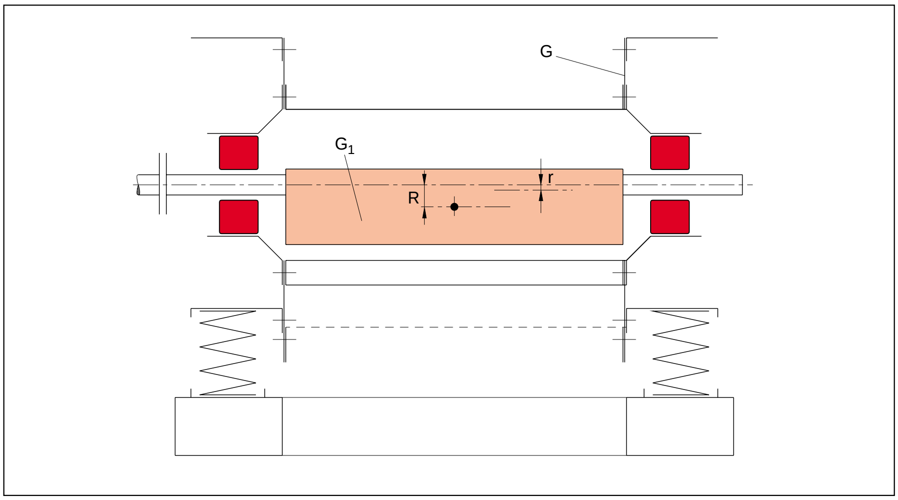
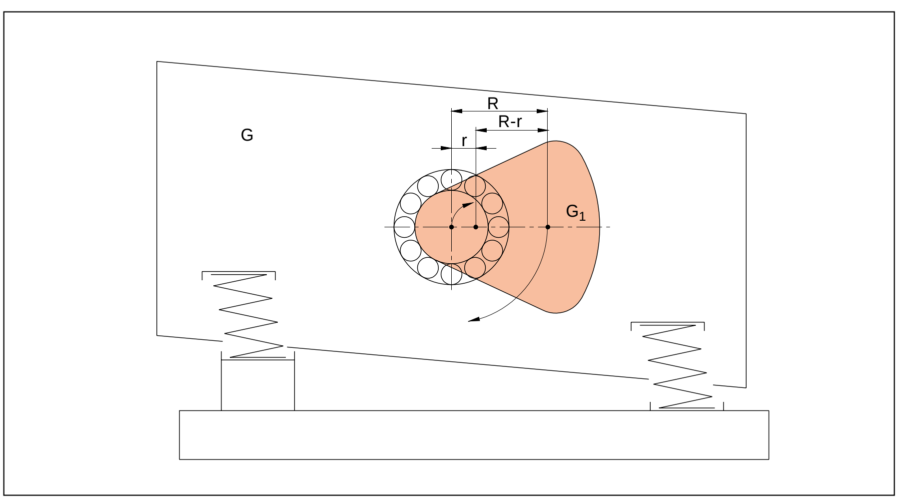
6: Principle of a two bearing screen with circle throw



7: The vibration radius is a function of the screen box weight and the imbalance weight



Example

Screen box weight G = 35 kN
Vibration radius r = 0.003 m
Speed n = 1200 min^{-1}
Number of bearings z = 2

Bearing load according to equation (1)

$$F_r = \frac{1}{2} \cdot \frac{35}{9.81} \cdot 0.003 \left(\frac{\pi \cdot 1200}{30}\right)^2 =$$

$$= 84.5 \text{ [kN]}$$

The equivalent dynamic bearing load needed to determine the required dynamic load rating of the bearing

$P = 1.2 \cdot F_r = 1.2 \cdot 84.5 = 101$ [kN]

2.2 Two bearing screen with straight-line motion

Basically, the exciter unit of a two bearing screen with straight-line motion consists of two contra-rotating synchronous circular throw systems, fig. 8.

The forces involved are determined by resolving the rotating centrifugal force vectors of the imbalance shafts into two components: one in the direction of the line connecting the two shafts and the other perpendicular to this line. It can be readily seen that the components lying in the direction of the shaft connecting line in overall effect cancel each other out, whereas the perpendicular components add up, generating a harmonic pulsating inertia force. This force is responsible for the straight line motions of the screen box.

Since, in the direction of vibration, the overcritical operation enables the so-called static amplitude to be reached and the common centroidal axis of the screen box and the imbalance masses does not vary during vibration the bearing loads are as follows:

In the direction of vibration

$$F_{r\,min} = \frac{1}{z} \cdot \frac{m}{10^3} \cdot r \cdot \omega^2 =$$

$$= \frac{1}{z} \cdot \frac{G}{g} \cdot r \cdot \left(\frac{\pi \cdot n}{30}\right)^2 =$$

$$= \frac{1}{z} \cdot \frac{G_1}{g} \cdot (R - r) \cdot \left(\frac{\pi \cdot n}{30}\right)^2 \quad [kN] \quad (4)$$

where

r [m] amplitude of the linear vibration

R [m] distance between the centres of gravity of imbalance and the pertinent bearing axes

Perpendicular to the direction of vibration

$$F_{r\,max} = \frac{1}{z} \cdot \frac{G_1}{g} \cdot R \cdot \left(\frac{\pi \cdot n}{30}\right)^2 \quad [kN] \quad (5)$$

meaning that the bearing load is slightly higher.

Contrary to a circle throw screen with a constant bearing load, the bearing loads on a straight-line motion screen vary twice between $F_{r\,max}$ and $F_{r\,min}$ during one revolution of the eccentric drive shafts

Comparing equation (4) with equation (1) shows that the minimum bearing load accommodated by a straight-line motion screen is exactly the same as that of a circle throw screen.

For a straight-line screen whose loading varies according to a sinusoidal pattern the bearing load can be calculated using the formula

$$F_r = 0.68 \cdot F_{r\,max} + 0.32 \cdot F_{r\,min} \quad [kN]$$

With a circle throw screen, the bearing load can be determined from the screen box weight G, the vibration radius r and the speed n. With a straight-line screen, these data merely allow the minimum load to be determined. An accurate calculation is only possible if either the imbalance weight G_1 or the distance R between the centres of gravity of imbalance and their pertinent bearing axes are known as well. The unknown quantity can then be determined from

$$G \cdot r = G_1 (R - r) \quad [kN\,m]$$

Example

Screen box weight G = 33 kN

Imbalance weight G_1 = 7.5 kN

Amplitude r = 0.008 m

Speed n = 900 min^{-1}

Number of bearings z = 4

$$\text{With } R = \frac{r\,(G + G_1)}{G_1} =$$

$$= \frac{0.008\,(33 + 7.5)}{7.5} = 0.0432 \quad [m]$$

then, according to (4) and (5)

$$F_{r\,min} = \frac{1}{4} \cdot \frac{33}{9.81} \cdot 0.008 \cdot \left(\frac{\pi \cdot 900}{30}\right)^2$$

= 59.8 [kN]

$$F_{r\,max} = \frac{1}{4} \cdot \frac{7.5}{9.81} \cdot 0.0432 \cdot \left(\frac{\pi \cdot 900}{30}\right)^2$$

= 73.3 [kN]

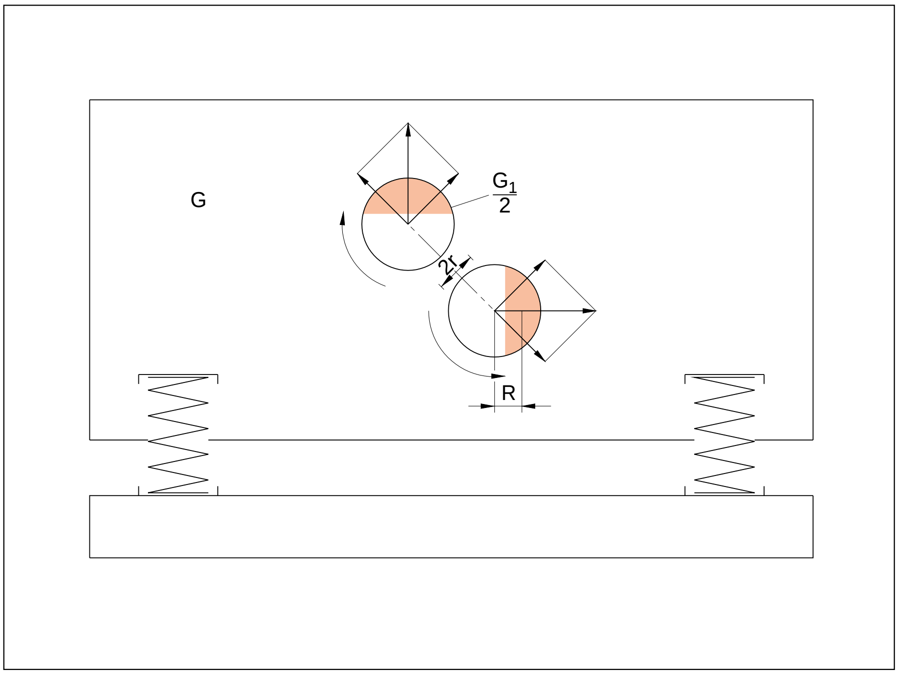
The bearing load

$$F_r = 0.68 \cdot 73.3 + 0.32 \cdot 59.8 =$$
$$= 69 \quad [kN]$$

Then, the equivalent dynamic bearing load required for determining the dynamic load rating

$$P = 1.2 \cdot 69 = 83 \quad [kN]$$

8: Principle of a two bearing screen with straight-line motion



2.3 Four bearing or eccentric screen

In contrast to a two bearing screen, the vibration radius of a four bearing screen is a function of the shaft eccentricity. The bearing load accommodated by the two inner bearings is determined using the same equation as for the circle throw screen:

$$F_r = \frac{1}{z} \cdot \frac{G}{g} \cdot r \left(\frac{\pi \cdot n}{30}\right)^2 \quad [kN] \qquad (1)$$

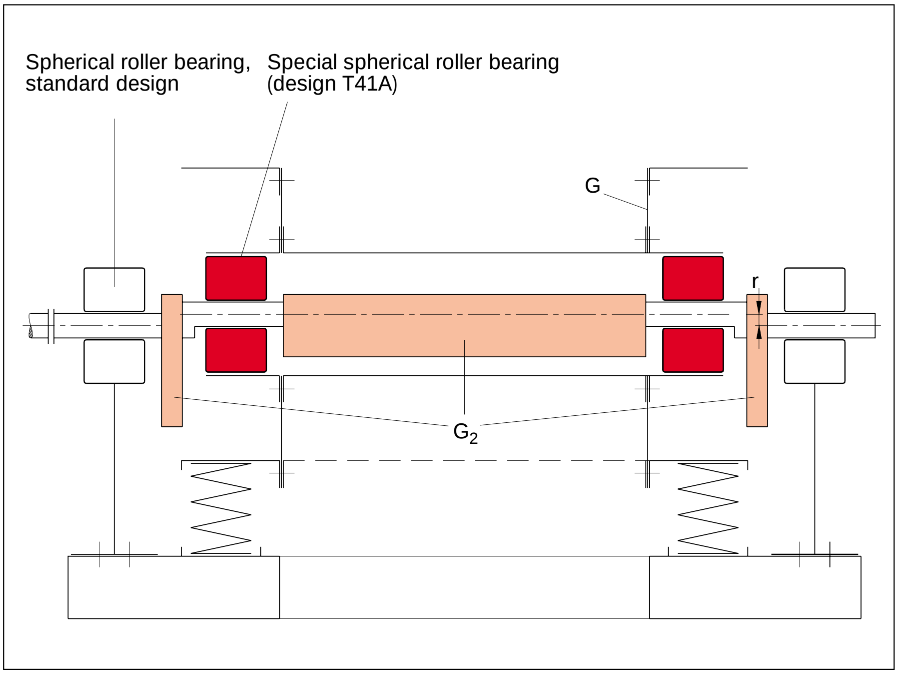
where r is the eccentric radius of the crankshaft and z is the number of inner bearings, fig. 9.

The effect of the support springs on the loading of the inner bearings is negligible.

The outer bearings of the four bearing screen are only lightly loaded since during idling of the screen the centrifugal forces of the screen box are compensated by counterweights (G_2). The load on these bearings is not constant and follows, because of the action of the support springs, a sinusoidal pattern. In operation the material in the box interferes with the balanced condition of the machine. This means some extra load on the outer bearings. However, the effect of this additional loading is also small.

The selection of the bearings depends on the shaft diameter. This results in bearings whose load carrying capacity is so high that a fatigue life analysis is unnecessary. Since these bearings do not perform vibrating motions the standard spherical roller bearing design suffices.

9: Principle of a four bearing screen



Example

Screen box weight G = 60 kN

Eccentric radius r = 0.005 m

Speed n = 850 min^{-1}

Number of bearings z = 2

Inner bearings:
Bearing load according to equation (1)

$$F_r = \frac{1}{2} \cdot \frac{60}{9.81} \cdot 0.005 \left(\frac{\pi \cdot 850}{30}\right)^2 =$$

$$= 121 \text{ kN}$$

Then, the equivalent dynamic bearing load required to determine the dynamic load rating of the bearing

P = 1.2 · 121 = 145 [kN]

2.4 Centrifugal force nomogram for calculating the centrifugal forces of the imbalance masses and the screen box masses

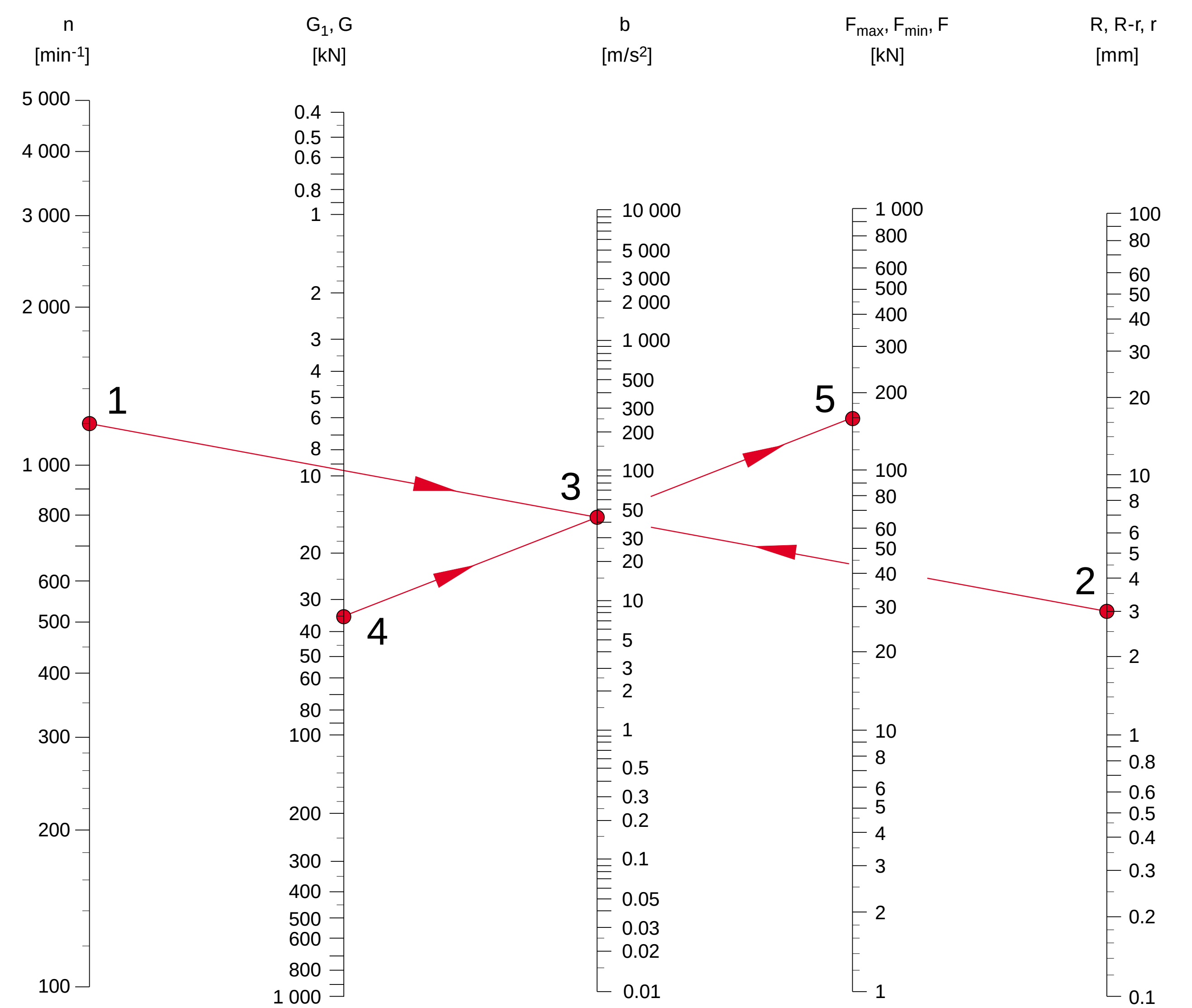
F_{max}, F_{min} and F are the centrifugal forces
n is the speed [min^{-1}]
r is the vibration radius [m]
R is the distance between the centre of gravity of imbalance and shaft axis [m]

b is the acceleration [m/s^2]
G is the weight of the screen box [kN]
G_1 is the weight of imbalance [kN]
g = 9.81 is the gravitational acceleration [m/s^2]

$$F_{max} = \frac{G_1}{g} \cdot R \cdot \left(\frac{\pi \cdot n}{30}\right)^2 \text{ [kN]}$$

$$F_{min} = \frac{G_1}{g} \cdot (R - r) \left(\frac{\pi \cdot n}{30}\right)^2 \text{ [kN]}$$

$$F = \frac{G}{g} \cdot r \cdot \left(\frac{\pi \cdot n}{30}\right)^2 \text{ [kN]}$$



Example: 1 n = 1200 min^{-1}
2 r = 3 mm
3 b = 47.3 m/s^2
4 G = 35 kN
5 F = 168 kN

2.5 Load rating nomogram for determining the required dynamic load rating and the theoretical fatigue life

$C = P \cdot \frac{f_L}{f_n}$ [kN]

C dynamic load rating [kN]
P equivalent dynamic load [kN]
f_L index of dynamic stressing
f_n speed factor

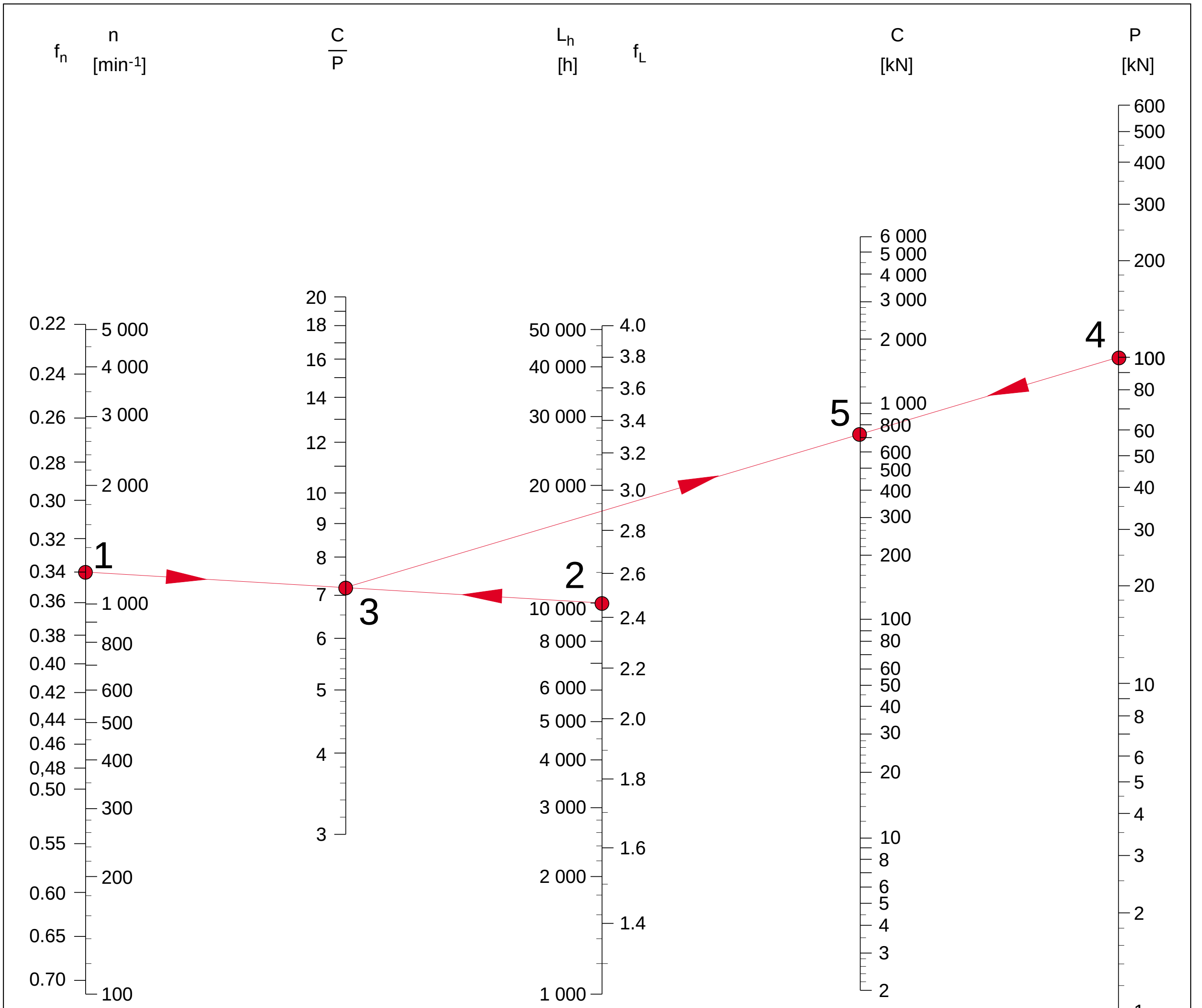
Two bearing screens with circle throw and inner bearings of four bearing screens

$P = 1.2 \cdot \frac{F}{z}$ [kN]

Two bearing screens wiht straight-line motion

$P = 1.2 \cdot \left(\frac{0.68 \cdot F_{max} + 0.32 \cdot F_{min}}{z}\right)$

1.2 is the supplementary factor
z is the number of bearings
F is the centrifugal force from nomogram 1 (section 2.4)

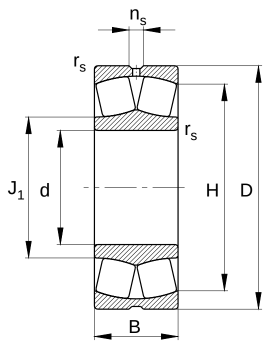


Example: 1 n = 1200 min-1
2 L_h = 10 000 h
3 C/P = 7.2
4 P = 100 kN
5 C = 720 kN

FAG Special Spherical Roller Bearings for Vibrating Machines

with a cylindrical bore

Series 223E.T41A

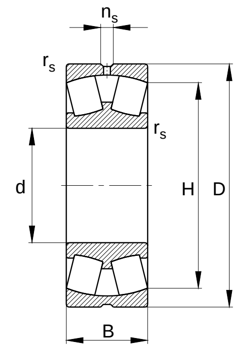


Shaft	Dimensions							Load rating		Limiting speed	Reference speed	Code	Mass
								dyn.	stat.				
	d	D	B	r_s min	n_s	H ≈	J_1 ≈	C	C_0			Bearing	≈
	mm							kN		min^{-1}		FAG	kg
40	40	90	33	1.5	4.8	77	52	129	143	7500	7000	22308E.T41A	0.984
45	45	100	36	1.5	6.5	86	58	156	176	6700	6300	22309E.T41A	1.36
50	50	110	40	2	6.5	94	63	190	216	6000	6000	22310E.T41A	1.87
55	55	120	43	2	6.5	102	68	224	255	5600	5600	22311E.T41A	2.02
60	60	130	46	2.1	6.5	111	74	260	300	5000	5000	22312E.T41A	2.8
65	65	140	48	2.1	9.5	120	83	290	355	4800	4500	22313E.T41A	3.57
70	70	150	51	2.1	9.5	129	86	325	375	4500	4300	22314E.T41A	4.25
75	75	160	55	2.1	9.5	137	92	375	440	4300	3800	22315E.T41A	5.01
80	80	170	58	2.1	9.5	146	98	415	500	4300	3600	22316E.T41A	6.27
85	85	180	60	3	9.5	155	104	455	540	4000	3200	22317E.T41A	6.84
90	90	190	64	3	12.2	163	110	510	620	3600	3000	22318E.T41A	8.08
95	95	200	67	3	12.2	172	115	560	680	3000	2800	22319E.T41A	9.21
100	100	215	73	3	12.2	184	124	655	815	3000	2600	22320ED.T41A	12
110	110	240	80	3	15	206	143	800	1060	2600	2200	22322ED.T41A	17.4
120	120	260	86	3	15	224	150	900	1140	2600	2000	22324ED.T41A	21
130	130	280	93	4	17.7	241	162	1040	1340	2400	1900	22326ED.T41A	27.1
140	140	300	102	4	17.7	257	173	1220	1600	2200	1700	22328ED.T41A	34
150	150	320	108	4	17.7	274	185	1370	1830	2000	1500	22330ED.T41A	40.6

FAG Special Spherical Roller Bearings for Vibrating Machines

with a cylindrical bore

Series 223A.MA.T41A
Series 233A(S).MA.T41A



Shaft	Dimensions						Loat rating		Limiting speed	Reference speed	Code	Mass
	d	D	B	r_s min	n_s	H ≈	dyn. C	stat. C_0			Bearing	≈
	mm						kN		min^{-1}		FAG	kg
160	160	340	114	4	17.7	289	1430	1900	2000	1500	22332A.MA.T41A	52.7
170	170	360	120	4	17.7	305	1600	2120	1800	1400	22334A.MA.T41A	59.5
180	180	380	126	4	23.5	324	1760	2360	1500	1300	22336A.MA.T41A	72.2
190	190	400	132	5	23.5	339	1860	2500	1500	1200	22338A.MA.T41A	81
200	200	420	138	5	23.5	359	2080	2800	1400	1100	22340A.MA.T41A	93.5
220	220	460	145	5	23.5	392	2320	3350	1300	950	22344A.MA.T41A	120

Shaft	Dimensions						Load rating		Limiting speed	Code	Mass
	d	D	B	r_s min	n_s	H ≈	dyn. C	stat. C_0		Bearing	≈
	mm						kN		min^{-1}	FAG	kg
100	100	215	82.6	3	9.5	180	680	900	2800	23320AS.MA.T41A	15.3
110	110	240	92.1	3	12.2	201	830	1080	2600	23322AS.MA.T41A	21.1
120	120	260	106	3	12.2	216	1020	1430	2400	23324AS.MA.T41A	28.9
130	130	280	112	4	12.2	233	1160	1600	2200	23326AS.MA.T41A	35.3
140	140	300	118	4	12.2	250	1270	1800	2000	23328AS.MA.T41A	40.7
150	150	320	128	4	15	266	1500	2120	2000	23330A.MA.T41A	49.8
160	160	340	136	4	17.7	282	1660	2320	2000	23332A.MA.T41A	62.6
190	190	400	155	5	17.7	334	2200	3200	1400	23338A.MA.T41A	97.1
200	200	420	165	5	17.7	351	2450	3600	1300	23340A.MA.T41A	108