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Vibration Frequencies of DODGE Anti-Friction Mounted Bearings

More and more manufacturing facilities are getting involved with plant-wide preventive maintenance programs. By monitoring vibration levels of motors, pumps, fans and compressors, maintenance supervisors can predict imminent failures. Knowing that a piece of equipment is showing signs of potential failure permits scheduling of maintenance at an appropriate time and avoids the consequences of catastrophic failures. Shown in Tables 1 - 10 are vibration frequencies generated by bearing components defects. All frequencies are based on unity inner ring or cone rotation.

How to Use the Tables

If a 2-7/16 Type E pillow block is rotating at 1000 RPM, the vibration due to a failed component will show up at the following frequencies: (Table 3, Line 6)

Frequency

Cup Nick or Spall	= 1000 x 9.251	= 9251 RPM
Cone Nick or Spall	= 1000 x 11.749	= 11749 PM
*Roller Nick or Spall	= 1000 x 4.011 x 2	= 8022 RPM
Cage (Train) Frequency (Inner Ring Rotation)	= 1000 x 0.441	= 441 RPM

Since all the values in Tables 1 - 10 are based on unity inner ring or cone rotation, the vibration due to flaws will show up at the frequencies obtained by multiplying the RPM times the factors found on the appropriate table. The resulting product will have units of RPM.

Table 1: All Setscrew, Eccentric, D-LOK & GT Ball Bearing Parameters For Vibration Analysis (1-RPS)

Series	SC Bore	SCM Bore	# Balls	Diameter of Balls	Pitch Diameter	Outer Ring Frequency Hz	Inner Ring Frequency Hz	* Ball Spin Frequency Hz	Cage Frequency Hz
203	1/2 - 5/8		8	17/64	1.151	3.078	4.923	2.050	0.385
204	1/2 - 3/4		8	5/16	1.325	3.057	4.943	2.002	0.382
205	7/8 - 1		9	5/16	1.533	3.582	5.418	2.350	0.398
206	1-1/6 - 1-1/4	1	9	3/8	1.823	3.575	5.426	2.328	0.397
207	1-1/4 - 1-7/16	1-3/16	9	7/16	2.136	3.579	5.422	2.339	0.398
208	1-1/2 - 1-5/8	1-7/16 - 1-1/2	9	1/2	2.387	3.558	5.443	2.283	0.395
209	1-11/16 - 1-3/4	1-1/2	9	13/25	2.559	3.586	5.414	2.360	0.398
210	1-15/16 - 2	1-11/16 - 1-3/4	10	1/2	2.765	4.056	5.904	2.674	0.410
211	2-2-1/4	1-15/16 - 2	10	9/16	3.092	4.090	5.910	2.657	0.410
212	2-1/4 - 2-7/16	2-3/16 - 2-1/4	10	5/8	3.385	4.077	5.923	2.616	0.408
214	2-11/16	2-7/16 - 2-1/2	10	11/16	3.775	4.089	5.911	2.654	0.409
215	2-15/16	2-11/16	11	11/16	4.085	4.574	6.456	2.887	0.416
216		2-15/16 - 3	11	3/4	4.330	4.547	6.453	2.800	0.413
218		3-7/16 - 3-1/2	11	27/32	4.920	4.557	6.443	2.830	0.414

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Table 2: Type E, K, DI, and TAF Tapered Roller Bearing Parameters For Vibration Analysis (1-RPS)

Bore Size	# Rollers Per Row	Mean Diameter of Rollers	Pitch Diameter	Contact Angle	Cup Frequency Hz	Cone Frequency Hz	* Roller Spin Frequency Hz	Cage Frequency Hz
1-3/16 - 1-1/4	19	0.23	1.774	17.533	8.326	10.675	3.798	0.438
1-3/8 - 1-7/16	20	0.29	2.084	16.500	8.666	11.334	3.529	0.433
1-1/2 - 1-11/16	18	0.35	2.411	16.000	7.744	10.256	3.377	0.430
1-3/4 - 2	17	0.41	2.709	12.033	7.241	9.758	3.231	0.426
2-3/16	19	0.41	3.014	13.283	8.242	10.758	3.611	0.434
2-1/4 - 2-1/2	21	0.41	3.337	14.500	9.251	11.749	4.012	0.441
2-11/16 - 3	24	0.41	3.900	16.733	10.792	13.208	4.708	0.450
3-3/16 - 3-1/2	26	0.46	4.780	18.167	11.811	14.189	5.152	0.454
3-15/16 - 4	26	0.51	5.120	17.567	11.766	14.235	4.974	0.453
4-7/16 - 4-1/2	25	0.59	5.727	18.983	11.282	13.718	4.807	0.451
4-15/16 - 5	25	0.68	6.568	17.000	11.262	13.738	4.782	0.455
5-7/16 - 6	32	0.67	8.444	17.750	14.791	17.209	6.266	0.462
6-7/16 - 7	27	0.93	9.791	19.167	12.289	14.711	5.222	0.455

Cup Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 120
Cone Frequency = N * RPM * (1 + (Bd * cos a / Pd)) / 120
Roller Spin Frequency = Pd * RPM * (1 - (Bd * cos a / Pd) ^2) / (120 * Bd)
Cage Frequency = RPM * (1 - (Bd * cos a / Pd)) /120

Pd = Pitch Diameter
N = Number of rollers
Bd = Roller Diameter
a = Cup Angle (contact angle)

Table 3: Type C Tapered Roller Bearing Parameters For Vibration Analysis (1-RPS)

Bore Size	# Rollers Per Row	Mean Diameter of Rollers	Pitch Diameter	Contact Angle	Cup Frequency Hz	Cone Frequency Hz	* Roller Spin Frequency Hz	Cage Frequency Hz
1-3/16 - 1-7/16	19	0.31	2.251	14.92	8.236	10.764	3.566	0.433
1-1/2 - 1-3/4	21	0.32	2.604	11.50	9.236	11.764	4.010	0.440
1-15/16	22	0.33	2.848	15.00	9.769	12.231	4.261	0.444
2 - 2-1/4	21	0.40	3.335	16.83	9.295	11.705	4.114	0.443
2-3/16 - 2-7/16	25	0.35	3.533	18.00	11.322	13.678	5.002	0.453
2-1/2 - 2-11/16	23	0.43	3.827	16.50	10.261	12.739	4.399	0.446
2-7/16 - 2-15/16	26	0.42	4.220	16.50	11.759	14.241	4.978	0.452
3 - 3-3/16	22	0.55	4.612	16.50	9.742	12.258	4.138	0.443
3-1/4 - 3-7/16	24	0.51	4.761	16.42	10.767	13.233	4.618	0.449
3-1/2 - 4	25	0.59	5.727	18.98	11.282	13.718	4.807	0.4513
4-7/16 - 4-1/2	33	0.46	3.109	11.50	14.108	18.892	3.308	0.428
4-15/16 - 5	26	0.68	6.983	18.00	11.796	14.204	5.091	0.4537

Cup Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 120
Cone Frequency = N * RPM * (1 + (Bd * cos a / Pd)) / 120
Roller Spin Frequency = Pd * RPM * (1 - (Bd * cos a / Pd) ^2) / (120 * Bd)
Cage Frequency = RPM * (1 - (Bd * cos a / Pd)) /120

Pd = Pitch Diameter
N = Number of rollers
Bd = Roller Diameter
a = Cup Angle (contact angle)

*** Note:** Ball and Roller Spin Frequencies are listed at one (1X) roller spin frequency. For thorough analysis it is important to check frequency level at two (2X) rotational speed of balls or rollers as this is the frequency that a single ball/roller defect will contact the raceways of the bearing. In other words, a ball/roller defect will strike both inner and outer ring in one revolution of the roller.

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Type 4: Special Duty Tapered Roller Bearing Parameters For Vibration Analysis (1-RPS)

Bore Size	# Rollers Per Row	Mean Diameter of Rollers	Pitch Diameter	Contact Angle	Cup Frequency Hz	Cone Frequency Hz	Roller Spin Frequency Hz	Cage Frequency Hz
1-3/8 - 1-1/2	21	0.32	2.603	11.50	9.2384	11.7616	4.0188	0.4399
1-9/16 - 1-3/4	26	0.32	3.061	16.00	11.6930	14.3070	4.7323	0.4497
1-7/8 - 2	27	0.32	3.267	17.00	12.2349	14.7651	5.0578	0.4531
2-1/8 - 2-1/4	25	0.35	3.533	18.00	11.3174	13.6826	4.9813	0.4527
2-3/8 - 2-1/2	29	0.35	3.828	18.77	13.2454	15.7546	5.4304	0.4567
2-5/8 - 3	26	0.48	4.572	10.17	11.6498	14.3502	4.6873	0.4481
3-3/16 - 3-1/2	27	0.56	5.541	16.00	12.1840	14.8160	4.8838	0.4513
3-11/16 - 4	23	0.68	6.103	15.88	10.2627	12.7373	4.4180	0.4462
4-7/16 - 4-1/2	26	0.68	6.983	18.00	11.7910	14.2090	5.0689	0.4535
4-15/16 - 5	30	0.75	7.896	17.00	13.6369	16.3631	5.2181	0.4546
5-7/16 - 6	24	0.93	9.123	17.33	10.8322	13.1678	4.8584	0.4513
6-1/2 - 7	29	0.93	10.190	19.23	13.2505	15.7495	5.4378	0.4569
7-15/16 - 8	27	1.12	11.471	12.42	12.2127	14.7873	5.0744	0.4523
8-1/2 - 10	41	0.87	13.979	16.40	19.2761	21.7239	8.0053	0.4701
11 - 12	37	1.20	16.061	12.50	17.1505	19.8495	6.6565	0.4635

Cup Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 2
Cone Frequency = N * RPM * (1 + (Bd * cos a / Pd)) / 2
Roller Spin Frequency = Pd * RPM * (1 - (Bd * cos a / Pd) ^2) / (2 * Bd)
Cage Frequency = RPM * (1 - (Bd * cos a / Pd)) / 2

Pd = Pitch Diameter
N = Number of rollers
Bd = Roller Diameter
a = Cup Angle (contact angle)

Table 5: All Steel Tapered Roller Bearing Parameters For Vibration Analysis (1-RPS

Bore Size	# Rollers Per Row	Mean Diameter of Rollers	Pitch Diameter	Contact Angle	Cup Frequency Hz	Cone Frequency Hz	* Roller Spin Frequency Hz	Cage Frequency Hz
2-11/16 - 3	27	0.36	4.114	15.50	12.362	14.638	5.673	0.458
3-1/4 - 3-1/2	26	0.51	5.120	17.57	11.766	14.235	4.974	0.453
3-15/16 - 4	33	0.48	5.814	12.50	15.170	17.830	6.017	0.460
4-7/16 - 4-1/2	29	0.60	6.503	12.92	13.196	15.804	5.375	0.455
4-15/16 - 5	32	0.61	7.355	12.50	14.705	17.296	5.989	0.460
5-7/16	27	0.84	8.272	12.00	12.159	14.841	4.875	0.450
5-15/16 - 6	26	0.85	8.323	12.00	11.701	14.300	4.847	0.450
6-7/16 - 7	32	0.81	9.748	12.50	14.702	17.300	5.978	0.459
7-1/2 - 8	27	1.12	11.471	12.42	12.213	14.787	5.074	0.452
9 - 10	32	1.28	14.026	12.03	14.572	17.428	5.435	0.455

Cup Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 120
Cone Frequency = N * RPM * (1 + (Bd * cos a / Pd)) / 120
Roller Spin Frequency = Pd * RPM * (1 - (Bd * cos a / Pd) ^2) / (120 * Bd)
Cage Frequency = RPM * (1 - (Bd * cos a / Pd)) / 120

Pd = Pitch Diameter
N = Number of rollers
Bd = Roller Diameter
a = Cup Angle (contact angle)

*** Note:** Ball and Roller Spin Frequencies are listed at one (1X) roller spin frequency. For thorough analysis it is important to check frequency level at two (2X) rotational speed of balls or rollers as this is the frequency that a single ball/roller defect will contact the raceways of the bearing. In other words, a ball/roller defect will strike both inner and outer ring in one revolution of the roller.

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Table 6: S-2000, UNISPHERE II and Imperial Spherical Roller Bearing Parameters for Vibration Analysis (1-RPS)

Basic Bearing Series	S-2000 Bore Size (in)	UNISPHERE II Bore Size (in)	Imperial Bore Size (in)	No. of Rollers	Mean Dia. Of Rollers	Pitch Dia.	Contact Angle	Outer Ring Frequency Hz	Inner Ring Frequency Hz	* Roller Spin Frequency Hz	Cage Frequency Hz
22208	1-3/8 - 1-1/2	1-7/16 - 1-1/2	1-1/8 - 1-1/2	15	0.449	2.449	10.583	6.149	8.851	2.640	0.410
22209	1-11/16 - 1-3/4	1-11/16 - 1-3/4	1-5/8 - 1-3/4	17	0.429	2.665	9.750	7.151	9.849	3.027	0.421
22210	1-15/16 - 2	1-15/16 - 2	1-7/8 - 2	18	0.433	2.858	9.083	7.653	10.347	3.226	0.425
22211	2-3/16	2-3/16	2-3/16 - 2-1/4	19	0.465	3.189	8.750	8.132	10.868	3.361	0.428
22213	2-7/16	2-7/16 - 2-1/2	2-3/8 - 2-1/2	18	0.583	3.795	9.083	7.635	10.365	3.182	0.424
22215	2-11/16 - 3	2-11/16 - 3	2-11/16 - 3	20	0.575	4.197	8.250	8.645	11.355	3.584	0.432
22218	3-7/16	3-7/16 - 3-1/2	3-3/16 - 3-1/2	18	0.780	5.079	8.833	7.635	10.365	3.183	0.424
22220	3-15/16 - 4	3-15/16 - 4	3-11/16 - 4	18	0.878	5.705	9.000	7.632	10.368	3.174	0.424
22222	4-7/16		4-7/16 - 4-1/2	17	1.020	6.287	9.417	7.140	9.860	3.004	0.420
22226	4-15/16		4-15/16 - 5	18	1.118	7.307	9.750	7.643	10.357	3.193	0.425
22228			5-7/16 - 5-1/2	18	1.217	7.933	9.583	7.639	10.361	3.186	0.424
22232			5-15/16 - 6	18	1.409	9.189	9.667	7.639	10.361	3.185	0.424
22236			6-7/16 - 7	18	1.559	10.157	9.417	7.637	10.363	3.183	0.424

Table 7: USAF and SAF-XT Spherical Roller Bearing Parameters for Vibration Analysis (1-RPS)

Basic Bearing Series	USAF/SAF-XT Bore Sizes (in)	No. Of Rollers	Mean Dia. Of Rollers	Pitch Dia.	Contact Angle	Outer Ring Frequency Hz	Inner Ring Frequency Hz	* Roller Spin Frequency Hz	Cage Frequency Hz
22209	1-7/16	18	0.408	2.626	9.633	7.623	10.377	3.147	0.424
22210	1-11/16	19	0.415	2.819	8.917	8.120	10.880	3.328	0.427
22211	1-15/16	19	0.465	3.097	8.833	8.092	10.908	3.260	0.426
22213	2-3/16	20	0.534	3.761	9.117	8.599	11.401	3.456	0.430
22215	2-7/16 - 2-1/2	20	0.587	4.093	8.433	8.582	11.418	3.419	0.429
22216	2-11/16 - 2-3/4	20	0.622	4.410	8.333	8.604	11.396	3.475	0.430
22217	2-15/16 - 3	20	0.679	4.723	8.367	8.578	11.422	3.409	0.429
22218	3-3/16	20	0.702	5.024	8.917	8.620	11.380	3.510	0.431
22220	3-7/16 - 3-1/2	19	0.823	5.609	8.917	8.123	10.877	3.336	0.428
22222	3-15/16 - 4	18	0.979	6.185	9.583	7.595	10.405	3.082	0.422
22224	4-3/16	19	0.999	6.700	9.633	8.103	10.897	3.280	0.426
22226	4-7/16 - 4-1/2	19	1.071	7.205	9.950	8.109	10.891	3.292	0.427
22228	4-15/16 - 5	18	1.217	7.933	9.583	7.639	10.361	3.186	0.424
22230	5-3/16	18	1.315	8.559	9.500	7.636	10.364	3.180	0.424
22232	5-7/16 - 5-1/2	18	1.409	9.189	9.667	7.639	10.361	3.185	0.424
22234	5-15/16 - 6	17	1.583	9.740	9.833	7.139	9.861	2.998	0.420
22236	6-7/16 - 6-1/2	18	1.559	10.157	9.417	7.637	10.363	3.183	0.424
22238	6-15/16 - 7	20	1.496	10.669	10.667	8.622	11.378	3.498	0.431
22240	7-3/16	19	1.614	11.021	10.833	8.133	10.867	3.343	0.428
22244	7-1/2 - 8	19	1.850	12.480	10.833	8.117	10.883	3.301	0.427
23048	8-7/16 - 9	29	1.142	12.008	9.333	13.140	15.860	5.213	0.453
23052	9-7/16 - 9-1/2	27	1.378	13.228	9.667	12.114	14.886	4.749	0.449
23056	9-15/16 - 10-1/2	28	1.378	13.976	9.333	12.638	15.362	5.023	0.451

*** Note:** Ball and Roller Spin Frequencies are listed at one (1X) roller spin frequency. For thorough analysis it is important to check frequency level at two (2X) rotational speed of balls or rollers as this is the frequency that a single ball/roller defect will contact the raceways of the bearing. In other words, a ball/roller defect will strike both inner and outer ring in one revolution of the roller.

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Table 8: DODGE USAF Air Handling Spherical Roller Bearing Parameters For Vibration Analysis (1-RPS)

Bore Size	Basic Bearing Series	# Rollers Per Row	Diameter of Rollers	Pitch Diameter	Contact Angle	Outer Ring Frequency Hz	Inner Ring Frequency Hz	*Roller Spin Frequency Hz	Cage Frequency Hz
1-7/16	22209E1K	17	0.3937	2.5976	10.0000	7.231	9.769	3.226	0.425
1-11/16	22210E1K	19	0.3937	2.7976	9.2500	8.180	10.820	3.484	0.431
1-15/16	22211E1K	18	0.4528	3.0921	8.9200	7.698	10.302	3.343	0.428
2-3/16	22213E1K	19	0.5315	3.7110	9.2500	8.157	10.843	3.421	0.429
2-7/16 - 2-1/2	22215E1K	21	0.5315	4.1098	8.3300	9.156	11.846	3.803	0.436
2-11/16 - 2-3/4	22216E1K	20	0.5709	4.3638	8.2500	8.705	11.295	3.758	0.435
2-15/16 - 3	22217E1K	20	0.6299	4.6811	8.5000	8.669	11.331	3.650	0.434
3-3/16	22218E1K	20	0.6693	4.9602	8.8300	8.667	11.333	3.640	0.433
3-7/16 - 3-1/2	22220E1K	19	0.7677	5.5606	9.0000	8.205	10.795	3.554	0.432
3-15/16 - 4	22222E1K	19	0.8661	6.1559	9.4200	8.181	10.819	3.485	0.431
4-3/16	22224E1K	19	0.9252	6.6382	9.5800	8.194	10.806	3.520	0.431
4-7/16 - 4-1/2	22226E1K	19	0.9843	7.1358	9.9200	8.209	10.791	3.558	0.432
4-15/16 - 5	22228E1K	19	1.0630	7.7232	9.6700	8.211	10.789	3.566	0.432

Outer Ring Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 120
Inner Ring Frequency = N * RPM * (1 + (Bd * cos a / Pd)) / 120
Roller Spin Frequency = Pd * RPM * (1 - (Bd * cos a / Pd) ^2) / (120 * Bd)
Cage Frequency = RPM * (1 - (Bd * cos a / Pd)) / 120

Pd = Pitch Diameter
N = Number of rollers
Bd = Roller Diameter
a = Contact Angle

Table 9: Split-Spherical Roller Bearing Parameters For Vibration Analysis

Bore Size	Basic Bearing Series	# Rollers Per Row	Diameter Of Rollers	Pitch Diameter	Contact Angle	Outer Ring Frequency Hz	Inner Ring Frequency Hz	*Roller Spin Frequency Hz	Cage Frequency Hz
2-3/16	22213SS	17	0.559	3.414	9.000	7.125	9.875	2.973	0.419
2-7/16	22215SS	18	0.551	3.748	9.083	7.693	10.307	3.328	0.427
2-11/16	22216SS	19	0.579	3.950	8.667	8.124	10.876	3.341	0.428
2-15/16	22217SS	20	0.575	4.153	8.250	8.630	11.370	3.545	0.431
3-3/16	22218SS	19	0.654	4.435	8.167	8.114	10.886	3.321	0.427
3-7/16	22220SS	18	0.780	5.079	8.833	7.635	10.365	3.183	0.424
3-15/16 - 4	22222SS	18	0.878	5.634	9.000	7.615	10.385	3.132	0.423
4-3/16	22224SS	17	1.110	6.203	9.417	7.000	10.000	2.708	0.412
4-7/16 - 4-1/2	22226SS	18	1.047	6.727	9.417	7.618	10.382	3.136	0.423
4-15/16	22228SS	18	1.118	7.202	9.750	7.623	10.377	3.145	0.424
5-3/16	22230SS	18	1.217	7.822	9.583	7.620	10.380	3.139	0.423
5-7/16	22232SS	18	1.315	8.442	9.500	7.617	10.383	3.134	0.423
5-15/16 - 6	22234SS	18	1.409	9.059	9.667	7.620	10.380	3.138	0.423
6-7/16 - 6-1/2	22236SS	18	1.409	9.059	9.667	7.620	10.380	3.138	0.423
6-15/16 - 7	22238SS	18	1.559	10.021	9.417	7.619	10.381	3.138	0.423
7-3/16	22240SS	16	1.579	10.716	9.417	6.837	9.163	3.322	0.427
7-1/2 - 8	22244SS	16	1.752	11.257	9.500	6.772	9.228	3.137	0.423
8-1/2 - 9	23048SS	20	1.307	11.189	8.083	8.843	11.157	4.223	0.442
9-1/2	23052SS	22	1.339	11.949	8.417	9.781	12.219	4.408	0.445
10	23056SS	20	1.539	13.175	8.667	8.845	11.155	4.222	0.442

Outer Ring Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 12
Olnner Ring Frequency = N * RPM * (1 + (Bd * cos a / Pd)) / 120
Roller Spin Frequency = Pd * RPM * (1 - (Bd * cos a / Pd) ^2) / (120 * Bd)
Cage Frequency = RPM * (1 - (Bd * cos a / Pd)) / 120

Pd = Pitch Diameter
N = Number of rollers
Bd = Roller Diameter
a = Contact Angle

*** Note:** Ball and Roller Spin Frequencies are listed at one (1X) roller spin frequency. For thorough analysis it is important to check frequency level at two (2X) rotational speed of balls or rollers as this is the frequency that a single ball/roller defect will contact the raceways of the bearing. In other words, a ball/roller defect will strike both inner and outer ring in one revolution of the roller.

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Table 10: USDAF Spherical Roller Bearing Parameters For Vibration Analysis (1-RPS)

Bore Size	Basic Bearing Series	# Rollers Per Row	Diameter of Rollers	Pitch Diameter	Contact Angle	Outer Ring Frequency Hz	Inner Ring Frequency Hz	* Roller Spin Frequency Hz	Cage Frequency Hz
10-15/16 - 11	23060K	27	1.575	15.066	9.500	12.108	14.892	4.732	0.448
11-7/16 - 12	23064K	28	1.575	15.850	9.333	12.627	15.373	4.983	0.451
12-7/16 - 12-1/2	23068K	27	1.732	17.007	9.500	12.144	14.856	4.860	0.450
12-15/16 - 13-1/2	23072K	28	1.732	17.793	9.333	12.655	15.345	5.089	0.452
13-15/16 - 14	23076K	30	1.732	18.587	9.000	13.620	16.381	5.320	0.454
15	23080K	29	1.929	19.822	9.167	13.107	15.893	5.091	0.452
15-3/4	23084K	30	1.929	20.609	9.000	13.613	16.387	5.296	0.454
9-7/16 - 9-1/2	23152K	23	1.693	13.914	12.500	10.134	12.866	4.051	0.441
10-7/16 - 10-1/2	23156K	24	1.732	14.711	12.000	10.618	13.382	4.191	0.442
10-15/16 - 11	23160K	23	1.89	15.923	12.333	10.167	12.834	4.156	0.442
11-15/16 - 12	23164K	23	2.087	17.044	12.833	10.127	12.873	4.025	0.440
12-7/16 - 12-1/2	23168K	23	2.244	18.272	12.833	10.123	12.877	4.013	0.440
13-7/16 - 13-1/2	23172K	24	2.244	19.077	12.333	10.621	13.379	4.195	0.443
13-15/16 - 14	23176K	25	2.323	19.833	12.000	11.068	13.932	4.213	0.443
8-15/16 - 9	23248K	20	1.929	13.523	14.000	8.616	11.384	3.438	0.431
9-7/16 - 9-1/2	23252K	19	2.126	14.745	14.000	8.171	10.829	3.400	0.430
10-7/16 - 10-1/2	23256K	20	2.126	15.537	13.583	8.670	11.330	3.590	0.434
10-15/16 - 11	23260K	20	2.323	16.706	13.833	8.650	11.350	3.530	0.433
11-15/16 - 12	23264K	20	2.441	17.878	14.000	8.675	11.325	3.598	0.434
12-7/16 - 12-1/2	23268K	20	2.638	19.048	14.167	8.657	11.343	3.545	0.433

Outer Ring Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 120
Inner Ring Frequency = N * RPM * (1 + (Bd * cos a / Pd)) / 120
Roller Spin Frequency = Pd * RPM * (1 - (Bd * cos a / Pd) ^2) / (120 * Bd)
Cage Frequency = RPM * (1 - (Bd * cos a / Pd)) / 120

Pd = Pitch Diameter
N = Number of rollers
Bd = Roller Diameter
a = Contact Angle

*** Note:** Ball and Roller Spin Frequencies are listed at one (1X) roller spin frequency. For thorough analysis it is important to check frequency level at two (2X) rotational speed of balls or rollers as this is the frequency that a single ball/roller defect will contact the raceways of the bearing. In other words, a ball/roller defect will strike both inner and outer ring in one revolution of the roller.

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Mounted Bearings Life Adjustment Factor

1.1 GENERAL. For certain applications, it is desirable to specify life for reliability other than 90%. In such cases a life adjustment factor for reliability may be applied to the RATING LIFE. Section 1.2 discusses life adjustment factors for reliability.

Some bearing steels; e.g., vacuum-melted steels, and improved processing techniques, permit manufacture of bearings which offer endurance greater than that calculated by the RATING LIFE formula. Section 1.3 recommends methods to incorporate life adjustment factors for bearing materials into the life formula.

Bearing life calculated according to the RATING LIFE formula assumes proper application conditions. If lubrication is not adequate, loading unusual, or temperatures extreme, the ability of the bearing to attain or exceed the RATING LIFE is seriously impaired. Section 1.4 contains some basic recommendations concerning the effect of unusual application conditions on bearing life.

1.2 LIFE ADJUSTMENT FACTOR FOR RELIABILITY. Bearing life estimated in accordance with this standard is RATING LIFE; i.e., the life associated With 90% reliability or the life which 90% of a group of apparently identical bearings in a given application under similar conditions of load and speed will complete or exceed. While RATING LIFE has proven useful over a period of years as a criterion of performance, some applications require definition of life at reliabilities greater than 90%.

To determine bearing life with reliabilities other than 90% (as previously calculated in the Selection Procedure) the L_{10} must be adjusted by factor a_1, such that $L_n=a_1 \times L10$.

The life adjustment factors for reliability from Table 11 are recommended.

Table 11: Life Adjustment Factors For Reliability

Reliability %	Ln		Life Adjustment Factor for Reliability a1
90	L10		1
95	L5		0.62
96	L4	(Rating Life)	0.53
97	L3		0.44
98	L2		0.33
99	L1		0.21

1.3 LIFE ADJUSTMENT FACTOR FOR MATERIAL. For bearings, which incorporate improved materials and processing, the L_{10} (as previously calculated in the Selection Procedure) must be adjusted by factor a_2. Factor a_2 depends upon steel analysis, metallurgical processing, forming methods, heat treatment and manufacturing methods in general.

Bearings fabricated from consumable vacuum remelted steels and certain other special analysis steels have demonstrated extraordinarily long endurance. These steels are of exceptionally high quality, and bearings fabricated from these are usually considered special manufacture. As such, a_2 values will not be specified for such steels in this discussion. Generally, a_2 values for such steels can be obtained from the bearing manufacturer.