Renk-Maag's Standard Calculation Method for the Sizing of Thrust Bearings for High Speed Gears

Base Definitions:

External thrust loads:

The external thrust loads are calculated in accordance with the catalog value from KOP-FLEX multiplied by 1.5 to cover the possible range of alternative coupling designers and manufacturers reasons because not all diaphragm couplings (other manufacturer) have the same axial force (see figure 1).

Internal thrust loads:

Internal thrust loads are generated by the internal gear mesh. The actual values are published on the API data sheets for a given application.

Calculation example:

- The following data is given on the gear data sheet:

Given External Thrust Load:

a) The gear layout program has selected the following KOP-FLEX couplings and the relevant MAX external axial coupling thrust is calculated:
   - pinion shaft RM 453: 1'300 lb * 1.5 * (4.448 conversion) = 8'675 N
   - gear shaft RM 554: 3'000 lb * 1.5 * (4.448 conversion)= 20'018 N

Given internal load value:

b) From the gear layout program is: 25'707 N

Pinion shaft tilting-pad thrust bearing:

c) 8 pads with an area of 13'100 mm^2

Wheel shaft tilting-pad thrust bearing:

d) 8 pads with an area of 18'600 mm_2

- So thrust bearing loads are calculated as follows:

Pinion shaft: 8 pads with an area of 13'100 mm^2
The actual loading is therefore: (25'707 N + 8'675 N) / 13'100 mm^2 = 2.63 N/mm^2

- The allowable spec. load indicated in the GLACIER catalog is 3.6 N/mm^2.

Gear shaft: 8 pads with an area of 18'600 mm^2
The actual loading is therefore: (25'707 N + 20'018 N) / 18'600 mm^2 = 2.46 N/mm^2

- The allowable spec. load indicated in the GLACIER catalog is 3.7 N/mm^2.

In this example the actual loading of both thrust bearings are well below the allowable values even with an increased coupling thrust calculation.

Note: The maximum load figures published by Glacier below complies with API 613 par. (2.7.3.3) i.e. it corresponds to no more than 50% of the bearing's "ultimate" load capability. See letter below from Glacier.

Figure 1: The external thrust loads can be extracted from the Kop-Flex Coupling Selection Guide on the following page:

Axial and Angular Data

AXIAL DATA

3 Bolt Series Axial Displacement

Size	Axial Displacement Max Continuous (in) ①	Max Force (lb)	Max Springrate (lb/in)	Floating Weights (lb) 18" Shaft Separation RM	RZ	MS	MP
103	±0.080	120	3000	8.7	8.9	5.5	5
153	±0.115	270	4800	13	13	10	10
203	±0.140	360	5200	20	19	13	12
253	±0.170	430	5400	30	27	19	17
303	±0.200	610	6400	43	40	28	25
353	±0.230	870	8000	63	59	41	36
403	±0.260	1100	9300	90	82	58	51
453	±0.285	1300	9600	120	110	71	62

4 Bolt Series Axial Displacement

Size	Axial Displacement Max Continuous (in) ①	Max Force (lb)	Max Springrate (lb/in)	Floating Weights (lb) 18" Shaft Separation RM	RZ	MS	MP
154	±0.080	396	10000	15	14	11	9.8
204	±0.100	570	11000	23	19	13	12
254	±0.120	640	11000	32	27	20	17
304	±0.140	900	13000	48	41	30	25
354	±0.160	1300	17000	73	60	44	37
404	±0.180	1700	19000	100	84	62	53
454	±0.200	1900	20000	140	110	77	64
504	±0.230	2500	23000	160	130	96	78
554	±0.250	3000	25000	240	180	130	100
604	±0.270	3300	26000	270	220	160	120
704	±0.320	4900	32000	—	370	—	220
804	±0.365	7100	41000	—	510	—	300

5 Bolt Series Axial Displacement

Size	Axial Displacement Max Continuous (in) ②	Max Force (lb)	Max Springrate (lb/in)	Floating Weights (lb) 18" Shaft Separation RM	RZ	MS	MP
505	±0.110	1900	34000	170	150	100	82
555	±0.120	2400	39000	250	200	140	110
605	±0.130	2800	42000	290	240	160	130
705	±0.155	4200	51000	—	400	—	230

① For transient conditions 133% Axial Deflection is allowed for 3 and 4 bolt designs
② For transient conditions 150% Axial Deflection is allowed for 5 bolt designs

ANGULAR DATA

3 Bolt Series

Size	Maximum Misalignment (degrees)	Bending Stiffness (lb-in/deg)
103	0.33	150
153	0.33	340
203	0.33	660
253	0.33	930
303	0.33	1410
353	0.33	2390
403	0.33	3690
453	0.33	4690

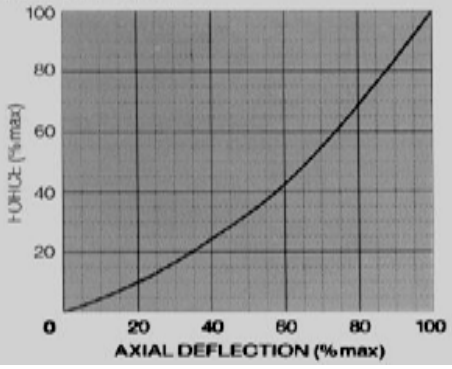
4 Bolt Series

Size	Maximum Misalignment (degrees)	Bending Stiffness (lb-in/deg)
154	0.25	650
204	0.25	1270
254	0.25	1800
304	0.25	2730
354	0.25	4600
404	0.25	7100
454	0.25	9020
504	0.25	11800
554	0.25	16000
604	0.25	18700
704	0.25	36100
804	0.25	59000

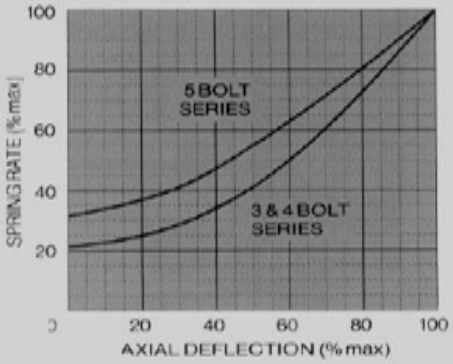
5 Bolt Series

Size	Maximum Misalignment (degrees)	Bending Stiffness (lb-in/deg)
505	0.20	23900
555	0.20	32400
605	0.20	40000
705	0.20	73900

Axial Force



Axial Natural Frequency



Due to the self damping and nonlinear characteristics of KOP-FLEX disc pack couplings, ANF is not generally a concern unless there is a large axial excitation at a frequency that closely matches the disc coupling ANF. To approximate ANF's, use the formula below and the graph at left. Contact KOP-FLEX if the ANF is too close (within 10%) of an operating speed or if additional information is required.

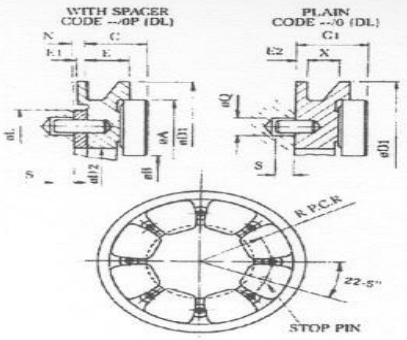
$$ANF = 375 \times \sqrt{SPRINGRATE / FLOATING\ WT.}$$

SPRINGRATE = % MAX x MAX SPRINGRATE

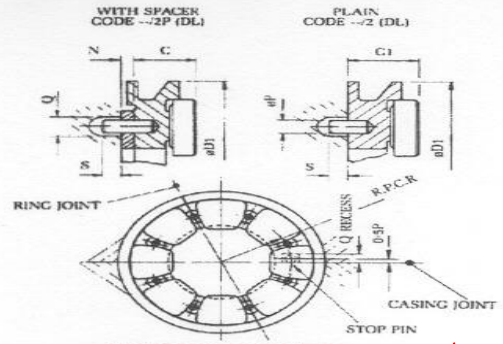
Glacier Catalog sheet:

Series 8

Glacier



ONE PIECE RING
Directed Lubrication



RING IN HALVES
Directed Lubrication

All dimensions are in mm

Size	Thrust pad		Carrier Ring Dimensions												Thrust surface	Mean dia	Allow. spec. load	Max. load See pg 17	Total Axial Clear'ce
	O. Dia	I. Dia	Thickness		Ring O.Dia.	Hsg. bore	Ring O.Dia	Hsg. bore	I. Dia										
	A	B	C	C1	D		D1		D2	E	E1	E2	X	F	mm²	d	MPa	Newton	
M847	52·5	28·5	12·710 12·670	–	63·40 63·33	63·57 63·50	–	–	31	10	–	–	–	3	1140	40·9	2·1	2394	0·20
M856	62	33·5	14·300 14·260	16·500 16·460	72·93 72·86	73·10 73·03	73·00 72·97	73·06 73·03	36	12	2·2	2.5	8·5	4	1 615	48·3	2·4	3 876	0·20
M867	74·5	39·5	15·890 15·850	18·090 18·050	85·61 85·52	85·82 85·73	85·69 85·66	85·77 85·73	44	13	2·2	3	9	4	2 360	57·9	2·65	6 254	0·20
M879	87·5	47·5	17·470 17·430	19·670 19·630	101·48 101·39	101·69 101·60	101·56 101·53	101·64 101·60	53	13	2·2	3	9.5	5	3 250	68·1	2·9	9 425	0·25
M894	105	55·5	19·060 19·020	21·260 21·220	120·51 120·41	120·75 120·65	120·61 120·57	120·69 120·65	63	14	2·2	3	10·5	5	4 610	81·8	3·2	14 752	0·25
M8103	114	62	20·650 20·610	23·953 23·897	130·04 129·94	130·28 130·18	130·14 130·10	130·22 130·18	67	16	3·3	3·5	12	6	5 500	89·2	3·3	18 150	0·30
M8112	124	66·5	22·243 22·187	25·543 25·487	139·56 139·46	139·80 139·70	139·66 139·62	139·74 139·70	74	17	3·3	4	12	6	6 500	96·5	3·4	22 100	0·30
M8123	137	73	23·823 23·707	27·123 27·067	152·26 152·16	152·50 152·40	152·36 152·32	152·44 152·40	82	17	3·3	4	13	6	7 750	106	3·45	26 737	0·30
M8134	149	79·5	25·413 25·357	28·713 28·657	168·14 168·04	168·38 168·28	168·24 168·20	168·32 168·28	90	19	3·3	4	14·5	6	9 250	116	3·5	32 375	0·35
M8146	162	87·5	27·003 26·947	30·303 30·247	180·79 180·68	181·08 180·96	180·91 180·86	181·01 180·96	98	20	3·3	4	15	6	11 000	126	3·6	39 600	0·35
M8159	176	93·5	28·593 28·537	31·893 31·337	196·68 196·57	196·97 196·85	196·80 196·75	196·90 196·85	105	21	3·3	4·5	15	6	13 100	137	3·6	47 160	0·35
M8174	192	103	31·763 31·707	35·063 35·007	215·73 215·62	216·02 215·90	215·85 215·80	215·95 215·90	115	22	3·3	4·5	16·5	7	15 500	150	3·65	56 575	0·40
M8190	210	113	34·943 34·887	38·943 38·887	234·75 234·67	235·07 234·95	234·90 234·85	235·00 234·95	126	25	4	5	19·5	8	18 600	163	3·7	68 820	0·40
M8207	229	122	38·113 38·057	42·115 42·044	253·81 253·68	254·13 254·00	253·94 253·89	254·05 254·00	138	27	4	5	21	10	22 100	178	3·7	81 770	0·40
M8225	251	135	41·295 41.224	45·295 45·224	279·21 279·08	279·53 279·40	279·34 279·29	279·45 279·40	150	30	4	5·5	23	10	26 300	196	3·75	98 625	0·50
M8246	273	146	44·465 44·394	48·465 48·394	301·44 301·31	301·76 301·63	301·57 301·52	301·68 301·63	164	32	4	6	23·5	11	31 300	213	3·8	118 940	0·50
M8269	297	159	47·645 47·574	51·645 51·574	323·64 323·50	323·99 323·85	323·79 323·73	323·91 323·85	179	33	4	6	25	11	37 300	232	3·8	141 740	0·50
M8293	324	175	50·815 50·744	57·815 57·744	355·39 355·25	355·74 355·60	355·54 355·48	355·66 355·60	195	35	7	7	28	11	44 300	253	3·85	170 555	0·50
M8320	354	191	57·165 57·094	64·165 64·094	383·97 383·83	384·32 384·18	384·12 384·06	384·24 384·18	213	40	7	7	32·5	13	52 900	276	3·85	203 665	0·60
M8348	384	206	60·345 60·274	67·350 67·259	415·70 415·55	416·09 415·93	415·86 415·80	415·99 415·93	232	41	7	8	32·5	13	62 700	300	3·9	244 530	0·60
M8380	419	225	66·700 66·609	73·700 73·609	453·80 454·65	454·19 454·03	453·96 453·90	454·09 454·03	253	46	7	8	37	14	74 800	328	3·9	291 720	0·60
M8415	457	246	73·050 72·959	80·050 79.959	495·07 491·92	495·46 495·30	495·23 495·17	495·36 495·30	277	51	7	9	40	16	89 000	358	3·9	347 100	0·60
M8453	502	268	79·400 79·309	89·100 89·009	539·49 539·32	539·93 539·75	539·67 539·60	539·82 539·75	301	56	9·7	10	45·5	17	105 800	391	3·9	412 620	0·70
M8494	546	294	85·750 85·659	95·450 95·359	583·94 583·77	584·38 584·20	584·12 584·05	584·27 584·20	329	59	9·7	10	46·5	17	126 000	425	3·9	491 400	0·70
M8538	597	321	92·100 92·009	101·800 101·709	641·06 640·86	641·55 641·35	641·27 641·19	641·43 641·35	358	64	9·7	11	50	19	149 500	465	3·9	583 050	0·70

Glacier axial bearings with tilting pads and API Specifications

It is required in API and similar regulatory specifications, that the nominal load of the axial bearings should be lower than 50% of the maximum load capacity. Paragraph 2.7.3.3 in API 613-4 "special purpose gear units for refinery services" with the selection of axial bearings, "Thrust bearings shall be selected at no more than 50 percent of the bearing's ultimate load capability (based on test data) for the specific application taking into account speed, lubricant, and lubricant temperature."

The axial bearings with tilting pads listed in Glacier handbook Nr. 5 (paragraph 1,2, and 3) meet this requirement. When the use of the bearings is according to the load values listed in the handbook, and may be modified if required by consulting the table in construction help No. 1.

These values for maximum load capacity are below 50% of the defined critical load capacity.

Glacier will be pleased to improve the calculated values, especially where running conditions of oil inlet temperature and temperature increase is very different from the values in the construction help No. 1.

This statement is based on the following definition:

The critical load is the maximum load the bearing can sustain without any damage, whereas any higher load will cause bearing damage.

NOTE: The load tables in Appendix E of the API 613 are only valid for a specific bearing manufacturer and are not compatible with bearing's of other manufacturers such as Glacier.

*This has been edited, clarified and translated to the latest API 613-4 Standard into English from German

THE GLACIER METAL COMPANY LIMITED

ALPERTON
WEMBLEY
MIDDLESEX
HAO 1HD
ENGLAND

TELEGRAMS CABLES: GLAMET WEMBLEY
TELEPHONE: 01-997 6611
TELEX NOS: 936881 AND 2
VAT. REG. NO: 226 7583 43

DATE June 1979
OUR REF RPD/AB/AJL/2338-G
YOUR REF

GLACIER KIPPSEGMENT AXIALLAGER UND DIE API VORSCHRIFTEN

Es wird häufig verlangt in API und ähnlichen Vorschriften, dass die Nennbelastung des Axiallagers nicht mehr als 50% dessen tatsächlichen Belastbarkeit betragen soll. Laut Absatz 2.7.3.3. der letzten Ausgabe der API Vorschrift Nr. 613 "Special Purpose Gear Units for Refinery Services" heisst es zum Beispiel: "Bei der Auswahl von Axiallagern soll darauf geachtet werden, dass (die Nennbelastung) nicht mehr als 50% der durch Versuche festgestellten Grenzbelastung beträgt, unter Berücksichtigung der jeweiligen Betriebsbedingungen wie Umfangsgeschwindigkeit, Oelsorte und Oelviskosität."

Die in Handbuch Nr. 5, (Abschnitte 1, 2 u. 3) aufgeführten Kippsegment Axiallager erfüllen diese Anforderung wenn deren Einsatz den im Handbuch enthaltenen Belastungswerten, gegebenenfalls abgeändert durch Hinzuziehung der Tabelle in Konstruktions-Hilfe Nr. 1, entspricht. Die aus diesen Unterlagen ermittelten Werte für Höchstbelastbarkeit werden nicht mehr als 50% der unten definierten Grenzbelastung betragen. Glacier ist gerne bereit ermittelte Werte zu prüfen, insbesondere dort wo die Betriebsbedingungen bezüglich Oeleintrittstemperatur und Temperaturanstieg wesentlich von denen abweichen die der Konstruktions-Hilfe zu Grunde liegen.

Diese Stellungnahme basiert auf folgender Definition der Grenzbelastung: die Grenzbelastung ist die Belastung die ohne Schaden von dem Lager getragen werden kann, bei deren geringfügiger Ueberschreitung jedoch ein Lagerschaden eintreten würde

N.B. Die in Anhang E der Vorschrift API 613 enthaltene Belastungstabellen beziehen sich auf ein bestimmtes Lagerfabrikat und sind auf Glacier Lager nicht übertragbar.