta_{H2} + \tan^2\beta_{V2}}$$

and the twist angle φ:

$$\tan \varphi_1 = \frac{\tan \beta_{H1}}{\tan \beta_{V1}}$$

$$\tan \varphi_2 = \frac{\tan \beta_{H2}}{\tan \beta_{V2}}$$

$$\varphi = \varphi_1 \pm \varphi_2$$

The sign must be taken from the graphic proces. If is φ greater than 90°, in practice the explement angle is taken.

6.4. Permitted Tolerances

If for design reasons, complete evenness of the deflection angle is not or is not always possible, the following condition should at least be observed:

$$\beta_E = \sqrt{\beta_1^2 - \beta_2^2} \quad \leqq 3^\circ$$

where β_E corresponds to the deflection angle of a single joint which generates the same degree of unevenness as the propeller shaft.

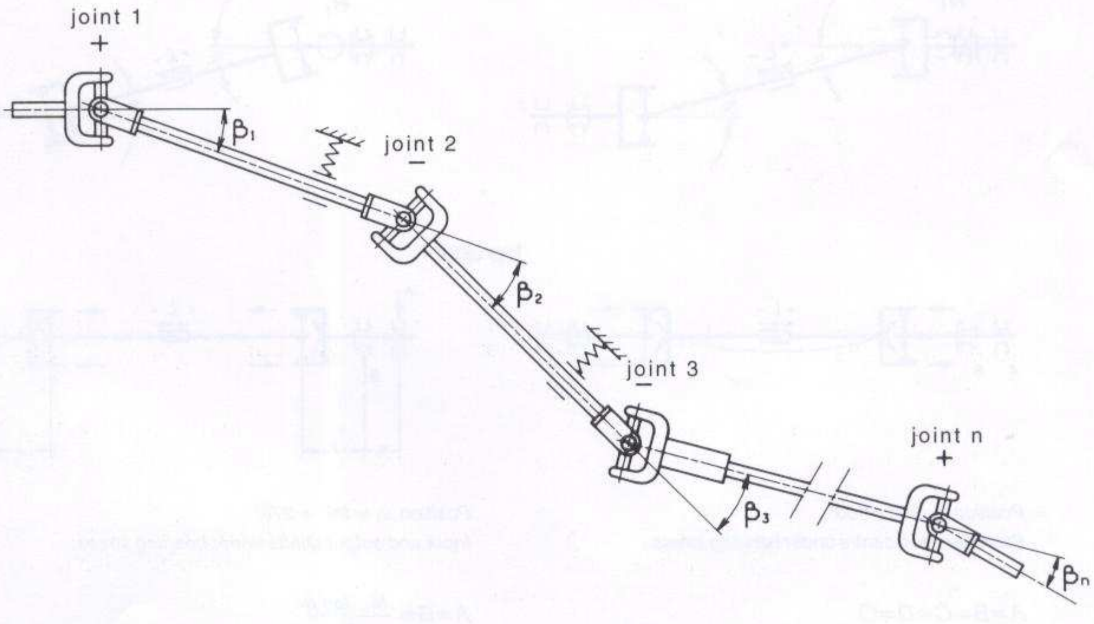
6.5 Multiple Joint Shafts

Multiple joint shafts with 3 or more joints are often used in vehicles. Then

$$\beta_E = \sqrt{\pm \beta_1^2 \pm \beta_2^2 \pm \beta_3^2 \ldots \pm \beta_n^2} \quad \leqq 3^\circ$$

Joints with the same fork position in relation to their deflection plane have the same sign (see Fig. 20).

Fig. 20:



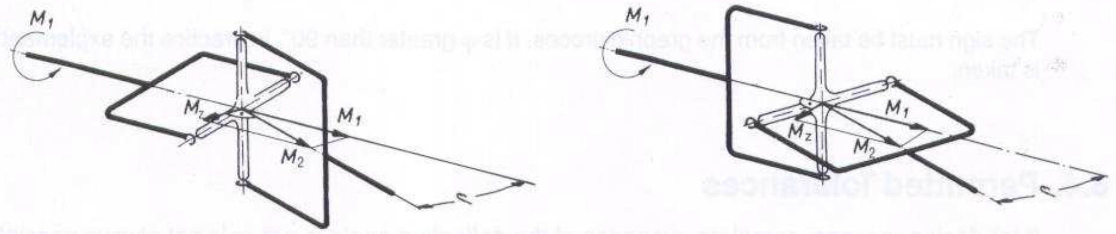
In many cases, even with multiple joint shafts with physical deflection, sufficient compensation can be achieved. Please ask; we would be pleased to advise you.

Further information on propeller shaft kinematics is given in VDI directive 2722.

7. Bearing Forces and Bending Moments

By deflecting the moment in the joint, the additional moment M_Z acts on the fork. For the joint shown in Fig. 21, M_2 and M_Z are calculated by dividing the moments vectors:

Fig. 21:



Position 0° and 180°

$M_2 = M_1 \cdot \cos\beta$

$M_Z = M_1 \cdot \sin\beta$

Position 90° and 270°

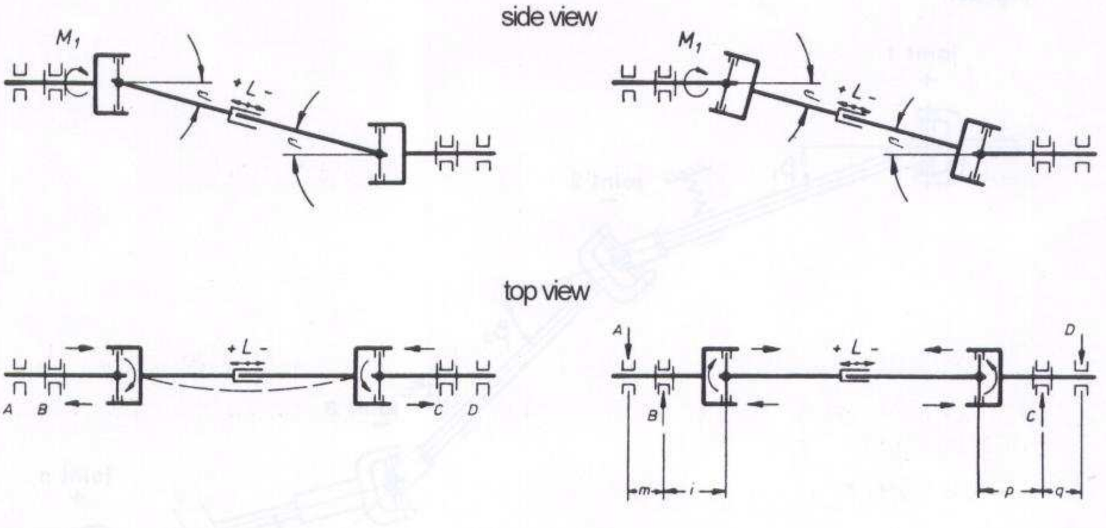
$M_2 = M_1 \cdot \frac{1}{\cos\beta}$

$M_Z = M_1 \cdot \tan\beta$

7.1 Bearing Forces in Z-Arrangement

The additional moment M_Z exerts forces on the bearing which apply bending stresses to the shaft. Fig. 22 shows the additional moments and bearing forces in the 0° and 90° position.

Fig. 22:



Position α_1 = 0° = 180°

Propeller shaft centre under bending stress..

$A{=}B{=}C{=}D{=}O$

Position α_1 = 90° = 270°

Input and output shafts under bending stress.

$$A{=}B{=}\frac{M_1 \cdot \tan\beta}{m}$$

$$C{=}D{=}\frac{M_1 \cdot \tan\beta}{q}$$

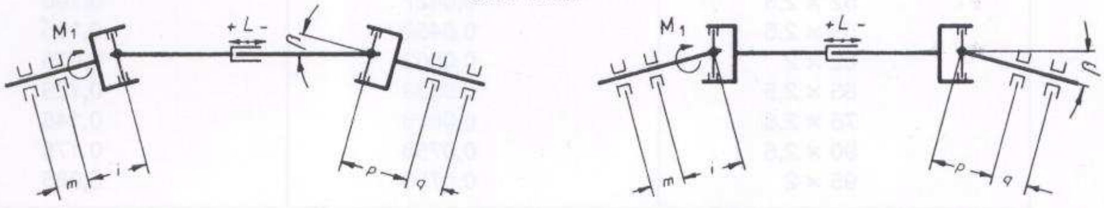
The bearing forces swing between zero and maximum twice per rotation.

7.2 Bearing Forces in W-Arrangement

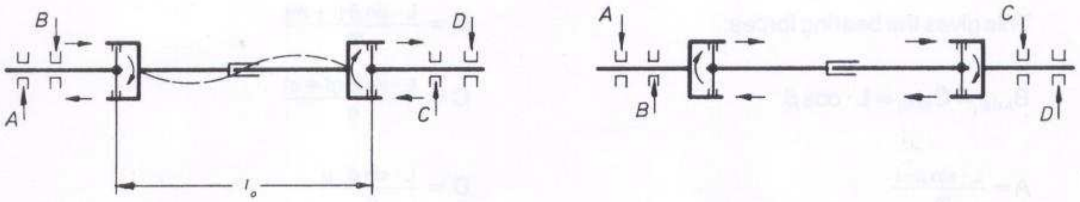
According to Fig. 23, in this arrangement the following additional moments and bearing forces apply:

Fig. 23:

side view



top view



Position $\alpha_1 = 0° = 180°$
Propeller shaft centre and input and output shafts under bending stress.

$$A = \frac{2 \cdot M_1 \cdot \sin\beta \cdot i}{l_O \cdot m}$$

$$B = \frac{2 \cdot M_1 \cdot \sin\beta \cdot (m + i)}{l_O \cdot m}$$

$$D = \frac{2 \cdot M_1 \cdot \sin\beta \cdot p}{l_O \cdot q}$$

$$C = \frac{2 \cdot M_1 \cdot \sin\beta \cdot (p + q)}{l_O \cdot q}$$

Position $\alpha_1 = 90° = 270°$
Input and output shafts under bending stress.

$$A = B = \frac{M_1 \cdot \tan\beta}{m}$$

$$C = D = \frac{M_1 \cdot \tan\beta}{q}$$

The bearing forces swing between minimum and maximum twice per rotation.

7.3 Displacement Force on Propeller Shafts with Length Extension

To displace the sliding piece under the effect of torque, a displacement force L is required which must be supported by the bearing A, B, C, D.

The maximum displacement force is:

$$L = 2 \cdot \mu \cdot M_1 \cdot \left(\frac{1}{d_t \cdot \cos t\,\tau \cdot \cos\beta} + \frac{\tan\beta}{C}\right)$$

where μ = coefficient of friction. For hardened, nitrated and/or phosphatized parts, $\mu = 0.1$ can be assumed; for rilsan-coated parts, $\mu = 0.06$

M_1 = drive torque

d_t = reference diameter of sliding profile (see table)

τ = angle between tooth flank and centre point beam (see table)

C = profile overlap (tooth engagement length, see table).

Table

Profile to DIN 5480	$d_t \cdot \cos \tau$ m	C_{min} m
38 × 2	0,0310	0,072
52 × 2,5	0,0427	0,100
55 × 2,5	0,0452	0,105
62 × 2	0,0503	0,075
65 × 2,5	0,0539	0,125
75 × 2,5	0,0626	0,145
90 × 2,5	0,0758	0,175
95 × 2	0,0789	0,085

This gives the bearing forces:

$$B_{axial} = C_{axial} = L \cdot \cos\beta$$

$$A = \frac{L \cdot \sin\beta \cdot i}{m}$$

$$B = \frac{L \cdot \sin\beta\,(i + m)}{m}$$

$$C = \frac{L \cdot \sin\beta\,(p + q)}{q}$$

$$D = \frac{L \cdot \sin\beta \cdot p}{q}$$

Usually only axial forces are significant.

8. Dimensions of Propeller Shafts

The dimensions of the shaft depend on many factors. The rules below will give an approximate selection. In borderline cases, please consult us. The questionnaires on pages 107 and 109 will help you. We would be pleased to give you advice.

8.1 Selection of Joint Size for Stationary Drives

The part of the propeller shaft which determines its useful life is normally the joint bearing. So the joint size should preferably be determined from the transferable torque of the bearing. The calculation below is based on the standard roller bearing calculation, where the oscillating movement is regarded as replaced by a rotational one.

The dimension for the transferability of the bearing is the joint load rating $T = C \cdot R$, where C is the dynamic transfer capacity of the bearing and R the distance of the bearing centre from the joint centre. The joint load rating is given in the data sheet for the shaft. T_{erf} can be determined using the same equation. It applies to uniform operation, i.e. when the torque M occurs throughout life L_h at rotation speed n and deflection angle β.

$$T_{erf} = M \cdot K \cdot \frac{1}{2 \cdot \cos\beta} \cdot \left(\frac{Lh_{erf} \cdot n \cdot \beta}{46{,}8 \cdot 16667}\right)^{0{,}3} \text{Nm}$$

T_{erf} = necessary joint load rating in Nm

K = shock factor (see table)

β = deflection angle of joint in ° (degrees). For angle $< 3°$, $\beta = 3°$ must always be used.

M = torque to be transferred in Nm

L_{herf} = necessary (required) life in h. This L_h at least is achieved by 90 % of all shafts. The average L_h of all shafts is then 5 times as high.

n = rotation speed of shaft in rpm.

Shock Factors

Drive Unit		K with rubber coupling	K without rubber coupling
Elec. motors		1	1
Motors with converter		1	1
Diesel engine	1-3 cylinders	2	2.5
	4 or more cylinders	1.5	2.0
Petrol engine	1-3 cylinders	1.5	2.0
	4 and more cylinders	1.25	1.75
Compressors	1-3 cylinders	1.25	1.75
	4 and more cylinders	1.15	1.5

Example:

A working machine with a small mass moment of inertia, which assumes a torque of 1 000 Nm at n = 1 450 rpm, should be driven by an electric motor via a shaft running under a deflection angle of 7°. The life should be 2000 h. What joint size is required?

Solution:

Electric motor and impact-free working machine gives an impact factor of 1.0. Then:

$$T_{erf} = 1000 \cdot 1 \cdot \frac{1}{2 \cdot \cos 7^\circ} \cdot \left(\frac{2000 \cdot 1450 \cdot 7}{46{,}8 \cdot 16667} \right)^{0{,}3} = 1339 \text{ Nm}$$

So T_{erf} is found to be 1 339 Nm. From the data sheet, we now select the shaft with the next highest value. If we are to use a shaft of design 008 for example, the type and joint size 008 195 are selected with a joint transfer capacity of 1 460 Nm.

For the joint found, we now check that $\frac{M \cdot K}{\cos \beta} \leqq M_{max}$

$1000 \text{ Nm} \cdot 1{,}0 \leqq 1460 \text{ Nm} \cdot \cos 7^\circ = 1449{,}1 \text{ Nm}$.

The condition is fulfilled, and the shaft can be used. It will achieve a life of:

$$L_h = L_{h\,erf} \cdot \left(\frac{T}{T_{erf}} \right)^{3{,}33} = 2000 \text{ h} \cdot \left(\frac{1460 \text{ Nm}}{1339 \text{ Nm}} \right)^{3{,}33} = 2667 \text{ h}$$

In many applications, in particular in vehicles, the moment, the rotation speed and/or the deflection angle are not constant. We must then try to form classes to which moment, rotation speed and deflection angle can be allocated and determine their time proportions.

For an initial estimated joint size, the individual life can then be assessed for each class:

$$L_{hn} = \left(\frac{2 \cdot T_{vorh} \cdot \cos\beta_n}{M_n \cdot K} \right)^{3{,}33} \cdot \frac{16667 \cdot 46{,}8}{n_n \cdot \beta} \text{ h}$$

Where:

L_{hn} = individual life of class n, where n = 1,2,3...n,

M_n = the moment allocated to class n,

T_{vorh} = joint power factor of estimated joint size,

n_n = rotation speed allocated to class n,

β_n = deflection angle allocated to class n,

See page 92 for other symbols.

From the individual life, the total life can be determined as follows:

$$L = \frac{100\,\%}{\frac{q_1}{L_{h1}} + \frac{q_2}{L_{h2}} + \ldots + \frac{q_n}{L_{hn}}}$$

where:
q = time proportion in %
$L_{h1} \ldots L_{hn}$ = individual life in h.

8.2 Selection of Joint Sizes for Vehicle Drives

In this section, the following symbols are used:

M_{FG} = funcition torque capacity (from data sheet)
M_x = general dimensioning moment for a propeller shaft
M_A, M_B, M_C = dimensioning moment for propeller shafts A, B, C
M_{mot} = general proportional engine torque on propeller shaft
$M_{mot\,max}$ = max. engine torque
$M_{Rad\,x}$ = general proportional wheel adhesion torque at propeller shaft
s = joint bearing safety factor = $1.5 < s < 2.0$
k = shock factor (see table page 93)
μ_R = tyre coefficient of friction = $0.6 < \mu < 1.0$
η = general gear efficiency
η_G = efficiency of engine gear
η_V = efficiency of transfer box
η_A = efficiency of final drive
i_W = theoretical value for converter ratio
i_{WF} = converter brake conversion
$i_{G\,max}$ = max. engine gear ratio (1st gear)
$i_{G\,min}$ = min. engine gear ratio (1st gear)
$i_{V\,max}$ = transfer box ratio (1st gear)
$i_{V\,min}$ = transfer box ratio (nth gear)
i_A = final drive ratio
V = engine torque distribution ratio $\frac{T_{mot\,V}}{T_{mot\,H}}$
R_{dyn} = dynamic rolling radius of tyre
G_V = front axle load; total front axle load
G_{V1} = front axle load, 1st axle
G_{V2} = front axle load, 2nd axle
G_H = rear axle load; total rear axle load
G_{H1} = rear axle load, 1st axle
G_{H2} = rear axle load, 2nd axle

The function torque capacity M_{FG} of the propeller shafts is given in the data sheets in this catalogue. This moment can be transferred by the propeller shaft for short periods at limited load frequency with 0° joint deflection angle.

With a joint deflection angle of $\beta°$, the function limit moment is reduced by the factor $\cos \beta°$.

The function torque capacity M_{FG} must be sufficiently larger than the dimensioning moment M_x

$M_{FG} \geqq 1{,}5 \cdot M_x$.

The dimensioning moments M_x for the propeller shafts between the engine and the final drive are calculated approximately from the moments of the torque M_{motx} exerted by the engine and the adhesion moment M_{radx} exerted by the wheel, as follows:

$$M_x = \frac{M_{motx} \cdot M_{radx}}{2}$$

For propeller shafts A between the engine and the gearbox, the influence of the high rotation speed part and the engine shock factor must be taken into account.

If a converter is fitted, some special features should be observed:

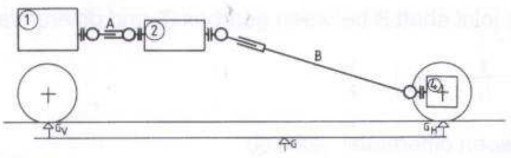
If the propeller shaft is installed between the engine with converter and the gearbox, the impact factor s = 1 must be used. If the propeller shaft is between the engine and gearbox with a converter in front, the effect of the wheel moment = 0.

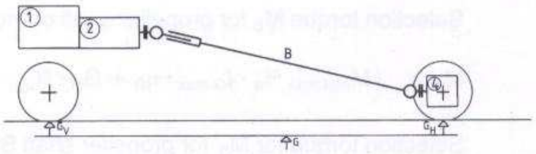
If the brake conversion $i_{WF} < 1.4$, its influence can be ignored, so $i_w = 1$.

If the brake conversion $i_{WF} > 1.4$, its influence must be allowed for by a factor of 0.76, so $i_W = 0.76\ i_{WF}$

8.3 Selection System for Propeller Shafts in Vehicles for Normal Use

Road Vehicle 4 × 2





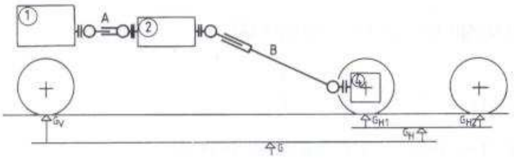
Selection torque for propeller shaft A between engine ① and gearbox ②.

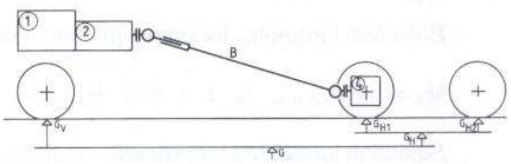
$$M_A = (M_{mot\,max} \cdot i_W \cdot s \cdot k \cdot + G_H \cdot R_{dyn} \cdot \mu_R \cdot \frac{1}{i_A \cdot i_{Gmin}} \cdot \eta_G \cdot \eta_A) \cdot \frac{1}{2}$$

Selection torque for propeller shaft or multiple joint shaft B between gearbox ② and differential ④.

$$M_B = (M_{mot\,max} \cdot i_W \cdot i_{G\,max} \cdot \eta_G + G_H \cdot R_{dyn} \cdot \mu_R \cdot \frac{1}{i_A} \cdot \eta_A) \cdot \frac{1}{2}$$

Road Vehicle 6 × 2





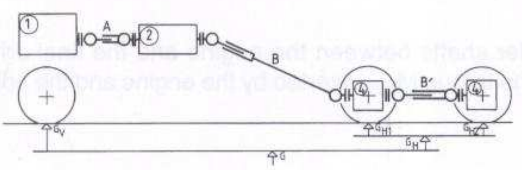
Selection torque for cardan shaft A between engine ① and gearbox ②.

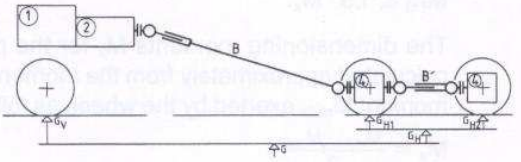
$$M_A = (M_{mot\,max} \cdot i_w \cdot s \cdot k \cdot + G_{H1} \cdot R_{yn} \cdot \mu_R \cdot \frac{1}{i_A \cdot i_{Gmin}} \cdot \eta_G \cdot \eta_A) \cdot \frac{1}{2}$$

Selection torque for propeller shaft or multiple joint shaft B between gearbox ② and differential ④

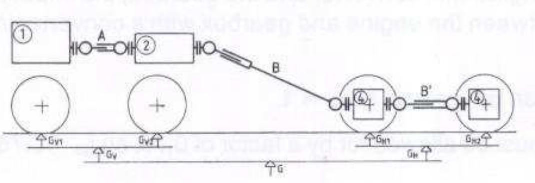
$$M_B = (M_{mot\,max} \cdot i_W \cdot i_{G\,max} \cdot \eta_G + G_{H1} \cdot R_{dyn} \cdot \mu_R \cdot \frac{1}{i_A} \cdot \eta_A) \cdot \frac{1}{2}$$

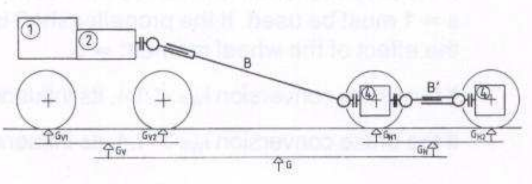
Road Vehicle 6 × 4





and Road Vehicle 8 × 4





Selection torque M_A for propeller shaft A between engine ① and gearbox ②

$$M_A = \left(M_{\text{mot max}}\, i_w \cdot s \cdot k + G_H \cdot R_{\text{dyn}} \cdot \mu_R \cdot \frac{1}{i_A \cdot i_{G\,\text{min}}} \cdot \eta_G \cdot \eta_A\right) \cdot \frac{1}{2}$$

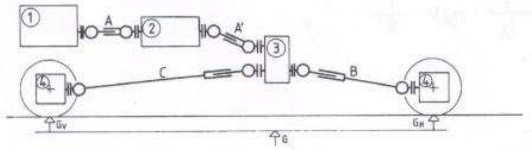
Selection torque M_B for propeller shaft or multiple joint shaft B between gearbox ② and differential ④

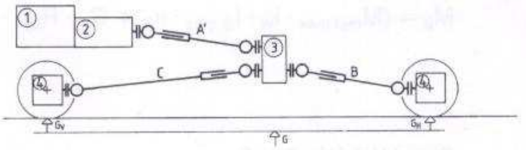
$$M_B = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,\text{max}} \cdot \eta_G + G_H \cdot R_{\text{dyn}} \cdot \mu_R\, \frac{1}{i_A} \cdot \eta_A\right) \cdot \frac{1}{2}$$

Selection torque for $M_{B'}$ for propeller shaft B' between differential gears ④

$$M_{B'} = \left(M_{\text{mot max}}\, i_w \cdot i_{G\,\text{max}} \cdot \eta_G + G_{H2} \cdot R_{\text{dyn}} \cdot \mu_R \cdot \frac{1}{i_A} \cdot \eta_A\right) \cdot \frac{1}{2}$$

All-Wheel Drive 4 × 4





Selection torque M_A for propeller shaft A between engine ① and gearbox ②.

$$M_A = \left(M_{\text{mot max}} \cdot i_w \cdot s \cdot k + G \cdot R_{\text{dyn}} \cdot \mu_R \cdot \frac{1}{i_A \cdot i_{G\,\text{min}} \cdot i_V} \cdot \eta_A \cdot \eta_G \cdot \eta_V\right) \cdot \frac{1}{2}$$

Selection torque $M_{A'}$ for propeller shaft A' between gearbox ② and transfer box ③.

$$M_{A'} = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,\text{max}} \cdot \eta_G + G \cdot R_{\text{dyn}} \cdot \mu_R \cdot \frac{1}{i_A \cdot i_{V_{\text{min}}}} \cdot \eta_A \cdot \eta_V\right) \cdot \frac{1}{2}$$

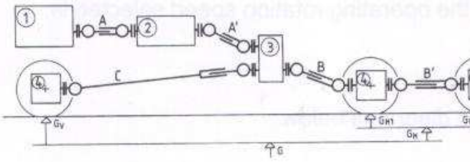
Selection torque M_B for propeller shaft or multiple joint shaft B between transfer box ③ and differential gears ④

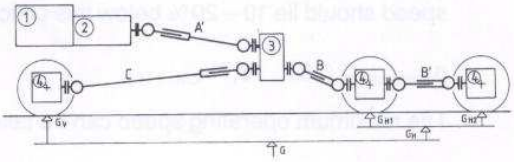
$$M_B = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,\text{max}} \cdot i_{V_{\text{max}}} \cdot \eta_G \cdot \eta_V \cdot \frac{V}{1+V} + G_H \cdot R_{\text{dyn}} \cdot \mu_R \cdot \frac{1}{i_A} \cdot \eta_A\right) \cdot \frac{1}{2}$$

Selection torque M_C for propeller shaft C between transfer box ③ and differential gears ④

$$M_C = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,\text{max}} \cdot i_{V_{\text{max}}} \cdot \eta_G \cdot \eta_V \cdot \frac{1}{1+V} + G_V \cdot R_{\text{dyn}} \cdot \mu_R \cdot \frac{1}{i_A} \cdot \eta_A\right) \cdot \frac{1}{2}$$

All-Wheel Drive 6 × 6





Selection torque M_A for propeller shaft A between engine ① and gearbox ②.

$$M_A = \left(M_{\text{mot max}} \cdot i_w \cdot s \cdot k + G \cdot R_{dyn} \cdot \mu_R \cdot \frac{1}{i_A \cdot i_{G_{min}} \cdot i_{V_{min}}} \cdot \eta_A \cdot \eta_G \cdot \eta_V \right) \cdot \frac{1}{2}$$

Selection torque $M_{A'}$ for propeller shaft A' between gearbox ② and transfer box ③.

$$M_{A'} = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,max} \cdot \eta_G \cdot + G \cdot R_{dyn} \cdot \mu_R \cdot \frac{1}{i_A \cdot i_{V_{min}}} \cdot \eta_A \cdot \eta_V \right) \cdot \frac{1}{2}$$

Selection torque M_B for propeller shaft or multiple joint shaft B between transfer box ③ and differential gears ④

$$M_B = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,max} \cdot i_{V_{max}} \cdot \eta_G \cdot \eta_V \cdot \frac{V}{1+V} + G_H \cdot R_{dyn} \cdot \mu_R \cdot \frac{1}{i_A} \cdot \eta_A \right) \cdot \frac{1}{2}$$

Selection torque $M_{B'}$ for propeller shaft B' between differential gears ④

$$M_{B'} = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,max} \cdot i_{V_{max}} \cdot \eta_G \cdot \eta_V \cdot \frac{V}{1+V} \cdot \frac{1}{2} + G_{H2} \cdot R_{dyn} \cdot \mu_R \cdot \frac{1}{i_A} \cdot \eta_A \right) \cdot \frac{1}{2}$$

Selection torque M_C for propeller shaft C between transfer box ③ and differential gears ④

$$M_C = \left(M_{\text{mot max}} \cdot i_w \cdot i_{G\,max} \cdot i_{V_{max}} \cdot \eta_G \cdot \eta_V \cdot \frac{1}{1+V} + G_V \cdot R_{dyn} \cdot \mu_R \frac{1}{i_A} \cdot \eta_A \right) \cdot \frac{1}{2}$$

These selections will avoid major dimensioning errors. However, they disregard important influences on the useful life such as deflection angle, rotation speed, loading, effect of dirt, temperature etc. For example, halving the deflection angle doubles the life, as 9.1 shows.

⚠ Please therefore use our questionnaire. We recommend the correct joint size using our computer program.

8.4 Critical Rotation Speed

The propeller shaft found from dimensioning specifications 8.1, 8.2 or 8.3 must now be checked for bending-critical rotation speed.

In general, propeller shafts run uncritically, i.e. their operating speed is below the critical speed. The critical speed for propeller shafts with steel tube is calculated from the equation:

$$n_{\text{crit tube}} = 1{,}22 \cdot 10^8 \cdot \frac{1}{l_o^2} \cdot \sqrt{D^2 + d^2}\ \text{min}^{-1}$$

where D = tube external diameter, d = internal diameter and l_o = free length between the joints or centre bearing assemblies all in mm.

If special propeller shafts are produced with steel rotating rod, calculate the critical rotation speed as

$$n_{\text{crit rod}} = 1{,}22 \cdot 10^8 \cdot \frac{D}{l_o^2}\ \text{min}^{-1}$$

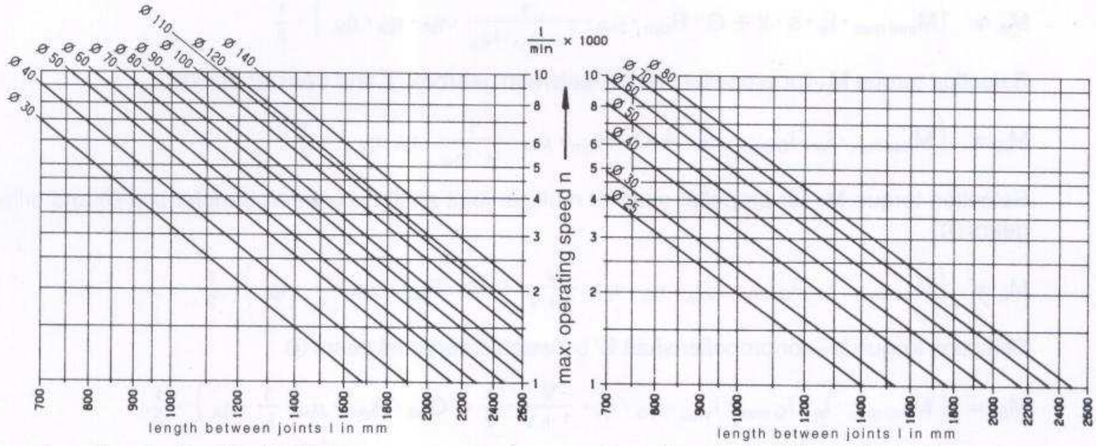
where D = rod diameter and l_o = free length, all in mm.

These equations apply for smooth tubes or rods. propeller shafts only achieve around 80 – 90 % of this speed because of play in bearings and sliding pieces and additional dimensions. As the max. operating speed should lie 10 – 20 % below this critical speed, the operating rotation speed selected is:

$n_{operation} \leqq 0{,}6 \ldots 0{,}7\ n_{crit}$

The maximum operating speed can be taken from the diagrams below.

Fig. 24:



Propeller shaft with steel tube

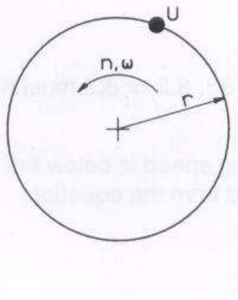
Propeller shaft with steel rotating rod

If the maximum operating speed is not sufficient, a larger tube diameter or rod design with centre bearings should be used.

8.5 Balancing Propeller Shafts

Propeller shafts for drive shafts in the automotive industry are dynamically balanced. Balancing is the equalization of weight of eccentrically running masses (Fig. 25) in the propeller shaft to achieve quiet running and reduce load on the joints and bearings in the connected assemblies.

Fig. 25:



Definition of imbalance:

Imbalance $U = u \cdot r$ in gmm
where u = unequalized individual mass on radius r

Shifting of centre of gravity

$\varepsilon = \frac{u \cdot r}{G} = \frac{U}{G}$ in gmm/kg.

where G = weight of part to be balanced.

Sensible Values for Permitted Imbalance

Practical experience has shown that as the rotation speeds increase, a smaller shift in the centre of gravity can be permitted. It is therefore sensible to take the product of rotation speed x shift in centre of gravity as a value for the permitted imbalance. DIN ISO 1940 "Requirements for balance qualitites of rigid rotors" is also based on this concept. A table there gives "quality classes" for different components, where it has been assumed that there is no point in balancing the different elements (wheels, rims, wheel sets, crankshaft components, shafts etc.) of a closed machine group, e.g. a vehicle, to widely differing quality classes.

According to DIN ISO 1940, propeller shafts should comply with class G40 ($\varepsilon \cdot \omega = 40$ mm/s), and propeller shafts for special requirements, class G16 ($\varepsilon \cdot \omega = 16$ mm/s).

Unless the customer specifies otherwise, the shafts are balanced at the maximum rotation speed to quality class G16. The permitted residual imbalance is determined from the equation below:

$$u = 99363 \cdot \frac{G}{n_{bal} \cdot d} \quad \text{in g per side}$$

where: u = permitted unequalized individual mass per side in g
G = shaft weight in kg
n_{bal} = balancing rotation speed in rpm
d = tube diameter in mm

Example:
Shaft of 44 kg, $n_{bal} = 3\,500$ rpm,
Tube diameter 90:

$$u = 99363 \cdot \frac{44}{3\,500 \cdot 90} = \underline{13{,}8\ \text{g}} \text{ unequalized individual mass per side}$$

As repeated clamping gives different values due to play, the values of the equation only correspond 65 % to the value permitted under DIN ISO 1940. In test runs with repeated clamping therefore, 135 % of the value given in DIN ISO 1940 is permitted, i.e. approximately double the equation value.

8.6 Mass Acceleration Moments – Influence of Rotation Speed and Deflection Angle

In order to achieve adequate smooth running of the propeller shaft, the mass acceleration moment of the centre part between the joints must not be too large. The mass acceleration moment depends on the mass moment of inertia of the centre part, the rotation speed n and the deflection angle of the joint. The permitted size of the mass acceleration moment increases with the moment transferability of the joint, i.e. as the joint power factor T increases, the permitted mass acceleration moment M_ε also increases.

For propeller shafts in goods vehicles, depending on requirements, installation conditions and sprung mass system, the specific mass acceleration moment

$$M_{\varepsilon\,spec} = 0{,}04 \text{ bis } 0{,}06 \ \frac{\text{Nm}}{\text{Nm.}}$$

If sound radiation is taken into account (buses etc.), the specific mass moment of acceleration $M_{\varepsilon\,spec}$ must be smaller; if humming noise is of secondary importance, $M_{\varepsilon\,spec}$ can be lager.

The specific mass acceleration moment $M_{\varepsilon\,spec}$ is the quotient of the mass acceleration moment of the centre part and the joint power factor T.

$$M_{\varepsilon\,spec} = \frac{M_\varepsilon}{T}$$

where $M_\varepsilon = \varepsilon \cdot J_m$

and $\varepsilon = \left(\frac{n \cdot \pi}{30}\right)^2 \cdot \frac{\sin^2\beta \cdot \cos\beta \cdot \sin 2\alpha}{(1 - \sin^2\beta \cdot \sin^2\alpha)}$ in s^{-2}

with β = deflection angle of joint α = rotation angle position of propeller shaft (ε_{max} at $\alpha \approx 45°$),
n = rotation speed of shaft in rpm and J_m = mass moment of inertia of shaft centre part in Nms^2.

The table below was produced from these equations and gives the max. $n \cdot \beta$ value for propeller shafts of centre length 1.5 m as approximate values.

Joint Size	n_{max} rpm	$n \times \beta$ rpm · degree
196	5500	28000
200	5500	34000
253	5000	24000
375	4800	21000
376	4800	19000
411	4600	19000
490	4400	17500
491	4500	17500
590	4000	16000
600	4200	18000
610	4000	17000
620	4000	16000
680	3800	15000
700	3700	16000
710	3600	14000

How far these values can be exceeded depends on the requirements for smooth running and many peripheral conditions. With favourable sprung mass systems, the values can be exceeded up to 50 %.

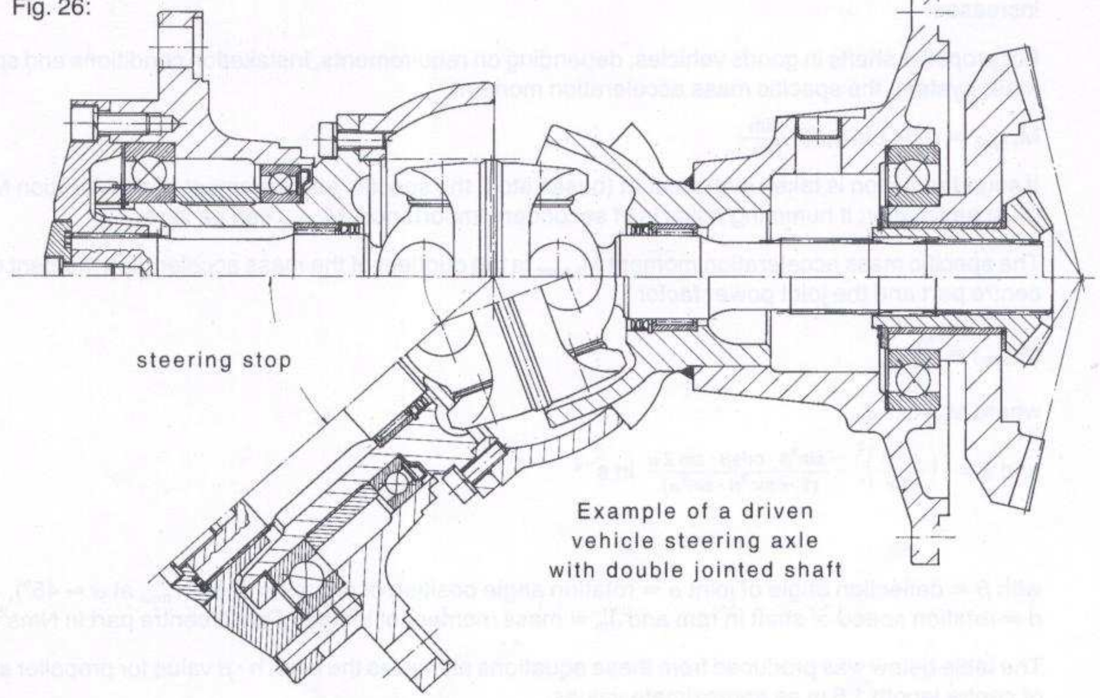
8.7 Measures to Improve Smoothness of Running

To reduce the radiated noise (gears or axle noise), the propeller shaft can be fitted with a cardboard tube pressed into the shaft tube. This effectively damps the higher frequencies.

9. Features of the Double Joint

Double joints are used to drive steerable rigid axles. Their main area of application is all-wheel drive goods vehicles. The dimensioning criteria below therefore relate to this area.

Fig. 26:



9.1 Axial Movement of Drive Shaft on Turning

In Fig. 27, 1 represents the fixed bearing driven shaft, 2 the mobile bearing drive shaft. A and B are joint bearings, 0 is the pivot pin axle.

If the joint is fitted such that rotation point 0 of the pivot pin axle agrees with centre point M of the extended joint, with the joint bent by deflection angle β, unequal deflection angles β_1 and β_2 occur and hence unequal transmission as shown in Fig. 29 curve $\beta_0 = 0°$ and $y = 0$.

Fig. 27:

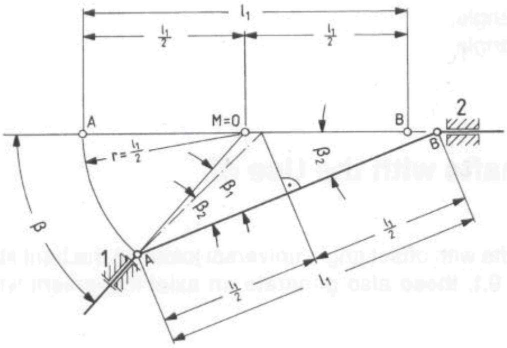
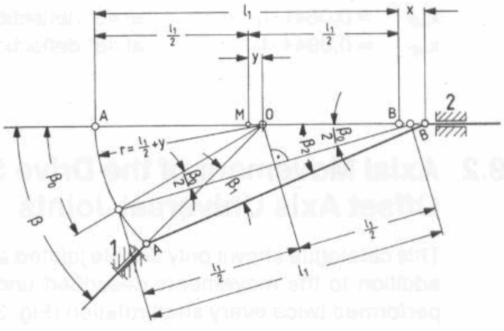
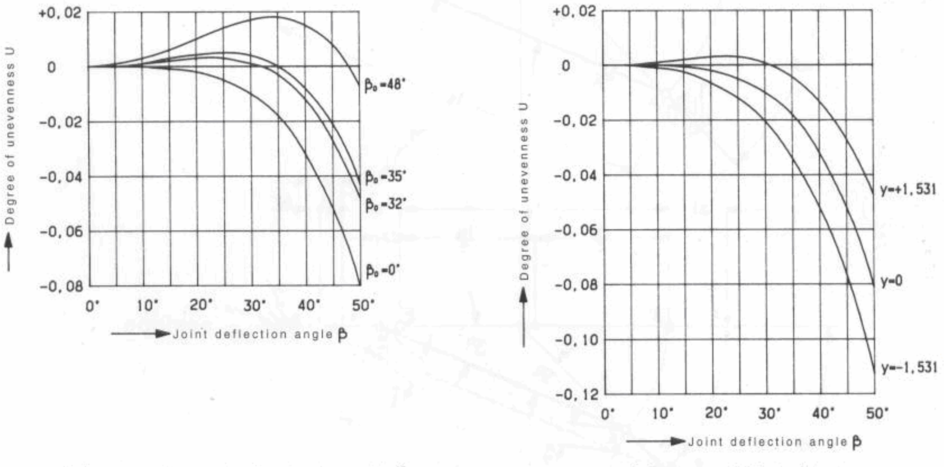


Fig. 28:



Now by offsetting the centre M of the extended joint by a dimension y in the direction of the fixed bearing, a specific deflection angle can be made to give constant velocity (Fig. 28). A constant velocity angle β_o of 32° – 35° is favourable, as this gives the minimum unevenness the entire deflection angle range (Fig. 29).

Fig. 29:



Influence of constant velocity angle β_o on degree of unevenness U

Influence of joint offset y on degree of unevenness U

The offset y to be applied in order to achieve totally constant velocity at deflection angle β_o is:

$$y = \frac{l_1}{2}\left(\frac{1}{\cos\frac{\beta_o}{2}} - 1\right)$$

When the joint is deflected, an axial displacement of the drive shaft 2 occurs, so this must therefore have mobile bearings. The maximum axial displacement is:

$$x = l_1 \left(\frac{\sin\left(90 + \frac{\beta}{2} - \arcsin \frac{\sin\beta}{2 \cdot \cos\frac{\beta_0}{2}}\right)}{\cos\frac{\beta}{2}} - 1 \right)$$

With a constant velocity angle of 32°:

$y_{32°} = 0{,}02 \cdot l_1$

and

$x_{40°} = 0{,}0641 \cdot l_1$ at 40° deflection angle,

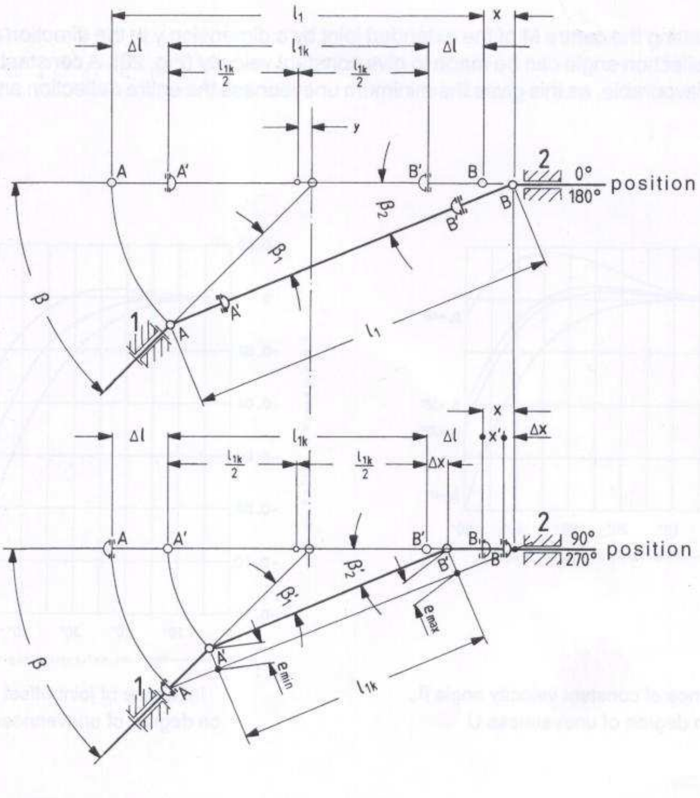
$x_{48°} = 0{,}0944 \cdot l_1$ at 48° deflection angle.

9.2 Axial Movement of the Drive Shafts with the Use of Offset Axis Universal Joints

This catalogue shows only double jointed shafts with offset angle universal joints. In the bent state, in addition to the movements described under 9.1, these also generate an axial movement which is performed twice every shaft rotation (Fig. 30).

In the 0° and 180° positions of the double joint, the axis offsets $\underline{\Delta l}$ ($\overline{AA'}$ and $\overline{BB'}$) are added linearly to the joint spacing l_{1k} ($\overline{A'B'}$).

Fig. 30:



In the 90° and 270° position of the double joint, the axis offsets Δl are added to the joint spacing l_{1K} according to the directions of the individual deflection angles β_1' and β_2'.

The difference ΔX of these sums is the movement described by the drive shaft of the double jointed shaft twice per rotation. This must be taken into account in the dimensions.

Movement travel $\Delta X = X - X'$

X is the displacement of the double joint in the 0° and 180° position as produced also in the double shaft without offset axis joints.

X' is the displacement produced when on deflection of the joint in the 180° and 270° position of the double jointed shaft with offset joints, due to the shorter joint interval.

$$X' = l_{1k} \cdot \left(\frac{\left(\sin\ 90 + \frac{\beta}{2} - \arc\sin \left(\left(\frac{1}{2} + \frac{l_1}{l_{1k}} \cdot \frac{1}{2} \cdot \left(\frac{1}{\cos\frac{\beta o}{2}} - 1 \right) \right) \cdot \sin\beta \right) \right)}{\cos\frac{\beta}{2}} - 1 \right)$$

With a constant velocity angle of 32°, assuming that $\Delta l = 0.1\ l_1$ and thus:

$l_{1k} \quad = l_1 - 2 \cdot \Delta L$

then

$X'_{40^\circ} \quad = 0.0756 \cdot l_{1k}$

Thus for movement travel ΔX:

$\Delta X_{40^\circ} \quad = 0.0641 \cdot l_1 - 0.0513 \cdot l_{1k}$

$\Delta X_{48^\circ} \quad = 0.0944 \cdot l_1 - 0.0756 \cdot l_{1k}$

The axial movement of the drive shafts takes place in the area of the axial movement of the deflection, i.e. the cardan shaft is “shortened” twice per rotation.

9.3 Centre Displacement of Fork Head (Carrier Ring) with Deflected Joint

When designing the space required for the yoke, it must be noted that, in addition to the deflection and axial movement, its centre is displaced twice per rotation. The centre displacement e is greater on the drive shaft side than on the driven shaft side.

For the drive shaft side:

$$e_{max} = (\Delta l + \Delta X) \cdot \sin\beta_2'$$

where the input drive deflection angle β_2' is calculated as follows:

$$\beta_2' = \arc\sin \left(\left(\frac{1}{2} + \frac{l_1}{l_{1k}} \cdot \frac{1}{2} \cdot \left(\frac{1}{\cos\frac{\beta_o}{2}} - 1 \right) \right) \cdot \sin\beta \right)$$

For the driven shaft side:

$$e_{min} = \Delta l \cdot \sin\beta_1'$$

where the drive deflection anglel β_1' is the difference between the total deflection angle β and the input drive deflection angle β_2'.

So $\beta_1' = \beta - \beta_2'$

10. Dimensions of Double Jointed Shafts – Selection of Joint Sizes

The selection torque for determining the double joint size is calculated from the engine moment distribution and the maximum gear ratio, including the differential gear ratio.

The load from the wheel adhesion torque, determined by the axle load, tyre rolling radius, coefficient of friction and possibly final drive ratio, must be checked.

$$M_{\text{shaft mot}} = M_{\text{mot max}} \cdot i_{\text{g max}} \cdot i_{\text{V max}} \cdot \eta_g \cdot \eta_V \cdot \frac{1}{1+V} \cdot i_D \cdot \eta_D$$

$$M_{\text{shaft Rad}} = G_x \, R_{\text{dyn}} \cdot \mu_R \cdot \frac{1}{i_R} \cdot \eta_R$$

Formulae symbols in addition to 8.2:

i_D = differential gear ratio
i_R = final drive ratio
η_R = efficiency of final drive
η_D = efficiency of differential gears

The lower of the two torques must not exceed the nominal moment of the double jointed shaft.

The double jointed shaft determined in this way has an adequate life as the time proportion of maximum load is usually very low.

If the vehicle is driven mainly or exclusively via driven steering axles, the life must be checked. In these cases, we recommend making the selection on the basis of the collective load in collaboration with us.

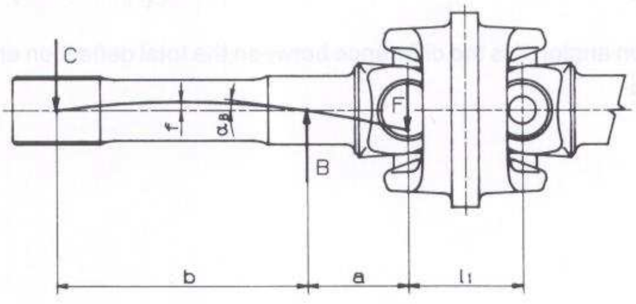
The transferability of double jointed shafts decreases as the deflection angle increases. This limitation is usually insignificant as in practice the maximum engine torque is not transmitted at full steering lock of the wheels for technical reasons.

10.1 Load on Shaft Bearings

Double jointed shafts must be supported on bearings on both shaft halves immediately next to the joint, where the driven shaft or wheel hub pin is axially fixed and the drive shaft must be axially mobile (see sections 9.1 and 9.2).

When the moment is transferred, additional forces are generated which must be taken into account in the dimensioning of the shaft bearings.

Fig. 31:



According to section 7.2, the bearing forces are calculated as follows (Fig. 31.)

Bearing load in B:

$$B = \frac{2 \cdot M \cdot \sin\frac{\beta}{2} \cdot (a+b)}{l_1 \cdot b}$$

Bearing load in C:

$$C = \frac{2 \cdot M \cdot \sin\frac{\beta}{2} \cdot a}{l_1 \cdot b}$$

The axle shaft which is normally longest in practice (drive shaft) should therefore not be dimensioned from the torque, but because of the bending must be stronger. Bearing B should be either an adjustable ball bearing or must have a small bearing width so that the oblique position α_B can be supported by the bearing without constraint.

The elastic flexion is determined as follows:

$$f_1 = \frac{2 \cdot M \cdot \sin\frac{\beta}{2} \cdot a \cdot b^2}{l_1 \cdot 9 \cdot \sqrt{3} \cdot E \cdot J}$$

The oblique position of the shaft bearing is:

$$\text{arc tan}\ \alpha_B = 0{,}1925 \cdot \frac{f_1}{b}$$

The loading conditions on the driven shaft (wheel hub pin) are similar. The flexion here is usually irrelevant because of the shorter lengths.

11. Safety Notes

- Selection, transport, storage, installation, maintenance and repair of a propeller shaft require specialist knowledge and may only be carried out by experts.
- The EC-Machine Directive must be observed.
- The most important safety notes in the text above are marked ⚠

The following should also be noted:

- The operating data established in selection of the propeller shaft, such as torques, rotation speeds, deflection angles, lengths, temperatures etc., must not be exceeded.
- The delivery state of the propeller shaft must not be modified.
- If people or safety-critical components such as electric leads, brake lines, hydraulic pipes or fuel pipes are in the tangential area of the propeller shaft, where necessary covers or protective brackets etc. must be fitted or equivalent security provided by appropriate engineering measures.

Questionnaire for Vehicles

To

Eugen Klein GmbH
Gelenkwellen
Parkstraße 27–29

D-73734 Esslingen

Company: ______
Dept.: ______
Contact: ______
Address: ______
______
Tel.: ______
Fax: ______

Description of application: ______

Vehicle model: ______ Type ______

Wheels × drive wheels: ☐ 4 × 2 ☐ 6 × 2 ☐ 4 × 4 ☐ 6 × 4 ☐ 6 × 6 ☐ 8 × 4 ☐ 8 × 6

Operating conditions/ traffic type: ☐ town ☐ scheduled ☐ suburban ☐ long-distance site ☐ building site

Drive machine: ☐ diesel engine ☐ petrol engine ☐ electric motor

Max. power: kW rpm Max. torque Nm rpm

Coupling: ☐ mech. ☐ hydr. converter ☐ | Stall ratio i_{WF} = | Stall torque Nm

Gears: ☐ mech. ☐ autom. 1st gear ig max. nth gear ig max.

Transfer box: tvert min = tvert max = | Moment distribution = FA % / RA % | Transfer lock ☐ yes ☐ no

Final drive: Iaxle = Idiff × Iwheel Idiff = Iwheel = Differential lock: ☐ yes ☐ no

Tyres: Type: radius = m coef. fric. =

Max. axle load: Front: 1st var: t 2nd: t 3rd: t 4th: t
Rear: 1st var: t 2nd: t 3rd: t 4th: t

Install. dimensions: Length between flanges: ______ mm Required lengh extension: ______ mm
Operating deflection angle: ______ °

Connection flange: ☐ for ISO 7646 ☐ for ISO 7647 ☐ to ISO 12667
flange-Ø ______ mm centring-Ø ______ mm
Screw holes: Number: ______ × hole-Ø ______ mm

Sketch installation limits for propeller shaft.

For multi-axle vehicles, please send a drive diagram showing all technical data in your possession to calculate the necessary joint sizes and determine the necessary propeller shaft connection flange.

Questionnaire for Stationary or Similar Drives

To

Eugen Klein GmbH
Gelenkwellen
Parkstraße 27–29

D-73734 Esslingen

Company: ____________________
Dept.: ____________________
Contact: ____________________
Address: ____________________
____
Tel.: ____________________
Fax: ____________________

Description of application: ____________________
____

Drive machine: ☐ Elec. motor ☐ Diesel engine ☐ Petrol engine ☐ Turbine

Previous element: ☐ elast coupling ☐ rigid coupling ☐ converter ☐ gears

Drive machine: ☐ compressor ☐ reciprocating pump ☐ generator ☐ fan

Application conditions: ☐ permanent use ☐ intermittent use ☐ reversing use

Ambient conditions: __________ C min. temperature __________ C max. temperature

☐ no soiling ☐ slight soiling ☐ heavy soiling

type of soiling: ____________________

Maintenance: ☐ no ☐ yes lubricating interval = __________ h

Operating data: Transfer torque = __________ Nm Transfer speed = __________ rpm

Operating deflection angle = __________ ° Life required = __________ h

For known loads, give the moments, deflection angles, rotation speeds and time proportions.

Install. dimensions: Length between flanges: __________ mm Required length extensions: __________ mm

Connection flange: ☐ for ISO 7646 ☐ to ISO 7647 ☐ to ISO 12667

flange-Ø __________ mm centring-Ø __________ mm

Screw holes: Number: __________ × hole-Ø __________ mm

Installation space: Screws – can be inserted from joint side? ☐ no ☐ yes

Sketch installation limits for propeller shaft.

Editor:
Eugen Klein GmbH, D-73734 Esslingen,Germany
Pictures:
DAF-Trucks N.V., Eindhoven, Niederlande
Grove Europe Limited, Sunderland, England
IVECO-Magirus AG, Ulm/Donau
Kramer-Werke GmbH, Überlingen/Bodensee
MAN- Nutzfahrzeuge AG, München
Mercedes Benz AG, Gaggenau
Mercedes Benz AG, Wörth
Scheuerle Fahrzeugfabrik GmbH, Pfedelbach
Vestas Windmühlen, Dänemark

– KLEIN Propeller Shafts Germany — KLEIN Propeller Shafts Germany — KLEIN Propeller Shafts Germa

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