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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 on Table 1 - Table 10are 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 9.249 = 9249 RPM
Cone Nick or Spall	1000 x 11.751 = 11751 RPM
Roller Nick or Spail	1000 x 8.068 = 8068 RPM
Roll Size Variation	1000 x.440 = 440 RPM

Since all the values on Table 1 - Table 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 REV./MIN.

Table 1: All Setscrew, Eccentric & D-Lok 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	1.1506	3.076569	4.923431	2.050406	0.384571
204	1/2 - 3/4		8	5/16	1.3251	3.056675	4.943325	2.002244	0.382084
205	7/8 - 1		9	5/16	1.5325	3.582382	5.417618	2.350042	0.398042
206	1-1/6 - 1-1/4	1	9	3/8	1.823	3.574328	5.425672	2.327814	0.397148
207	1-1/4 - 1-7/16	1-3/16	9	7/16	2.136	3.578301	5.421699	2.338732	0.397589
208	1-1/2 - 1-5/8	1-7/16 - 1-1/2	9	1/2	2.387	3.557394	5.442606	2.282266	0.395266
209	1-11/16 - 1-3/4	1-1/2	9	13/25	2.5591	3.585616	5.414384	2.359075	0.398402
210	1-15/16 - 2	1-11/16 - 1-3/4	10	1/2	2.7645	4.095677	5.904323	2.674068	0.409568
211	2 2-1/4	1-15/16 - 2	10	9/16	3.092	4.090395	5.909605	2.657484	0.409039
212	2-1/4 - 2-7/16	2-3/16 - 2-1/4	10	5/8	3.385	4.076809	5.923191	2.615681	0.407681
214	2-11/16	2-7/16 - 2-1/2	10	11/16	3.775	4.089404	5.910596	2.654395	0.408940
215	2-15/16	2-11/16	11	11/16	4.085	4.574357	6.425643	2.886760	0.415851
216		2-15/16 - 3	11	3/4	4.33	4.547344	6.452656	2.800062	0.413395
218		3-7/16 - 3-1/2	11	27/32	4.9199	4.556764	6.443236	2.829748	0.414251

Table 2: CC Ball Bearing Parameters For Vibration Analysis (1-RPS)

Series	Shaft Size	# Balls	Diameter of Balls	Pitch Diameter	Outer Ring Frequency Hz	Inner Ring Frequency Hz	Ball Spin Frequency Hz	Cage Frequency Hz
205	15/16 - 1	9	5/16	1.516	3.572394	5.427606	2.322533	0.396933
206	1-1/8 - 1-3/16	9	3/8	1.811	3.568194	5.431806	2.311133	0.396466
207	1-1/4 - 1-7/16	9	7/16	2.106	3.565171	5.434829	2.302987	0.396130
209	1-11/16 - 1-3/4	9	1/2	2.362	3.547417	5.452583	2.256157	0.394157
210	1-15/16	10	1/2	2.756	4.092888	5.907112	2.665289	0.409289
211	2-3/16	10	9/16	3.051	4.078171	5.921829	2.619817	0.407817

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Table 3: 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	8.325540	10.674460	3.797580	0.438186
1-3/8 - 1-7/16	20	0.29	2.084	16.5	8.665750	11.334250	3.529138	0.433287
1-1/2 - 1-11/16	18	0.35	2.411	16	7.744100	10.255900	3.377216	0.430228
1-3/4 - 2	17	0.41	2.709	12.033	7.241814	9.758186	3.231274	0.425989
‘2-3/16	19	0.41	3.014	13.283	8.242270	10.757730	3.611184	0.433804
2-1/4 - 2-1/2	21	0.41	3.337	14.5	9.251011	11.748989	4.011931	0.440524
2-11/16 - 3	24	0.41	3.9	16.733	10.791879	13.208121	4.707891	0.449662
3-3/16 - 3-1/2	26	0.46	4.78	18.167	11.811316	14.188684	5.152213	0.454281
3-15/16 - 4	26	0.51	5.12	17.567	11.765467	14.234533	4.974340	0.452518
4-7/16 - 4-1/2	25	0.59	5.727	18.983	11.282275	13.717725	4.807330	0.451291
4-15/16 - 5	25	0.68	6.568	17	11.262395	13.737605	4.782071	0.450496
5-7/16 - 6	32	0.67	8.444	17.75	14.790895	17.209105	6.265507	0.462215
6-7/16 - 7	27	0.93	9.791	19.167	12.288783	14.711217	5.221605	0.455140

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 4: 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	8.235801	10.764199	3.566352	0.433463
1-1/2 - 1-3/4	21	0.32	2.604	11.50	9.235581	11.764419	4.009748	0.439790
1-15/16	22	0.33	2.848	15.00	9.768852	12.231148	4.261097	0.444039
2 - 2-1/4	21	0.40	3.335	16.83	9.294571	11.705429	4.113807	0.442599
2-3/16 - 2-7/16	25	0.35	3.533	18.00	11.322284	13.677716	5.002340	0.452891
2-1/2 - 2-11/16	23	0.43	3.827	16.50	10.261076	12.738924	4.398352	0.446134
2-7/16 - 2-15/16	26	0.42	4.22	16.50	11.759442	14.240558	4.978061	0.452286
3 - 3-3/16	22	0.55	4.612	16.50	9.742225	12.257775	4.137910	0.442828
3-1/4 - 3-7/16	24	0.51	4.761	16.42	10.766982	13.233018	4.618367	0.448624
3-1/2 - 4	25	0.59	5.727	18.98	11.282253	13.717747	4.807328	0.451290
4-7/16 - 4-1/2	33	0.46	3.109	11.50	14.107710	18.892290	3.308310	0.427506
4-15/16 - 5	26	0.68	6.983	18.00	11.796028	14.203972	5.090519	0.453693

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)

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Type 5: 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	16	0.40	2.563	11.54	6.776702	9.223298	3.128839	0.423544
1-9/16 - 1-3/4	18	0.40	2.854	12.72	7.769570	10.230430	3.500820	0.431643
1-7/8 - 2	19	0.41	3.014	13.28	8.242255	10.757745	3.611183	0.433803
2-1/8 - 2-1/4	22	0.41	3.475	15	9.746381	12.253619	4.182764	0.443017
2-3/8 - 2-1/2	20	0.46	3.695	14.38	8.794078	11.205922	3.957897	0.439704
2-5/8 - 3	22	0.51	4.336	15.07	9.750677	12.249323	4.196146	0.443213
3-3/16 - 3-1/2	23	0.59	5.22	17.42	10.259806	12.740194	4.372280	0.446079
3-11/16 - 4	23	0.68	5.942	15.50	10.231809	12.768191	4.315984	0.444861
4-7/16 - 4-1/2	26	0.68	6.983	18	11.796028	14.203972	5.090519	0.453693
4-15/16 - 5	24	0.81	7.537	16.42	10.762960	13.237040	4.603028	0.448457
5-7/16 - 6	24	0.93	9.123	17.33	10.832249	13.167751	4.858391	0.451344
6-1/2 - 7	29	0.93	10.19	19.23	13.250482	15.749518	5.437812	0.456913
7-15/16 - 8	27	1.12	11.471	12.42	12.212741	14.787259	5.074422	0.452324
8-1/2 - 10	41	0.87	13.979	16.40	19.276067	21.723933	8.005271	0.470148
11 - 12	37	1.20	16.061	12.50	17.150534	19.849466	6.656476	0.463528

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 6: 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	12.361632	14.638368	5.673261	0.457838
3-1/4 - 3-1/2	26	0.51	5.120	17.57	11.765488	14.234512	4.974342	0.452519
3-15/16 - 4	33	0.48	5.814	12.50	15.170061	17.829939	6.016904	0.459699
4-7/16 - 4-1/2	29	0.60	6.503	12.92	13.196026	15.803974	5.375340	0.455035
4-15/16 - 5	32	0.61	7.355	12.50	14.704466	17.295534	5.989163	0.459515
5-7/16	27	0.84	8.272	12	12.159067	14.840933	4.875231	0.450336
5-15/16 - 6	26	0.85	8.323	12	11.701366	14.298634	4.847026	0.450053
6-7/16 - 7	32	0.81	9.748	12.50	14.702011	17.297989	5.977683	0.459438
7-1/2 - 8	27	1.12	11.471	12.42	12.212741	14.787259	5.074422	0.452324
9 - 10	32	1.28	14.026	12.03	14.571921	17.428079	5.435259	0.455373

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 7: Spherical Roller Bearing Parameters for Vibration Analysis (1-RPS)

Basic Bearing Series	USAF/SAF-XT Bore Sizes (in)	S2000 Unisphere II Sizes (in)	Imperial Bore Sizes (in)	# Rollers Per Row	Diameter of Rollers	Pitch Diameter	Contact Angle	Outer Ring Frequency Hz	Inner Ring Frequency Hz	Spin Frequency Hz	Cage Frequency Hz
22207E1ASKM				15	0.3937	2.166	11.750	6.165339	8.834661	2.663713	0.411023
22208E1ASKM		1-3/8 - 1-1/2	1-1/8 - 1-1/2	15	0.4488	2.449	10.583	6.148942	8.851058	2.639849	0.409929
22209E1ASKM	1-7/16	1-11/16 - 1-3/4	1 5/8 - 1-3/4	17	0.4291	2.665	9.750	7.151157	9.848843	3.027139	0.420656
22210E1ASKM	1-11/16	1-15/16 - 2	1 7/8 - 2	18	0.4331	2.858	9.083	7.653247	10.346753	3.225588	0.425180
22211E1ASKM	1-15/16	2-3/16	2-3/16 - 2-1/4	19	0.4646	3.189	8.750	8.132069	10.867931	3.360826	0.428004
22213E1ASKM	2-3/16	2 -7/16	2-3/8 - 2-1/2	18	0.5827	3.795	9.083	7.635432	10.364568	3.181534	0.424191
22215E1ASKM	2 7/16 - 2-1/2	2-11/16 - 3	2-11/16 - 3	20	0.5748	4.197	8.250	8.644623	11.355377	3.583768	0.432231
22216E1ASKM	2-11/16 - 2-3/4			19	0.6535	4.48	8.167	8.128283	10.871717	3.356234	0.427804
22217E1ASKM	2-15/16 - 3			18	0.7323	4.764	8.417	7.631462	10.368538	3.177554	0.423970
22218E1ASKM	3-3 /16	3-7 /16	3-3/16 - 3-1 /2	18	0.7795	5.079	8.833	7.635107	10.364893	3.182930	0.424173
22220E1ASKM	3-7 /16 - 3-1 /2	3-1 5/16 - 4	3-1 1/16 - 4	18	0.878	5.705	9.000	7.631952	10.368048	3.173794	0.423997
22222E1ASKM	3-1 5/16 - 4	4-7/16	4-7/16 - 4-1/2	17	1.0197	6.287	9.417	7.139947	9.860053	3.003844	0.419997
22224E1ASKM	4-3/16			18	1.0472	6.819	9.417	7.636487	10.363513	3.181095	0.424249
22226E1ASKM	4-7/16 - 4-1/2	4-15/16	4-15/16 - 5	18	1.1181	7.307	9.750	7.642733	10.357267	3.193282	0.424596
22228E1ASKM	4-15/16 - 5		5-7/16 - 5-1/2	18	1.2165	7.933	9.583	7.639139	10.360861	3.186035	0.424397
22230E1ASKM	5-3/16			18	1.315	8.559	9.500	7.636209	10.363791	3.179646	0.424234
22232E1ASKM	5-7/16 - 5-1/2		5-15/16 - 6	18	1.4094	9.189	9.667	7.639189	10.360811	3.185371	0.424399
22234E1ASKM	5-15/16 - 6			17	1.5827	9.74	9.833	7.139085	9.860915	2.998143	0.419946
22236E1ASKM	6-7/16 - 6-1/2		6-7/16 - 7	18	1.5591	10.157	9.417	7.637116	10.362884	3.182632	0.424284
22238E1ASKM	6-15/16 - 7			20	1.4961	10.669	10.667	8.621944	11.378056	3.497892	0.431097
22240E1ASKM	7-3/16			19	1.6142	11.021	10.833	8.133372	10.866628	3.343119	0.428072
22244E1ASKM	7-1/2 - 8			19	1.8504	12.48	10.833	8.116546	10.883454	3.300728	0.427187
23048KMB	8-7/16 - 9			29	1.1417	12.008	9.333	13.139616	15.860384	5.212536	0.453090
23052KMB	9-7/16 - 9-1/2			27	1.378	13.228	9.667	12.113633	14.886367	4.749092	0.448653
23056KMB	9-15/16 - 10-1/2			28	1.378	13.976	9.333	12.637908	15.362092	5.023115	0.451354

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 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	7.231287	9.768713	3.225462	0.425370
1-11/16	22210E1K	19	0.3937	2.7976	9.2500	8.180471	10.819529	3.484413	0.430551
1-15/16	22211E1K	18	0.4528	3.0921	8.9200	7.698000	10.302000	3.342963	0.427667
2-3/16	22213E1K	19	0.5315	3.7110	9.2500	8.157076	10.842924	3.421302	0.429320
2-7/16 - 2-1/2	22215E1K	21	0.5315	4.1098	8.3300	9.156413	11.843587	3.802922	0.436020
2-11/16 - 2-3/4	22216E1K	20	0.5709	4.3638	8.2500	8.705275	11.294725	3.757794	0.435264
2-15/16 - 3	22217E1K	20	0.6299	4.6811	8.5000	8.669157	11.330843	3.649937	0.433458
3-3/16	22218E1K	20	0.6693	4.9602	8.8300	8.666651	11.333349	3.639636	0.433333
3-7/16 - 3-1/2	22220E1K	19	0.7677	5.5606	9.0000	8.204572	10.795428	3.554256	0.431820
3-15/16 - 4	22222E1K	19	0.8661	6.1559	9.4200	8.181428	10.818572	3.485342	0.430601
4-3/16	22224E1K	19	0.9252	6.6382	9.5800	8.194401	10.805599	3.519683	0.431284
4-7/16 - 4-1/2	22226E1K	19	0.9843	7.1358	9.9200	8.209178	10.790822	3.557887	0.432062
4-15/16 - 5	22228E1K	19	1.0630	7.7232	9.6700	8.211024	10.788976	3.565861	0.432159

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

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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	7.125120	9.874880	2.973241	0.419125
2-7/16	22215SS	18	0.551	3.748	9.083	7.693012	10.306988	3.328155	0.427390
2-11/16	22216SS	19	0.579	3.950	8.667	8.124082	10.875918	3.341232	0.427583
2-15/16	22217SS	20	0.575	4.153	8.250	8.630263	11.369737	3.544783	0.431513
3-3/16	22218SS	19	0.654	4.435	8.167	8.114365	10.885635	3.321078	0.427072
3-7/16	22220SS	18	0.780	5.079	8.833	7.635107	10.364893	3.182930	0.424173
3-15/16 - 4	22222SS	18	0.878	5.634	9.000	7.614712	10.385288	3.132415	0.423040
4-3/16	22224SS	17	1.110	6.203	9.417	6.999864	10.000136	2.707845	0.411757
4-7/16 - 4-1/2	22226SS	18	1.047	6.727	9.417	7.617839	10.382161	3.136146	0.423213
4-15/16	22228SS	18	1.118	7.202	9.750	7.622945	10.377055	3.145244	0.423497
5-3/16	22230SS	18	1.217	7.822	9.583	7.619828	10.380172	3.139355	0.423324
5-7/16	22232SS	18	1.315	8.442	9.500	7.617307	10.382693	3.134123	0.423184
5-15/16 - 6	22234SS	18	1.409	9.059	9.667	7.619661	10.380339	3.138182	0.423314
6-7/16 - 6-1/2	22236SS	18	1.409	9.059	9.667	7.619661	10.380339	3.138182	0.423314
6-15/16 - 7	22238SS	18	1.559	10.021	9.417	7.618619	10.381381	3.138004	0.423257
7-3/16	22240SS	16	1.579	10.716	9.417	6.837308	9.162692	3.322243	0.427332
7-1/2 - 8	22244SS	16	1.752	11.257	9.500	6.771984	9.228016	3.136916	0.423249
8-1/2 - 9	23048SS	20	1.307	11.189	8.083	8.843406	11.156594	4.222831	0.442170
9-1/2	23052SS	22	1.339	11.949	8.417	9.780985	12.219015	4.408432	0.444590
10	23056SS	20	1.539	13.175	8.667	8.844916	11.155084	4.222170	0.442246

Outer Ring Frequency = N * RPM * (1 - (Bd * cos a / Pd)) / 12
OInner 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 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	9.5	12.108065	14.891935	4.732011	0.448447
11-7/16 - 12	23064K	28	1.575	15.85	9.333	12.627248	15.372752	4.983368	0.450973
12-7/16 - 12-1/2	23068K	27	1.732	17.007	9.5	12.144010	14.855990	4.860109	0.449778
12-15/16 - 13-1/2	23072K	28	1.732	17.793	9.333	12.655257	15.344743	5.089157	0.451973
13-15/16 - 14	23076K	30	1.732	18.587	9	13.619458	16.380542	5.320311	0.453982
15	23080K	29	1.929	19.822	9.167	13.106938	15.893062	5.090472	0.451963
15-3/4	23084K	30	1.929	20.609	9	13.613287	16.386713	5.296232	0.453776
9-7/16 - 9-1/2	23152K	23	1.693	13.914	12.5	10.133894	12.866106	4.051285	0.440604
10-7/16 - 10-1/2	23156K	24	1.732	14.711	12	10.618053	13.381947	4.190502	0.442419
10-15/16 - 11	23160K	23	1.89	15.923	12.333	10.166494	12.833506	4.155793	0.442021
11-15/16 - 12	23164K	23	2.087	17.044	12.833	10.127024	12.872976	4.025170	0.440305
12-7/16 - 12-1/2	23168K	23	2.244	18.272	12.833	10.122953	12.877047	4.012925	0.440128
13-7/16 - 13-1/2	23172K	24	2.244	19.077	12.333	10.621032	13.378968	4.194537	0.442543
13-15/16 - 14	23176K	25	2.323	19.833	12	11.067894	13.932106	4.212801	0.442716
8-15/16 - 9	23248K	20	1.929	13.523	14	8.615913	11.384087	3.438035	0.430796
9-7/16 - 9-1/2	23252K	19	2.126	14.745	14	8.170935	10.829065	3.399907	0.430049
10-7/16 - 10-1/2	23256K	20	2.126	15.537	13.583	8.669925	11.330075	3.589401	0.433496
10-15/16 - 11	23260K	20	2.323	16.706	13.833	8.649811	11.350189	3.530230	0.432491
11-15/16 - 12	23264K	20	2.441	17.878	14	8.675192	11.324808	3.597751	0.433760
12-7/16 - 12-1/2	23268K	20	2.638	19.048	14.167	8.657198	11.342802	3.545213	0.432860

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

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	(Rating Life)	1
95	L5		0.62
96	L4		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.

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1.4 LIFE ADJUSTMENT FACTOR FOR APPLICATION CONDITIONS.

Application conditions which affect bearing life include:

1. Lubrication.
2. Load distribution (including effects of clearance, misalignment, housing, and shaft stiffness, type of loading and thermal gradients).
3. Temperature.

Consideration of (1.2) and (1.3) above requires analytical and experimental techniques beyond the scope of this discussion, therefore, the user should consult the bearing manufacturer for evaluations and recommendations.

In most bearing applications, lubrication serves to separate the rolling surfaces; i.e., rolling elements and raceways; to reduce retainer-rolling elements and retainer-land friction and sometimes to act as a coolant to remove frictional heat generated by the bearing.

If all limitations and qualifications specified by this discussion are observed, then the life adjustment application factor for bearings which are adequately lubricated is 1; i.e., a_3=1.

Operating conditions where a_3 might be less than 1 include:

a) exceptionally low values of Ndm (rpm times bore diameter in mm); e.g., Ndm 1000.

b) Lubricant viscosity less than 20.4 centistokes (100 SUS) at operating temperature.

c) Excessively high operating temperatures.

When a3 is less than 1, it may not be assumed that the deficiency in lubrication can be overcome by using an improved steel.

1.5 FACTOR COMBINATIONS. A fatigue life formula including the life adjustment factors is:

Ball Bearings:

$$L_n = a_1 \times a_2 \times a_3 \left(\frac{C^*}{P}\right)^3 \times \frac{(16.667)}{RPM}$$

Tapered Roller Bearings:

$$L_n = a_1 \times a_2 \times a_3 \left(\frac{C90^*}{P}\right)^{10/3} \times \frac{(1,500,000)}{RPM}$$

Spherical Roller Bearings:

$$L_n = a_1 \times a_2 \times a_3 \left(\frac{C^*}{P}\right)^{10/3} \times \frac{(16.667)}{RPM}$$

Indiscriminate application of the life adjustment factors in this formula may lead to serious over-estimation of bearing endurance, since fatigue life is only one criterion for bearing selection.

Care must be exercised to select bearings which are of sufficient size for the application. Undersizing of shaft and housing structures by using bearings which appear adequate from a life standpoint could lead to misalignment and fitting problems which could invalidate the formulas in this discussion.

* C = Basic Load Rating computed in accordance with ABMA-ANSI Standards. C90 = C x .259

V-Belt Drive Formulas

V-belt tensioning In cases where tensioning of a drive effects belt pull and bearing loads, the following formulas may be used.

$T_1 - T_2 = 33{,}000 \left(\frac{HP}{V}\right)$

where:
- T_1 = tight side tension, pounds
- T_2 = slack side tension, pounds
- HP = design horsepower
- V = belt speed, feet per minute

$T_1 + T_2 = 33{,}000\,(2.5\text{-}G) \left(\frac{HP}{GV}\right)$

where:
- T_1 = tight side tension, pounds
- T_2 = slack side tension, pounds
- HP = design horsepower
- V = belt speed, feet per minute"
- G = arc of contact correction factor*

$T_1/T_2 = \frac{1}{1-0.8G}$ (Also $T1/T2 = e^{K\emptyset}$)

where:
- T_1 = tight side tension, pounds
- T_2 = slack side tension, pounds
- G = arc of contact correction factor*
- e = base of natural logarithms
- K = .51230, a constant for V-belt drive design
- Ø = arc of contact in radians

$T_1 = 41{,}250\ (HP/GV)$

where:
- T_1 = tight side tension, pounds
- HP = design horsepower
- V = belt speed, feet per minute
- G = arc of contact correction factor

$T_2 = 33{,}000\ (1.25\text{-}G)\ (HP/GV)$

where:
- T_2 = slack side tension, pounds
- HP = design horsepower
- V = belt speed, feet per minute
- G = arc of contact correction factor

Belt Speed

$V = \frac{(PD)\ (RPM)}{3.82} = (PD)\ (rpm)\ (.262)$

where:
- V = belt speed, feet per minute
- PD = pitch diameter of sheave or pulley
- rpm = revolutions per minute of the same sheave or pulley

* See Table 12 at left

Table 12: Arc of Contact Correction Factor G

D-d / C	Small Sheave Arc of Contact	Factor G	D-d / C	Small Sheave Arc of Contact	Factor G
.00	180°	1.00	.80	133°	.87
.10	174°	.99	.90	127°	.85
.20	169°	.97	1.00	120°	.82
.30	163°	.96	1.10	130°	.80
.40	157°	.94	1.20	106°	.77
.50	151°	.93	1.30	99°	.73
.60	145°	.91	1.40	91°	.70
.70	139°	.89	1.50	83°	.65

D = Diam. of large sheave. d = Diam. of small sheave
C = Center distance

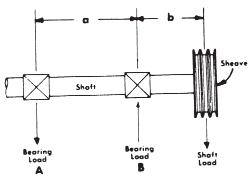
Table 13: Allowable Sheave Rim Speed

Sheave Material	Rim Speed in Feet per Minute
Cast Iron	6,500
Ductile Iron	8,000
Steel	10,000

NOTE: Above rim speed values are maximum for normal considerations. In some cases these values may be exceeded. Consult factory and include complete details of proposed application.

Bearing Load Calculations

To find actual bearing loads, it is necessary to know machine component weights and values of all other forces contributing to the load. Sometimes it becomes desirable to know the bearing load imposed by the V-belt drive alone. This can be done if you know bearing spacing with respect to the sheave center and shaft load and apply it to the following formulas:

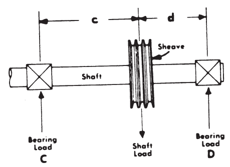


Overhung Sheave

Load at B, lbs. = $\frac{\text{Shaft Load} \times (a + b)}{a}$

Load at A, lbs = Shaft Load x $\frac{b}{a}$

Where: a and b = Spacing, inches



Sheave Between Bearings

Load at D, lbs. = $\frac{\text{Shaft Load} \times c}{c + d}$

Load at C, lbs = $\frac{\text{Shaft Load} \times d}{c + d}$

Where: c and d = Spacing, inches

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Nominal V-Belt Cross Sections

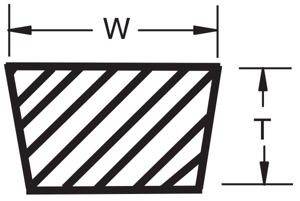

Table 14: Nominal V-Belt Cross Sections

Belt Section	Industry Standard Description	Width W, in Inches	Thickness T, in Inches
3L	FHP, Single	3/8	7/32
4L		1/2	5/16
5L		21/32	3/8
3V	Narrow	3/8	5/16
5V		5/8	17/32
8V		1	29/32
A	Classical Multiple	1/2	5/16
B		21/32	13/32
C		7/8	17/32
D		1-1/4	3/4

Pulley Dia. Inches	FPM												
	100	150	200	250	300	350	400	500	600	700	800	900	1000
6	64	95	127	159	191	223	254	318	382	445	509	573	636
8	48	72	95	119	143	167	191	239	286	334	382	429	477
10	38	57	76	95	115	134	153	191	229	267	305	344	382
12	32	48	64	80	95	111	127	159	191	223	254	286	318
14	27	41	55	68	82	95	109	136	164	191	218	245	273
16	24	36	48	60	72	83	95	119	143	167	191	215	239
18	21	32	42	53	64	74	85	106	127	148	170	191	212
20	19	29	38	48	57	67	76	95	115	134	153	172	191
24	16	24	32	40	48	56	64	80	95	111	127	143	159
30	13	19	25	32	38	45	51	64	76	89	102	115	127
36	11	16	21	27	32	37	42	53	64	74	85	95	106
42	9	14	18	23	27	32	36	45	55	64	73	82	91
48	8	12	16	20	24	28	32	40	48	56	64	72	80
54	7	11	14	18	21	25	28	35	42	49	57	64	71
60	6	10	13	16	19	22	25	32	38	45	51	57	64

For values not shown use formula below:

SFM =.2618 x D x RPM

SFM = Surface feet Per Minute

D = Pulley Diameter, Inches

RPM = Revolutions per Minute

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Table 15: Material Characteristics

MATERIAL	DENSITY (LB/fT3)	ANGLE OF REPOSE (DEG)	RECOMMENDED MAXIMUM INCLINATION
Alfalfa, Ground	16	45°	
Alum, Lumpy	50 - 60	35°	
Alum, Pulverized	45 - 50	35°	
Alumina	60	30°	10-12
Aluminum Oxide	70 - 120	30°	
Ammonium Sulphate	45 - 60	45°	
Asbestos, Shredded	20 - 25	45°	
Ashes, Dry	35 - 40	45°	
Ashes, Wet	45 - 50	45°	
Ashes, Soft Coal	35 - 45	40°	
Asphalt, Crushed	45	35°	
Bagasse	7.50	45°	
Bakelite, Powder	30 - 40	45°	
Baking Powder	40 - 50	35°	
Bark, Wood Refuse	10 - 20	45°	27
Barley	38	25°	10-15
Basalt	80 - 120	25°	
Bauxite, Crushed	75 - 85	35°	20
Beans, Castor, Whole	30 - 45	25°	8-10
Beans, Cocoa	30 - 45	35°	
Beans, Navy	50	25°	
Beans, Whole	45	45°	
Bentonite, Crude	35 - 40	45°	
Bentonite, Fine	50 - 60	45°	
Bones, Pulverized	50 - 60	45°	
Borax, Fine	50 - 55	35°	
Borax Coarse	60 - 70	35°	
Bran	16	35°	
Brewers Grain, Dry	25 - 35	45°	
Brewers Grain, Wet	55 - 60	45°	
Buck Wheat	40	25°	11-13
Calcium, Carbide	70 - 80	35°	
Carbon Black, Pellets	25	25°	
Carbon Black, Powder	5	35°	
Cast Iron Chips	100 -120	45°	
Cement, Clinker	75 - 90	35°	
Cement, Portland	80 -100	35°	20-23
Chalk, Fine	65 - 75	45°	
Chalk, Lumpy	80 - 95	45°	
Charcoal, Wood	15 - 30	35°	20-25
Chromium Ore	125 - 140	35°	
Cinders, Coal	40	35°	20
Clay, Dry, Fine	100 - 120	35°	20-22
Clay, Dry, Lumpy	60 - 75	35°	18-20
Coal, Anthracite, Coarse	60 - 70	35°	18
Coal, Anthracite, Loose	50 - 60	30°	16
Coal, Bituminous, Coarse	50 - 60	35°	18
Coal, Bituminous, Loose	45 - 50	35°	16
Cocoa Nibs	35 - 40	35°	
Coconut, Shredded	20 - 25	45°	
Coffee, Fresh Beans	30 - 40	35°	10-15
Coffee, Roasted Beans	22 - 30	25°	
Coke, Loose	23 - 32	35°	18
Coke Pulverized	25 - 35	45°	20-22
Coke, Petroleum Calcinated	35 - 45	35°	20
Concrete, Cinder	112	0°	12-30
Concrete, Gravel & Sand	150	0°	
Copper Ore	120 - 150	35°	20
Copper Sulfate	75 - 85	30°	17
Cork, Ground	5 - 15	45°	
Corn, On Cob	45	0°	

MATERIAL	DENSITY (LB/fT3)	ANGLE OF REPOSE (DEG)	RECOMMENDED MAXIMUM INCLINATION
Corn, Shelled	45	25°	10
Corn Sugar	30	35°	
Corn Grits	40 - 45	35°	
Cornmeal	32- 40	35°	22
Cottonseed, Dry, De-Linted	35	35°	16
Cottonseed, Dry, Not De-Linted	18- 25	45°	19
Cottonseed, Cake, Lumpy	40- 45	35°	
Cottonseed, Hulls	12	45°	
Cottonseed, Meal	35- 40	35°	22
Cottonseed, Meats	40	35°	
Cryolite	90-110	35°	
Cullet	80-120	35°	20
Diatomaceous Earth	11- 14	35°	
Dolomite, Lumpy	90-100	35°	22
Dolomite, Pulverized	46	40°	
Earth, Dry"	70- 80	35°	20
Earth, Moist	75-110	40°	23
Earth, Fullers Dry	30- 35	23°	20
Emery	225	25°	
Epsom Salt	40- 50	35°	
Feldspar, Lumps	70-100	35°	17
Feldspar, Dust	80-100	40°	
Fish, Meal	35- 40	40°	
Fish, Scrap	40- 50	0°	
Flaxseed, Whole	45	25°	12
Flaxseed, Meal	25	35°	
Flour, Wheat	35- 40	45°	21
Flue Dust, Dry	30- 40	20°	
Fluorspar, Dust	85- 95	45°	
Fluorspar, Lumps	80-110	45°	
Foundry, Refuse	60- 80	35°	
Foundry Sand, Loose	80- 90	35°	
Foundry Sand, Rammed	100-110	0°	
Galena	250	35°	
Garbage, Average	30	25°	
Glass, Batch Fiber	45 - 55	10°	
Glass, Batch Wool	80-100	35°	20-22
Glass, Broken	80-100	10°	
Glue, Animal, Flaked	35	25°	
Glue, Vegetable, Powdered	40	35°	
Gluten, Meal	39	35°	
Granite, Lumps	150 -170	25°	
Graphite, Flakes	40	35°	
Graphite, Powder	30	25°	
Graphite, Ore	65 - 75	35°	
Grass Seed	10	35°	
Gravel, Dry	90-100	35°	15-17
Gravel, Wet	100-120	35°	
Gypsum, Lumps	90-100	35°	15
Gypsum, Ground	75- 80	35°	21
Hay, Loose	5	0°	
Hay, Pressed	25	0°	
Hominy	35- 50	35°	
Hops, Spent, Dry	25- 35	45°	
Hops, Spent, Wet	55- 60	45°	
Ice, Crushed	35- 40	20-	
Ilmenite Ore	140-160	35°	
Iron Ore	120-180	35°	18-20
Iron Ore, Pellets	120-140	35°	13-15
Iron Sulphate	50- 75	35°	
Iron Sulfide	120-140	35°	

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Table 16: Material Characteristics

MATERIAL	DENSITY (LB/fT3)	ANGLE OF REPOSE (DEG)	RECOMMENDED MAXIMUM INCLINATION
Kaolin, Clay	60	35˚	19
Lactose	30	35˚	
Lead Ore, Crushed	180 - 270	30˚	
Lead Oxides	60 - 150	40˚	
Lead Sulfate	170 - 190	45˚	
Lead Sulfide	240 - 260	35˚	
Lignite, Air Dried	45 - 55	35˚	
Lime, Ground	60 - 65	40˚	23
Lime, Hydrated	40	40˚	21
Lime, Pebble	30 - 40	40˚	17
Limestone, Loose	80 - 100	35˚	20
Limestone, Pulverized	85 - 90	45˚	18
Linseed, Whole	45 - 50	25˚	
Linseed, Meal	30 - 40	35˚	20
Magnesium Chloride	30 - 35	40˚	
Magnesium Sulfate	40 - 60	35˚	
Malt, Dry	25 - 30	30˚	
Malt, Wet	60 - 65	45˚	
Malt, Meal	35 - 40	35˚	
Manganese Ore	125 - 140	40˚	
Manganese Oxide	120	35˚	
Manganese Sulfate	70	35˚	
Manure	25	0˚	
Marble, Crushed	80 - 95	35˚	
Marl	80	35˚	
Mica, Flakes	20	20˚	
Mica, Ground	15	35˚	23
Milk, Dried, Flaked	5	35˚	
Milk, Malted	25 - 35	45˚	
Milk, Powdered	20 - 30	40˚	
Milo Maize	55 - 60	35˚	
Molybdenum Ore	100 - 110	40˚	
Mortar, Wet	150	0˚	
Niacin	35	35˚	
Nickel-Cobalt Sulfate Ore	80 - 150	35˚	
Oats	25 - 35	25˚	10
Oats, Rolled	20	35˚	
Oil Cake	50	45˚	
Oxalic Acid Crystals	60	35˚	
Oyster Shells, Ground	50 - 60	35˚	
Oyster Shells, Whole	80	35˚	
Paper Pulp Stock	40 - 60	20˚	
Peanuts, Shelled	35 - 45	35˚	
Peanuts, Not Shelled	15 - 20	35˚	
Peas, Dried	45 - 50	0˚	
Phosphate, Fertilizer	50 - 60	35˚	30
Phosphate, Rock, Crushed	60 - 100	35˚	25
Potash	70 - 80	30˚	
Potassium Chloride	120 - 130	35˚	
Potassium Nitrate	75 - 80	25˚	
Potassium Sulfate	45	45˚	
Potatoes, White"	48	0˚	
Pumice, Ground	40 - 45	45˚	
Pyrites, Lumps	135 - 145	25˚	
Pyrites, Pellets	120 - 130	35˚	
Quartz, Lumps	95 - 100	25˚	
Quartz, Sand	70 - 80	25˚	
Rice, Hulled	45 - 50	20˚	8
Rice, Rough	35	35˚	
Rice, Grits	40 - 45	35˚	
Rock, Crushed	100 - 150	30˚	

MATERIAL	DENSITY (LB/fT3)	ANGLE OF REPOSE (DEG)	RECOMMENDED MAXIMUM INCLINATION
Rubber, Pellets	50 - 55	35˚	22
Rubber, Ground Scrap	25 - 35	45˚	18
Rye	42 - 45	25˚	8
Rye Meal	35 - 40	20˚	
Salt Cake	80 - 95	30˚	21
Salt, Coarse"	45 - 55	35˚	18-22
Salt, Fine"	70 - 80	35˚	11
Sand, Wet	110 - 130	45˚	20-22
Sand, Dry	90 - 110	35˚	16-18
Sand, Loose, Foundry	80 - 100	35˚	22
Sand, Foundry, Rammed	100 - 110	0˚	24
Sandstone	80 - 90	35˚	
Sawdust	10 - 25	30˚	22
Scale, Rolling Mill	125 - 160	45˚	
Sewage Sludge, Dry	45 - 55	35˚	
Sewage Sludge, Wet	50 - 60	35˚	
Shale, Broken	90 - 100	25˚	
Shale, Crushed	85 - 90	40˚	22
Silica Gel, Dry	45	35˚	
Slag, Blast Furnace	80 - 90	25˚	10
Slag, Granular, Dry	60 - 65	25˚	13-16
Slag, Granular, Wet	90 - 100	45˚	20-22
Slate, Ground	80 - 90	30˚	15
Slate, Lumps	85 - 95	0˚	
Snow, Compacted	15 - 50	0˚	
Soap	10 - 25	35˚	
Soda Ash, Briquettes	50	20˚	7
Soda Ash, Heavy	55 - 65	30˚	19
Soda Ash, Light	20 - 35	35˚	22
Sodium Aluminum, Ground	72	35˚	
Sodium Nitrate, Ground	70 - 80	24˚	11
Sodium Phosphate	50 - 65	35˚	
Soybeans, Cracked	30 - 40	35˚	15-18
Soybeans, Whole"	45 - 50	25˚	12-16
Starch, Powdered	25 - 45	25˚	12
Steel, Chips	100 - 150	35˚	18
Steel, Turnings	60 - 120	45˚	
Sugar, Cane, Raw	55 - 65	45˚	
Sugar. Granulated, Dry	50 - 55	35˚	
Sugar, Granulated, Wet	55 - 65	40˚	
Sugar Cane, Knifed	15 - 18	45˚	
Sulphur, Lumps	80 - 85	35˚	
Sulphur, Dust	50 - 70	35˚	
Saconite, Pellets	120 - 140	35˚	13-15
Salc, Granulated	50 - 70	20˚	
Titanium Dioxide	140	35˚	
Titanium Sponge	60 - 70	45˚	
Tobacco, Leaves	14	45˚	
Tobacco, Scraps	15 - 25	45˚	
Tobacco, Stems	15	45˚	
Traprock, Crushed	95 - 110	35˚	
Traprock, Lumps	100 - 110	35˚	
Turf	20 - 30	0˚	
Walnut, Shells	35 - 45	35˚	
Wheat	48	25˚	12
Wheat, Cracked	40 - 45	35˚	
Wheat Germ, Dry	20 - 30	25˚	27
Wood Chips	10 - 30	45˚	22
Zinc Ore, Granular	160	35˚	
Zinc Oxide	10 - 35	45˚	

Shafting

Table 17: Typical Commercial Shaft Tolerances

Shaft Size	Plus	Minus
Up to 1-1/2"	.000	.002
Over 1-1/2 to 2-1/2"	.000	.003
Over 2-1/2 to 4"	.000	.004
Over 4 to 6"	.000	.005
Over 6 to 8"	.000	.006
Over 8 to 9"	.000	.007
Over 9"	.000	.008

Table 18: Shaft Tolerances

Shaft Size	Tolerance, Inches
Up to 1-1/2"	+.0000 -.0005"
1-5/8 to 4"	+.000 -.001"
4-7/16 to 6"	+.000 -.0015"
6-7/16 to 8"	+.000 -.002"

Table 18 lists the recommended tolerances for all setscrew locking, eccentric locking and D-LOK locking ball and roller bearings

Table 19: Shaft Tolerances

Shaft Size	Tolerance, Inches
Up to 1-1/2"	+.000 -.002"
1-9/16 to 2-1/2"	+.000 -.003"
2-5/8 to 4"	+.000 -.004"
4-3/16 to 6"	+.000 -.005"
6-7/16" and above	+.000 -.006"

Table 19 list the recommended tolerances for all tapered adapter sleeve ball and roller bearings

Standard Shafting-Table 17 indicates standard shafting is cold drawn in the smaller sizes and turned and polished in the larger diameters. It has a smooth surface, is commercially straight and is readily machinable; suitable and recommended for general power transmission and material handling service.

Special Shafting-While standard shafting is suitable for most installations, special shafting is sometimes required for certain chemical, temperature or physical requirements. Such materials as high carbon steel, alloy steel, stainless steel, brass, Monel metal, etc., can be furnished plain or heat treated. Stepped, flanged, hollow or other special forms are available.

Special shafting should be avoided in favor of standard shafting wherever possible because special shafting is usually considerably more expensive and requires a greater length of time to obtain, which is an especially important consideration should quick replacement ever become necessary.

Ordering Shafting-Standard shafting can be obtained from most supply houses and dealers who handle power transmission material.

Turning Down Shaft Ends-When necessary to turn down shaft ends, use as large a fillet as possible to keep the stress concentration to a minimum. The radius of this fillet should preferably be not less than the difference in the two diameters joined by the fillet. The fillet should be finished and polished as smoothly as possible to avoid scratches which might start cracks and lead to failure of the shaft by fatigue.

Selection of Shaft Diameters

Tables 20 - 23 inclusive can be used to find approximate shaft diameter for various service conditions For greater accuracy use chart under heading "Combined Torsion and Bending of Standard Shafts" (B16-19).

Tables and chart are based upon a safe shear stress of 6,000 pounds per square inch for standard keyseated shafting. Be generous in the selection of shaft diameters as liberal diameters not only reduce deflection and vibration but also generally increase bearing life.

When necessary to use other than standard shafting, find the required diameter for standard shafting as outlined above and multiply by proper factor shown in Table 24, under heading "Factors for Shafting Other than Standard Shafting, "(B16-18).

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Selection of Shaft Diameters (Cont'd)

Table 20: No Bending Moment (Shafts without pulleys, sprockets or gears - Torsion only)

Shaft Size	Horse Power at Various Revolutions per Minute																	
	25	50	75	100	125	150	175	200	225	250	275	300	350	400	500	600	700	800	900
15/16	0.30	0.70	1.10	1.50	1.90	2.30	2.60	3	3.40	3.80	4.20	4.60	5.30	6.10	7.70	9.20	10.70	12.30	13.80
1-3/16	0.70	1.50	2.30	3.10	3.90	4.60	5.40	6.20	7	7.80	8.60	9.30	10.90	12.50	15.60	18.70	21.90	25	28.10
1-7/16	1.30	2.70	4.10	5.50	6.90	8.30	9.70	11.10	12.40	13.80	15.20	16.60	19.40	22.20	27.70	33.30	38.80	44.40	49.90
1-11/16	2.20	4.40	6.60	8.90	11.20	13.40	15.70	17.90	20.20	22.40	24.70	26.90	31.40	35.90	44.90	53.80	62.80	71.80	80.80
1-15/16	3.30	6.70	10.10	13.50	16.90	20.30	23.70	27.10	30.50	33.90	37.30	40.70	47.50	54.30	67.90	81.50	95.10	108	122
2-3/16	4.90	9.80	14.60	19.50	24.40	29.30	34.20	39.10	44	48.90	53.80	58.60	68.40	78.20	97.80	117	136	156	176
2-7/16	6.70	13.50	20.20	27	33.80	40.60	47.30	54.10	60.90	67.60	74.40	81.20	94.70	108	135	162	189	216	243
2-11/16	9	18.10	27.10	36.20	45.30	54.40	63.40	72.50	81.60	90.70	99.70	108	126	145	181	217	253	290	326
2-15/16	11.80	23.60	35.40	47.30	59.20	71	82.90	94.70	106	118	130	142	165	189	236	284	331	379	426
3-7/16	19	37.90	57	75.90	94.90	113	132	151	170	189	208	227	265	303	379	455	531	607	683
3-15/16	28.50	57	85.50	114	142	171	199	228	256	285	313	342	399	456	570	684	798	912	1026
4-7/16	40.80	81.60	122	163	204	245	286	327	367	408	449	490	572	653	816	980	1143	1306	1470

Table 21: Limited Bending Moment (Pulleys, sprockets or gears near bearings. Ordinary line shafts.)

Shaft Size	Horse Power at Various Revolutions per Minute																	
	25	50	75	100	125	150	175	200	225	250	275	300	350	400	500	600	700	800	900
15/16	0.20	0.50	0.70	1	1.20	1.50	1.70	2	2.30	2.50	2.80	3	3.50	4.10	5.10	6.10	7.10	8.20	9.20
1-3/16	0.50	1	1.50	2	2.60	3.10	3.60	4.10	4.70	5.20	5.70	6.20	7.30	8.30	10.40	12.50	14.60	16.70	18.80
1-7/16	0.90	1.80	2.70	3.70	4.60	5.50	6.40	7.40	8.30	9.20	10.10	11.10	12.90	14.80	18.50	22.20	25.90	29.60	33.30
1-11/6	1.40	2.90	4.30	5.90	7.40	8.90	10.40	11.90	13.40	14.90	16.40	17.90	20.90	23.90	29.90	35.90	41.90	47.90	53.90
1-15/16	2.20	4.50	6.70	9	11.30	13.60	15.80	18.10	20.40	22.60	24.90	27.20	31.70	36.20	45.30	54.40	63.40	72.50	81.60
2-3/16	3.20	6.50	9.70	13	16.30	19.50	22.80	26.10	29.30	32.60	35.80	39.10	45.60	52.20	65.20	78.30	91.30	104	117
2-7/16	4.50	9	13.50	18	22.50	27	31.60	36.10	40.60	45.10	49.60	54.10	63.20	72.20	90.20	108	126	144	162
2-11/16	6	12.10	18.10	24.20	30.20	36.30	42.30	48.40	54.40	60.50	66.50	72.60	84.70	96.80	121	145	169	193	217
2-15/16	7.90	15.80	23.70	31.60	39.50	47.40	55.30	63.20	71.10	79	86.90	94.80	110	126	158	189	221	252	284
3-7/16	12.60	25.30	37.90	50.60	63.30	75.90	88.60	101	113	126	139	151	177	202	253	303	354	405	455
3-15/16	19	38	57	76.10	94.10	114	133	152	171	190	209	228	266	304	380	456	532	608	685
4-7/16	27	54	81	108	136	163	190	217	245	272	299	326	381	435	544	653	762	871	980
4-15/16	37	75	112	150	187	225	262	300	337	375	412	450	525	600	750	900	1050	1200	1350
5-7/16	50	100	150	200	250	300	350	400	451	501	551	601	701	801	1002	1202	1403	1603	1804
5-15/16	65	130	195	261	326	391	456	522	587	652	717	783	913	1044	1305	1566	1827	2088	2349
6-1/2	85	171	256	342	427	513	598	684	769	855	940	1026	1197	1368	1710	2052	2394	2736	3078

Selection of Shaft Diameters (Cont'd)

Table 22: Heavy Bending Moment. (Use for main or important shafts.)

Shaft Size	Horse Power at Various Revolutions per Minute																	
	25	50	75	100	125	150	175	200	225	250	275	300	350	400	500	600	700	800	900
1-11/16	0.80	1.70	2.50	3.50	4.40	5.30	6.20	7.10	8	8.90	9.80	10.70	12.50	14.30	17.90	21.50	25.10	28.70	32.30
1-15/16	1.30	2.70	4	5.40	6.70	8.10	9.50	10.80	12.20	13.50	14.90	16.30	19	21.70	27.10	32.60	38	43.50	48.90
2-3/16	1.90	3.90	5.80	7.80	9.70	11.70	13.70	15.60	17.60	19.50	21.50	23.40	27.40	31.30	39.10	46.90	54.80	62.60	70.40
2-7/16	2.70	5.40	8.10	10.80	13.50	16.20	18.90	21.60	24.30	27	29.70	32.40	37.90	43.30	54.10	64.90	75.80	86.60	97.40
2-11/16	3.60	7.20	10.80	14.50	18.10	21.70	25.40	29	32.60	36.20	39.90	43.50	50.80	58	72.50	87.10	101	116	130
2-15/16	4.70	9.40	14.10	18.90	23.60	28.40	33.10	37.90	42.60	47.30	52.10	56.80	66.30	75.80	94.70	113	132	151	170
3-7/16	7.50	15.10	22.60	30.30	37.90	45.50	53.10	60.70	68.30	75.90	83.50	91.10	106	121	151	182	212	243	273
3-15/16	11.40	22.80	34.20	45.60	57	68.40	79.90	91.30	102	114	125	136	159	182	228	273	319	365	410
4-7/16	16.30	32.60	48.90	65.30	81.60	98	114	130	147	163	179	196	228	261	326	392	457	522	588
4-15/16	22.50	45	67.50	90	112	135	157	180	202	225	247	270	315	360	450	540	630	720	810
5-7/16	30	60	90	120	150	180	210	240	270	300	330	360	420	480	601	721	841	961	1082
5-15/16	39	78	117	156	195	234	273	313	352	391	430	469	547	626	782	939	1095	1252	1409
6-1/2	51	102	153	205	256	308	359	410	462	513	564	616	718	821	1027	1232	1437	1643	1848
7	64	128	192	256	320	384	448	513	577	641	705	769	897	1026	1282	1539	1795	2052	2308
7-1/2	78.50	157	235	315	394	473	552	631	709	788	867	946	1104	1262	1577	1893	2208	2524	2839
8	95.50	191	286	382	478	574	670	765	861	957	1053	1148	1340	1531	1914	2297	2680	3063	3446
8-1/2	114	229	343	459	574	688	803	918	1033	1148	1263	1377	1607	1837	2296	2755	3215	3674	4133
9	136	272	408	545	681	817	954	1090	1226	1363	1499	1635	1908	2181	2726	3271	3816	4362	4907
9-1/2	160	320	480	641	801	961	1122	1282	1442	1603	1763	1923	2244	2565	3206	3847	4488	5130	5771
10	186	373	559	747	934	1121	1308	1495	1682	1869	2056	2243	2617	2991	3739	4487	5235	5983	6731

Table 23: Severe Conditions (Heavy shock loads. Excessively tight belts, long clutch sleeves.)

Shaft Size	Horse Power at Various Revolutions per Minute																	
	25	50	75	100	125	150	175	200	225	250	275	300	350	400	500	600	700	800	900
1-11/16	0.4	0.8	1.2	1.7	2.2	2.6	3.1	3.5	4	4.4	4.9	5.3	6.2	7.1	8.9	10.7	12.5	14.3	16.10
1-15/16	0.6	1.3	2	2.7	3.3	4	4.7	5.4	6.1	6.7	7.4	8.1	9.5	10.8	13.5	16.3	19	21.7	24.40
2-3/16	0.90	1.90	2.90	3.90	4.80	5.80	6.80	7.80	8.80	9.70	10.70	11.70	13.70	15.60	19.50	23.40	27.40	31.30	35.20
2-7/16	1.30	2.70	4	5.40	6.70	8.10	9.40	10.80	12.10	13.50	14.80	16.20	18.90	21.60	27	32.40	37.90	43.30	48.70
2-11/16	1.80	3.60	5.40	7.20	9	10.80	12.70	14.50	16.30	18.10	19.90	21.70	25.40	29	36.20	43.50	50.50	58	65
2-15/16	2.30	4.70	7	9.40	11.80	14.20	16.50	18.90	21.30	23.60	26	28.40	33.10	37.90	47.30	56.50	66	75.50	85
3-7/16	3.70	7.50	11.30	15.1	18.90	22.70	26.50	30.30	34.10	37.90	41.70	45.50	53	60.50	75.50	91	106	121	136
3-15/16	5.70	11.40	17.10	22.8	28.50	34.20	39.90	45.60	51	57	62.50	68	79.50	91	114	136	159	182	205
4-7/16	8.10	16.30	24.40	32.6	40.80	49	57	65	73.50	81.50	89.50	98	114	130	163	196	228	261	294
4-15/16	11.20	22.50	33.70	45	56	67.50	78.50	90	101	112	123	135	157	180	225	270	315	360	405
5-7/16	15	30	45	60	75	90	105	120	135	150	165	180	210	240	300	360	420	480	541
5-15/16	19.50	39	58.50	78	97.10	117	136	156	171	195	215	234	273	313	391	469	547	626	704
6-1/2	25.50	51	76.50	102.5	128	154	179	205	231	256	282	308	359	410	513	616	718	821	924
7	32	64.90	96	128	160	192	224	256	288	320	352	384	448	513	641	769	897	1026	1154
7-1/2	39.20	78.50	117	157	197	236	276	315	354	394	433	473	552	631	788	946	1104	1262	1419
8	47.70	95.50	143	191	239	287	335	382	430	478	526	574	670	765	957	1148	1340	1531	1723
8-1/2	57	114	171	229	287	344	401	459	516	574	631	688	803	918	1148	1377	1607	1837	2066
9	68	136	204	272	340	408	477	545	613	681	749	817	954	1090	1363	1635	1908	2181	2453
9-1/2	80	160	240	320	400	480	561	641	721	801	881	961	1122	1282	1603	1923	2244	2565	2885
10	93	186	279	373	467	560	654	747	841	934	1028	1121	1308	1495	1869	2243	2617	2991	3365

Caution Be generous in the selection of shaft diameters as liberal diameters not only reduce deflection and vibration but also generally increase bearing life. See notes on next page.

Selection of Shaft Diameters (Cont'd)

Shaft Stiffness, Shaft Deflection-Standard shafting of adequate strength usually has a sufficiently large diameter to prevent excessive deflection in ordinary installations. It is wise to select shafting of generous diameter, as the greater the diameter, the greater the stiffness. A high tensile strength alloy shaft, although stronger, is no stiffer than a standard shaft of the same diameter.

While it is sometimes possible to use an alloy shaft of less diameter than a standard shaft of equal strength, this practice is usually inadvisable, as the deflection is increased.

Shafts carrying medium or long clutch sleeves should be especially generous.

High Speed Shafts - High speed sometimes causes shaft whipping or vibration. This can be prevented by making the shaft diameter generous and the distance between bearing centers short.

Location of the bearings close to wheels and couplings is advisable whether the shaft is transmitting heavy or light loads.

The use of high tensile strength alloy shafting instead of standard shafting is of no help in preventing vibration as this will not improve the stiffness nor deflection characteristics of the shaft.

Stepped Shafts - For a heavily loaded wheel, a shaft with a boss or enlarged section under the wheel and turned to a smaller diameter at the bearings often provides the most economical installation. The two different diameters should be joined by a very generous fillet, otherwise a dangerous concentration of stress will occur at the fillet. See heading -"Turning Down Shaft Ends." (B16-15).

Shaft Keyseats - Plain keyseats are preferable to round end keyseats in respect to causing the least concentration of stress. However, round end keyseats are often used because of design and assembly requirements. Ends left by the milling cutter should not project into babbitted or bronze bushed bearing, but may project under the sleeve of any DODGE anti-friction bearing.

Shaft diameters obtained from the tables or chart allow for the use of keyseats.

Shaft Bearings - On ordinary line shafting, bearings are commonly spaced about eight feet centers. On large diameter shafts, the spacing may be somewhat greater.

Wheels and clutches should be located near bearings to avoid dangerous bending, deflection and vibration.

Bearings should be mounted on adequate supports so that accurate alignment may be maintained. Shaft misalignment may cause shaft or bearing failure.

Shaft Couplings - Where a rigid coupling is used, it is preferable to have a bearing fairly close. Where a cutoff coupling or a flexible coupling is used, locate bearings close to each end of the coupling.

Expansion of Shafting - Where changes in the length of the shaft due to changes in temperature are to be expected and the bearings are mounted on supporting structures other than steel, consideration must be given to expansion. For more detailed information see B16-20, headed: "Expansion of Shafting."

Factors for Shafting Other Than Standard Shafting

When it is necessary to use other than standard shafting, multiply required diameter for standard shafting as found in the tables or chart by proper factor from Table 24 below.

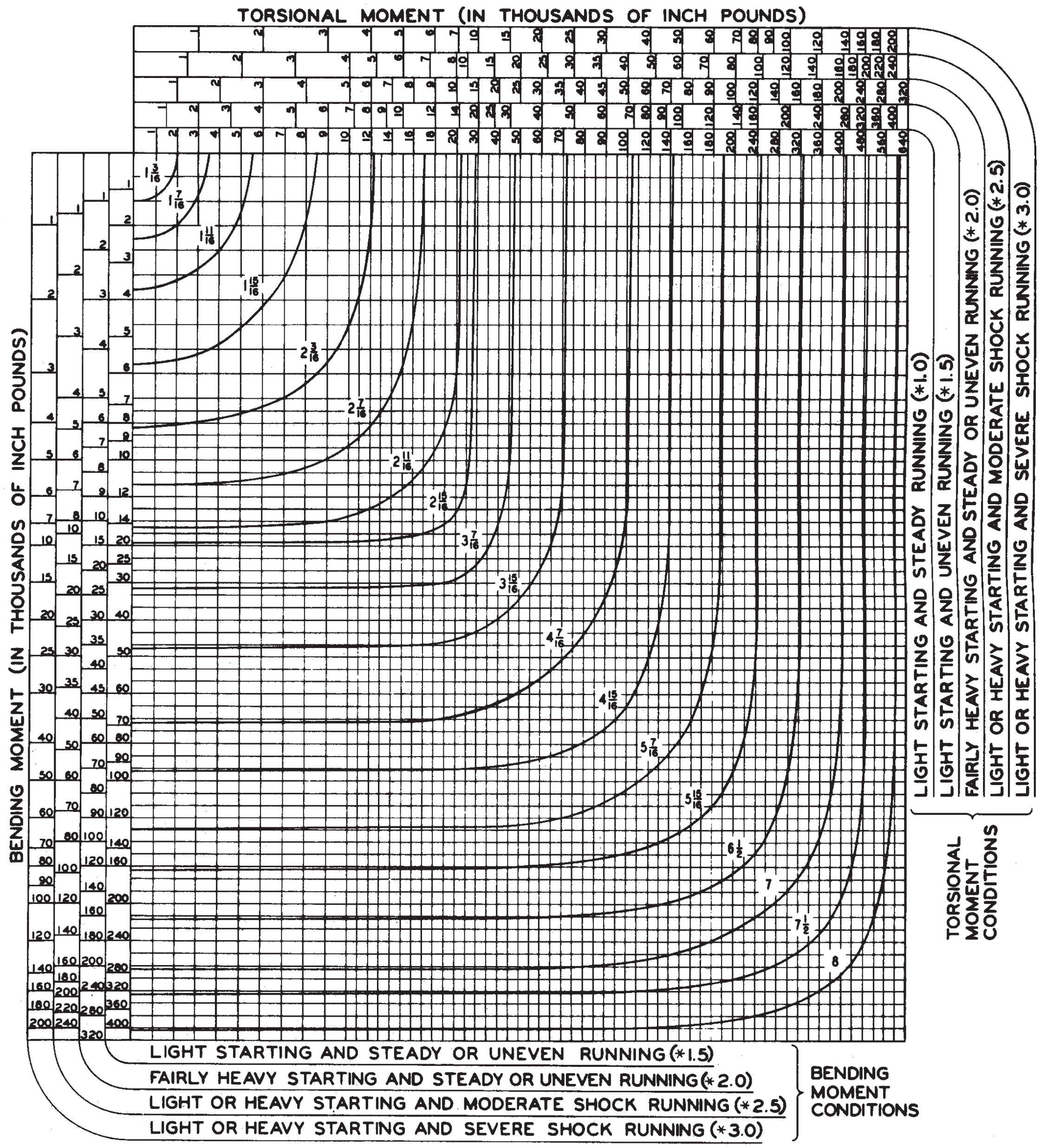
Standard keyseated shafting, using a safe shear stress of 6,000 PSI is the basis of shafting tables and chart. For safe shear stress of other materials, use 1/10 of nominal ultimate tensile strength. For example, use 8,000 for C1045 and 10,000 for 4140 keyseated shafting. When definite physical specifications are known the least of 13.5% of minimum ultimate tensile strength and 22.5% of minimum elastic limit in tension may be used for keyseated shafting; 18% and 30% respectively if not keyseated.

Caution - As the deflection of steel shafting depends upon the diameter and not upon the analysis of the steel, care should be exercised in the use of alloy shafting not to reduce the diameter unduly. Deflection should not be excessive and bearing capacities should be adequate. It is usually best to use standard shafting instead of a smaller diameter alloy shaft. The smaller alloy shaft may safely transmit the torque but often is undesirable in respect to deflection, vibration and bearing life

Table 24: Shear Stress Factors

Safe Shear Stress	Factor	Safe Shear Stress	Factor	Safe Shear Stress	Factor	Safe Shear Stress	Factor	Safe Shear Stress	Factor
500	2.289	3,000	1.260	5,500	1.029	9,000	.874	14,000	.754
1,000	1.817	3,500	1.197	6,000	1.000	10,000	.843	15,000	.737
1,500	1.587	4,000	1.145	6,500	.974	11,000	.817	16,000	.721
2,000	1.442	4,500	1.101	7,000	.950	12,000	.794	17,000	.707
2,500	1.339	5,000	1.063	8,000	.909	13,000	.773	18,000	.693

Combine Torsion and Bending of Standard Shaft
(Based on a Safe Shear Stress of 6,000 PS for KeyseatedShafting)



Example: Engine extension shaft driving single cylinder compressor, 15,000 pound-inches torsional moment, 14,000 pound- inches bending moment. Because of the heavy shock running load conditions use scales designated “Light or Heavy Starting and Severe Shock Running”. Project a line down from 15,000 torsional moment. Project a line to the right from 14,000 bending moment. The two lines intersect between 3-7/16 and 3-15/ 16 curves. Use 3-15/16 standard shafting.

Note: The above chart is based on ASME approved standard ASA-B17C-1927 withdrawn in 1954. If the latest shaft selection analysis is required refer to ANSI/ASME B106.1M-1985.

Note: If considering use of other shafting material refer to “Selection of Shaft Diameters” on page B16-18.

Expansion of Shafting

Provision should be made to permit the free movement of shafting endwise due to temperature changes. One bearing should serve as an anchor bearing to locate the shaft endwise. All other bearings should permit the shaft to move freely endwise.

The anchor bearing is often located near an important wheel. On long shafts it should preferably be located near the center of the shaft to keep the expansion of the two ends to a minimum. If the anchor bearing is babbitted it should be fitted with collars. If it is an anti-friction bearing it should be of the non-expansion type, which is the designation of DODGE roller and ball bearings for use as anchor bearings.

All bearings on the shafting other than the anchor bearing should permit the shaft to move freely endwise. If babbitted there should be no thrust collars. If anti-friction these bearings should be of the expansion type.

Several shafts firmly fastened together expand as if one continuous shaft. An example of this is line shafting with flange couplings. If the expansion is considered excessive a long line shaft may be split into two or more sections, the sections being connected with expansion couplings.

Amount of Expansion to be provided for-

The amount of shaft expansion is given in Table 25 below. For example, with a 100°F temperature rise on a 150 ft. line shaft with the anchor bearing located 70 ft. from one end and 80 ft. from the other end the ends will move .529" and .605" respectively away from the anchor bearing. The structure supporting the bearings may also expand but usually not as rapidly and as much as the shafting. Several cases follow:

Case 1- Bearings supported on steel structures, where the shaft and structure are exposed to the same temperatures, will expand at the same rate. Expansion allowance is usually not required. If the shaft is exposed to a higher temperature than the support, allowances should be made. For example, if the shaft temperature is expected to change 80°, and the temperature of the structure 60°, the resulting movement between shafting and support ends will be equivalent to a 20° change.

Case 2 - For bearings supported on wood, brick, or concrete walls, or on piers with foundations in the ground, the amount of expansion is usually considered negligible. Therefore, the full amount of shafting expansion as calculated in Table 25 below, may be accommodated.

Case 3 - Certain structural designs have built-in flexibility. Where this is the case, expansion type bearings are not necessary.

Case 4 - Short shafts with only two bearings are usually designed without compensation for expansion, if temperature variations are not excessive.

Advice on Expansion Problems-

DODGE power transmission engineers will gladly make recommendations concerning shaft expansion problems and the use of suitable bearings.

Table 25: Linear Expansion of Steel Shafting

Base on Expansion In Inches = 0.0000063 x 12 x Length in Feet x Temp. Increase in Degrees Fahrenheit

Length (Feet)	Temperature Increase-Degrees F.					Length (Feet)	Temperature Increase-Degrees F.				
	20°	40°	60°	80°	100°		20°	40°	60°	80°	100°
1	.0015	.0030	.0045	.0060	.0075	40	.060	.121	.181	.242	.302
2	.0030	.0060	.0091	.0121	.0151	45	.068	.136	.204	.272	.340
3	.0045	.0091	.0136	.0181	.0227	50	.076	.151	.227	.302	.378
4	.0060	.0121	.0181	.0242	.0302	55	.083	.166	.249	.333	.416
5	.0076	.0151	.0227	.0302	.0378	60	.091	.181	.272	.363	.454
6	.0091	.0181	.0272	.0363	.0454	65	.098	.197	.295	.393	.491
7	.0106	.0212	.0318	.0423	.0529	70	.106	.212	.317	.423	.529
8	.0121	.0242	.0363	.0484	.0605	75	.113	.227	.340	.454	.567
9	.0136	.0272	.0408	.0544	.0680	80	.121	.242	.363	.484	.605
10	.0151	.0302	.0454	.0605	.0756	85	.129	.257	.386	.514	.643
12	.0181	.0363	.0544	.0726	.0907	90	.136	.272	.408	.544	.680
14	.0212	.0423	.0635	.0847	.1058	95	.144	.287	.431	.575	.718
16	.024	.048	.073	.097	.121	100	.151	.302	.454	.605	.756
18	.027	.054	.082	.109	.136	110	.166	.333	.499	.665	.832
20	.030	.060	.091	.121	.151	120	.181	.363	.544	.726	.907
25	.038	.076	.113	.151	.189	130	.197	.393	.590	.786	.983
30	.045	.091	.136	.181	.227	140	.212	.423	.635	.847	1.058
35	.053	.106	.158	.212	.265	150	.227	.454	.680	.907	1.134

Weights and Properties of Steel Shafting

Table 26: Weight of Round Steel Shafting

Shaft Size	Weight of Shafting for Various Lengths in feet																	Weight
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22	24	Per Inc.
3/4	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15	18	21	24	27	30	33	36	.125
7/8	2.0	4.0	6.1	8.1	10.2	12.2	14.3	16.3	18.4	20	25	29	33	37	41	45	49	.170
*15/16	2.3	4.7	7.0	9.4	11.7	14.1	16.5	18.8	21.2	23	28	33	38	42	47	52	56	.195
1	2.7	5.3	8.0	10.6	13.3	16.0	18.6	21.3	24.0	27	32	37	43	48	53	59	64	.223
1-1/8	3.4	6.8	10.0	13.4	16.7	20.1	23.4	26.7	30.1	34	41	47	54	61	68	74	81	.281
*1-3/16	3.8	7.6	11.3	15.1	18.9	22.6	26.4	30.1	34.0	38	45	53	60	68	75	83	90	.314
1-1/4	4.2	8.3	12.5	16.7	20.8	25.0	29.2	33.3	37.5	42	50	58	67	75	83	92	100	.348
1-3/8	5.0	10.1	15.3	20.2	25.3	30.3	35.4	40.4	45.4	50	60	71	81	91	101	111	121	.420
*1-7/16	5.5	11	17	22	28	33	39	44	50	55	66	77	88	99	110	121	133	.460
1-1/2	6.0	12	18	24	30	36	42	48	54	60	72	84	96	108	120	132	144	.500
*1-11/16	7.6	15	23	30	38	46	53	61	68	76	91	107	122	137	152	167	183	.634
*1-15/16	10.0	20	30	40	50	60	70	80	90	100	120	140	161	181	201	221	241	.835
2	10.7	21	32	43	53	64	75	85	96	107	128	150	171	192	214	235	256	.890
*2-3/16	12.8	26	38	51	64	77	90	102	115	128	153	179	205	230	256	281	307	1.06
*2-7/16	15.9	32	48	63	79	95	111	127	143	159	190	222	254	286	317	349	381	1.32
2-1/2	16.7	34	50	67	83	100	117	134	150	167	200	234	267	301	334	367	401	1.39
*2-11/16	19.3	39	58	77	97	116	135	154	174	193	232	270	309	348	386	425	463	1.61
*2-15/16	23.0	46	69	92	115	138	161	184	208	231	277	323	369	415	461	507	553	1.92
*3-7/16	31.6	63	95	126	158	189	221	253	284	316	379	442	505	568	631	695	758	2.63
*3-15/16	41.4	83	124	166	207	248	290	331	373	414	497	580	662	745	828	911	994	3.45
*4-7/16	52.6	105	158	210	263	315	368	421	473	526	631	736	841	946	1052	1157	1262	4.38
*4-15/6	65.1	130	195	260	326	391	456	521	586	651	781	911	1041	1172	1302	1432	1562	5.42
*5-7/16	79.0	158	237	316	395	474	553	632	711	790	947	1105	1263	1421	1579	1737	1894	6.58
*6	96	192	288	384	481	577	673	769	865	961	1154	1346	1538	1730	1923	2115	2307	8.01

* **Recommended Diameters** These shaft diameters are recommended for use whenever possible as various transmission items such as couplings, collars, clutches, pulleys, etc., are carried in stock in these sizes, at least up to 3-15/16", in the principal cities throughout the United States.

Table 27: Weight and Properties of Round Steel Shafting

Shaft Size	Weight per Inch	Section Modulus		Moment of Inertia		Shaft Size	Weight per Inch	Section Modulus		Moment of Inertia	
		Bending	Torsion	Bending	Torsion			Bending	Torsion	Bending	Torsion
1/16	.00087	.000024	.000048	.000001	.000002	2-7/16	1.32	1.422	2.844	1.733	3.466
1/8	.0035	.000192	.000383	.000012	.000024	2-1/2	1.39	1.534	3.068	1.918	3.835
3/16	.0078	.000647	.001294	.000061	.000121	2-9/16	1.46	1.652	3.304	2.117	4.233
1/4	.0139	.001534	.003068	.000192	.000383	2-5/8	1.53	1.776	3.552	2.331	4.661
5/16	.0217	.002996	.005992	.000468	.000936	2-11/16	1.61	1.906	3.811	2.561	5.122
3/8	.0313	.005177	.010354	.000971	.001941	2-3/4	1.68	2.042	4.084	2.807	5.615
7/16	.0425	.008221	.016442	.001798	.003597	2-13/16	1.76	2.184	4.368	3.071	6.143
1/2	.0556	.0123	.0245	.0031	.0061	2-7/8	1.84	2.333	4.666	3.354	6.707
9/16	.0703	.0175	.0349	.0049	.0098	2-15/16	1.92	2.489	4.977	3.655	7.310
5/8	.0868	.0240	.0479	.0075	.0150	3	2.00	2.651	5.301	3.976	7.952
11/16	.1051	.0319	.0638	.0110	.0219	3-1/16	2.08	2.820	5.640	4.318	8.636
3/4	.125	.0414	.0828	.0155	.0311	3-1/8	2.17	2.996	5.992	4.681	9.363
13/16	.1467	.0527	.1053	.0214	.0428	3-3/16	2.26	3.179	6.359	5.067	10.13
7/8	.1701	.0658	.1315	.0288	.0575	3-1/4	2.35	3.370	6.740	5.477	10.95
15/16	.1954	.0809	.1618	.0379	.0758	3-5/16	2.44	3.568	7.137	5.910	11.82
1	.22	.0982	.1963	.0491	.0982	3-3/8	2.53	3.774	7.548	6.369	12.74
1-1/16	.25	.1178	.2355	.0626	.1251	3-7/16	2.63	3.988	7.976	6.854	13.71
1-1/8	.28	.1398	.2796	.0786	.1573	3-1/2	2.72	4.209	8.419	7.366	14.73
1-3/16	.31	.1644	.3288	.0976	.1952	3-9/16	2.82	4.439	8.878	7.907	15.81
1-1/4	.35	.1917	.3835	.1198	.2397	3-5/8	2.92	4.677	9.353	8.476	16.95
1-5/16	.38	.2220	.4439	.1457	.2913	3-11/16	3.02	4.923	9.845	9.076	18.15
1-3/8	.42	.2552	.5104	.1755	.3509	3-3/4	3.13	5.177	10.35	9.707	19.41
1-7/16	.46	.2916	.5832	.2096	.4192	3-13/16	3.23	5.440	10.88	10.37	20.74
1-1/2	.50	.3313	.6627	.2485	.4970	3-7/8	3.34	5.712	11.42	11.07	22.14
1-9/16	.54	.3745	.7490	.2926	.5852	3-15/16	3.45	5.993	11.99	11.80	23.60
1-5/8	.59	.4213	.8425	.3423	.6846	4	3.56	6.283	12.57	12.57	25.13
1-11/16	.63	.4718	.9435	.3981	.7961	4-1/16	3.67	6.582	13.16	13.37	26.74
1-3/4	.68	.5262	1.052	.4604	.9208	4-1/8	3.78	6.891	13.78	14.21	28.42
1-13/16	.73	.5846	1.169	.5298	1.060	4-3/16	3.90	7.209	14.42	15.09	30.19
1-7/8	.78	.6471	1.294	.6067	1.213	4-1/4	4.01	7.536	15.07	16.01	32.03
1-15/16	.83	.7140	1.428	.6917	1.384	4-5/16	4.13	7.874	15.75	16.98	33.96
2	.89	.7854	1.571	.7854	1.571	4-3/8	4.25	8.221	16.44	17.98	35.97
2-1/16	.94	.8614	1.723	.8883	1.777	4-7/16	4.38	8.579	17.16	19.03	38.07
2-1/8	1.00	.9421	1.884	1.001	2.002	4-1/2	4.50	8.946	17.89	20.13	40.26
2-3/16	1.06	1.028	2.055	1.124	2.248	4-9/16	4.63	9.324	18.65	21.27	42.54
2-1/4	1.13	1.118	2.237	1.258	2.516	4-5/8	4.75	9.713	19.43	22.46	44.92
2-5/16	1.19	1.214	2.428	1.404	2.808	4-11/16	4.88	10.11	20.22	23.70	47.40
2-3/8	1.25	1.315	2.630	1.562	3.124	4-3/4	5.01	10.52	21.04	24.99	49.98

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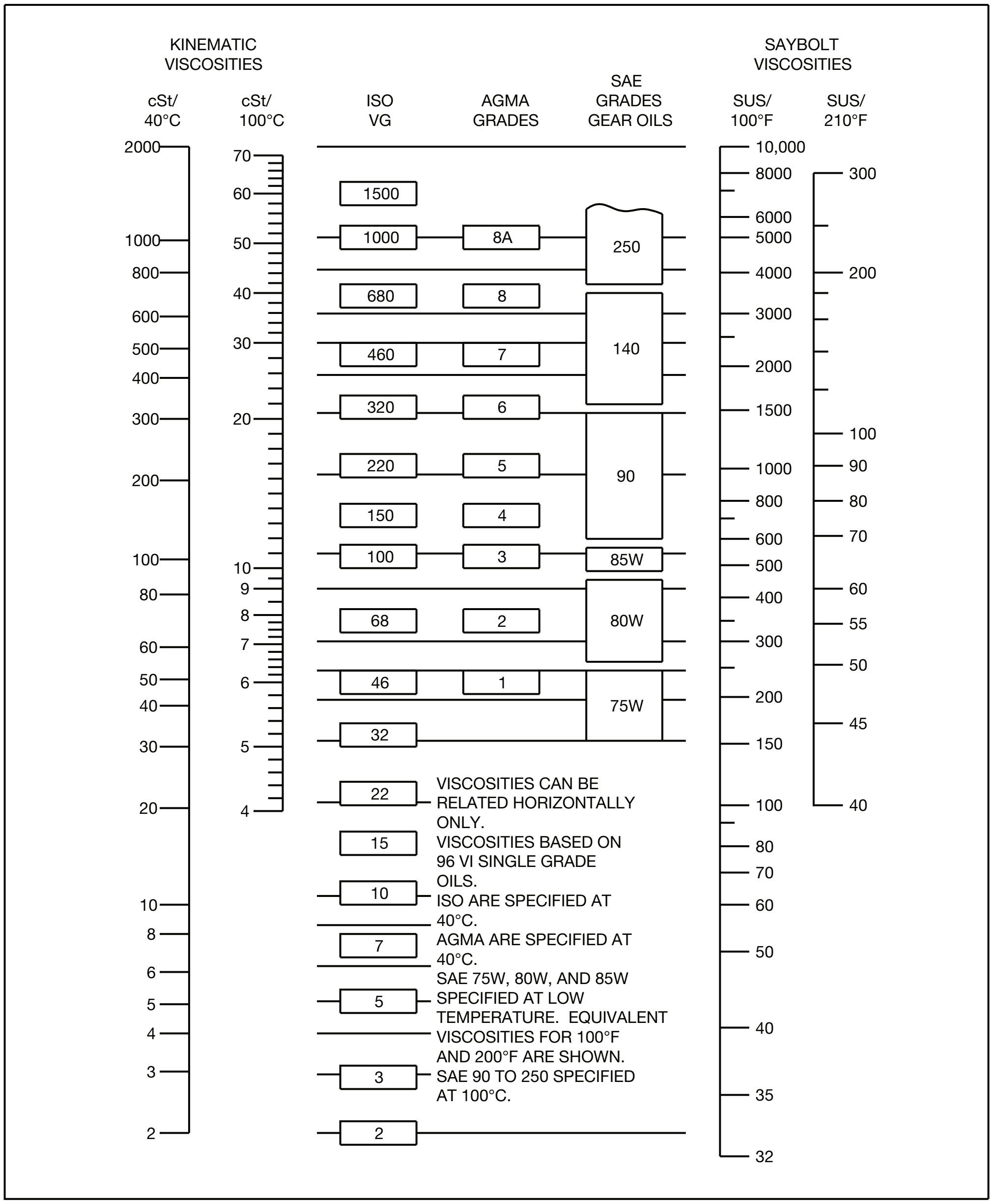
Table 27: Weight and Properties of Round Steel Shafting

Shaft Size	Weight per Inch	Section Modulus		Moment of Inertia	
		Bending	Torsion	Bending	Torsion
4-13/16	5.15	10.94	21.88	26.33	52.66
4-7/8	5.28	11.37	22.75	27.72	55.45
4-15/16	5.42	11.82	23.63	29.17	58.35
5	5.56	12.27	24.54	30.68	61.36
5-1/16	5.70	12.74	25.48	32.24	64.49
5-1/8	5.84	13.22	26.43	33.86	67.73
5-3/16	5.98	13.70	27.41	35.55	71.09
5-1/4	6.13	14.21	28.41	37.29	74.58
5-5/16	6.27	14.72	29.44	39.10	78.20
5-3/8	6.42	15.25	30.49	40.97	81.94
5-7/16	6.58	15.78	31.57	42.91	85.82
5-1/2	6.72	16.33	32.67	44.92	89.84
5-9/16	6.88	16.90	33.79	46.99	93.99
5-5/8	7.03	17.47	34.95	49.14	98.29
5-11/16	7.19	18.06	36.12	51.36	102.70
5-3/4	7.35	18.66	37.33	53.66	107.30
5-13/16	7.51	19.28	38.56	56.03	112.10
5-7/8	7.67	19.91	39.82	58.48	117.00
5-15/16	7.84	20.55	41.10	61.01	122.00
6	8.00	21.21	42.41	63.62	127.20
6-1/16	8.17	21.88	43.75	66.31	132.60
6-1/8	8.34	22.56	45.12	69.09	138.20
6-3/16	8.51	23.26	46.51	71.95	143.90
6-1/4	8.68	23.97	47.94	74.90	149.80
6-5/16	8.86	24.69	49.39	77.94	155.90
6-3/8	9.03	25.44	50.87	81.08	162.20
6-7/16	9.21	26.19	52.38	84.30	168.60
6-1/2	9.39	26.96	53.92	87.62	175.20
6-5/8	9.76	28.55	57.09	94.56	189.10
6-3/4	10.10	30.19	60.39	101.90	203.80
6-7/8	10.50	31.90	63.80	109.70	219.30
7	10.90	33:67	67.35	117.90	235.70
7-1/8	11.30	35.51	71.02	126.50	253.00
7-1/4	11.70	37.41	74.82	135.60	271.20
7-3/8	12.10	39.38	78.76	145.20	290.40
7-1/2	12.50	41.42	82.84	155.30	310.60
7-5/8	12.90	43.52	87.05	165.90	331.90
7-3/4	13.30	45.70	91.40	177.10	354.20
7-7/8	13.80	47.95	95.89	188.80	377.60
8	14.30	50.27	100.50	201.10	402.10
8-1/8	14.70	52.66	105.30	213.90	427.90
8-1/4	15.10	55.13	110.30	227.40	454.80
8-3/8	15.60	57.67	115.30	241.50	483.00
8-1/2	16.10	60.29	120.60	256.20	512.50
8-5/8	16.50	62.99	126.00	271.60	543.30
8-3/4	17.00	65.77	131.60	287.70	575.50
8-7/8	17.50	68.63	137.30	304.50	609.10
9	18.00	71.57	143.10	322.10	644.10
9-1/8	18.50	74.59	149.20	340.30	680.70
9-1/4	19.00	77.70	155.40	359.40	718.70
9-3/8	19.50	80.89	161.80	379.20	758.40
9-1/2	20.10	84.17	168.30	399.80	799.60
9-5/8	20.60	87.54	175.10	421.30	842.60
9-3/4	21.10	90.99	182.00	443.60	887.20
9-7/8	21.70	94.54	189.10	466.80	933.60
10	22.20	98.17	196.30	490.90	981.70
10-1/4	23.40	105.72	211.40	541.80	1084
10-1/2	24.50	113.65	227.30	596.70	1193
10-3/4	25.70	121.96	243.90	655.50	1311
11	26.90	130.67	261.30	718.70	1437
11-1/4	28.10	139.78	279.60	786.30	1573
11-1/2	29.40	149.31	298.60	858.50	1717
11-3/4	30.70	159.26	318.50	935.70	1871
12	32.00	169.65	339.30	1018	2036
12-1/4	33.40	180.47	360.90	1105	2211
12-1/2	34.70	191.75	383.50	1198	2397
12-3/4	36.10	203.48	407.00	1297	2594
13	37.60	215.69	431.40	1402	2804
13-1/4	39.00	228.37	456.70	1513	3026
13-1/2	40.50	241.50	483.10	1630	3261
13-3/4	42.00	255.20	510.40	1755	3509
14	43.60	269.40	538.80	1886	3771
14-1/4	45.10	284.10	568.20	2024	4048
14-1/2	46.70	299.30	598.60	2170	4340
14-3/4	48.40	315.00	630.10	2324	4647
15	50.00	331.30	662.70	2485	4970
15-1/4	51.70	348.20	696.40	2655	5310
15-1/2	53.40	365.60	731.20	2833	5667
15-3/4	55.10	383.60	767.10	3021	6041
16	56.90	402.10	804.20	3217	6434
16-1/4	58.70	421.30	842.50	3422	6846
16-1/2	60.50	441.00	882.00	3638	7277
16-3/4	62.40	461.40	922.70	3864	7728
17	64.20	482.30	964.70	4100	8200
17-1/4	66.10	503.90	1008	4346	8693
17-1/2	68.10	526.20	1052	4604	9208
17-3/4	70.00	549.10	1098	4873	9745
18	72.00	572.60	1145	5153	10306
18-1/4	74.00	596.70	1193	5445	10891
18-1/2	76.10	621.60	1243	5750	11500
18-3/4	78.10	647.10	1294	6067	12134
19	80.20	673.40	1347	6397	12794
19-1/4	82.40	700.30	1401	6741	13481
19-1/2	84.50	728.00	1456	7098	14195
19-3/4	86.70	756.30	1513	7469	14937
20	88.90	785.40	1571	7854	15708
20-1/4	91.10	815.20	1630	8254	16508
20-1/2	93.40	845.80	1692	8669	17339
20-3/4	95.70	877.10	1754	9100	18200
21	98.00	909.20	1818	9547	19093
21-1/4	100.40	942.10	1884	10009	20019
21-1/2	102.70	975.70	1951	10489	20978
21-3/4	105.10	1010	2020	10985	21970
22	107.60	1045	2091	11499	22998
22-1/4	110.00	1081	2163	12031	24061
22-1/2	112.50	1118	2237	12581	25161
22-3/4	115.00	1156	2312	13149	26298
23	117.60	1194	2389	13737	27473
23-1/4	120.10	1234	2468	14344	28687
23-1/2	122.70	1274	2548	14971	29941
23-3/4	125.40	1315	2630	15618	31236
24	128.00	1357	2714	16286	32572
24-1/4	130.70	1400	2800	16975	33951
24-1/2	133.40	1444	2888	17686	35372
24-1/4	136.20	1488	2977	18419	36838
25	138.90	1534	3068	19175	38350
25-1/4	141.70	1580	3161	19954	39907
25-1/2	144.50	1628	3256	20755	41511
25-3/4	147.40	1676	3352	21581	43163
26	150.30	1726	3451	22432	44864
26-1/4	153.20	1776	3552	23307	46614
26-1/2	156.10	1827	3654	24208	48415
26-3/4	159.00	1879	3758	25134	50268
27	162.00	1932	3865	26087	52174
27-1/2	168.10	2042	4083	28074	56148
28	174.30	2155	4310	30172	60344
28-1/2	180.50	2273	4545	32385	64771
29	186.90	2394	4789	34719	69437
29-1/2	193.40	2520	5041	37176	74351
30	200.00	2651	5301	39761	79522
30-1/2	206.80	2785	5571	42479	84957
31	213.60	2925	5849	45333	90666
31-1/2	220.50	3069	6137	48329	96659
32	227.60	3217	6434	51472	102944
32-1/2	234.80	3370	6740	54765	109530
33	242.10	3528	7056	58214	116428
34	256.90	3859	7717	65597	131194
35	272.30	4209	8418	73662	147324

Viscosity Classification Equivalents

OIL VISCOSITY EQUIVALENCY CHART



ISO VISCOSITY CLASSIFICATION SYSTEM

All industrial oils are graded according to the ISO Viscosity Classification System, approved by the International Standards Organizations (ISO). Each ISO viscosity grade number corresponds to the mid-point of viscosity range expressed in centistokes (cSt) at 40°C. For example, a lubricant with an ISO grade of 32 has a viscosity within the range of 28.80-35.2, the midpoint of which is 32.

Rule-of-Thumb: The comparable ISO grade of a competitive product whose viscosity in SUS at 100°F is known can be determined by using the following conversion formula:

SUS @ 100° F ÷ 5 = cSt @ 40°C

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ENGINEERING

English Standard Measures

Long Measure

1 mile = 1760 yards = 5280 feet.
1 yard = 3 feet = 36 inches.
1 foot = 12 inches.

Surveyor's Measure

1 mile = 8 furlongs = 80 chains.
1 furlong = 10 chains = 220 yards.
1 chain = 4 rods = 22 yards = 66 feet = 100 links.
1 link = 7.92 inches.

Square Measure

1 square mile = 640 acres = 6400 square chains.
1 acre = 10 square chains = 4840 square yards = 43,560 square feet.
1 square chain = 16 square rods = 484 square yards = 4356 square feet.
1 square rod = 30.25 square yards = 272.25 square feet = 625 square links.
1 square yard = 9 square feet.
1 square foot = 144 square inches.
An acre is equal to a square, the side of which is 208.7 feet.

Dry Measure

1 bushel (U.S. or Winchester struck bushel) = 1.2445 cubic foot = 2150.42 cubic inches.
1 bushel = 4 pecks = 32 quarts = 64 pints.
1 peck = 8 quarts = 16 pints.
1 quart = 2 pints.
1 heaped bushel = 1 1/4 struck bushel.
1 cubic foot = 0.8036 struck bushel.
1 British Imperial bushel=8 Imperial gallons=1.2837 cubic foot = 2218.19 cubic inches.

Liquid Measure

1 U.S. gallon = 0.1337 cubic foot = 231 cubic inches = 4 quarts = 8 pints.
1 quart = 2 pints = 8 gills.
1 pint = 4 gills.
1 British Imperial gallon = 1.2003 U.S. gallon = 277.27 cubic inches.
1 cubic foot = 7.48 U.S. gallons.

Circular and Angular Measure

60 seconds (")	=1 minute (')
60 minutes	=1 degree (-)
360 degrees	=1 circumference (C)
57.3 degrees	=1 radian
2 π radians	=1 circumference (C)

Specific Gravity

The specific gravity of a substance is its weight as compared with the weight of an equal bulk of pure water.

For making specific gravity determinations the temperature of the water is usually taken at 62° F. when 1 cubic foot of water weighs 62.355 lbs. Water is at its greatest density at 39.20° F. or 4° Centigrade.

Temperature

The following equation will be found convenient for transforming temperature from one system to another:

Let F = degrees Fahrenheit; C = degrees Centigrade; R = degrees Reamur.

$$\frac{F-32}{180} = \frac{C}{100} = \frac{R}{80}$$

Avoirdupois or Commercial Weight

1 gross or long ton = 2240 pounds.
1 net or short ton = 2000 pounds.
1 pound = 16 ounces = 7000 grains.
1 ounce = 16 drams = 437.5 grains.

Measures of Pressure

1 pound per square inch = 144 pounds per square foot = 0.068 atmosphere = 2.042 inches of mercury at 62 degrees F. = 27.7 inches of water at 62 degrees F. = 2.31 feet of water at 62 degrees F.

1 atmosphere = 30 inches of mercury at 62 degrees F. = 14.7 pounds per square inch = 2116.3 pounds per square foot = 33.95 feet of water at 62 degrees F.

1 foot of water at 62 degrees F. = 62.355 pounds per square foot = 0.433 pound per square inch.

1 inch of mercury at 62 degrees F. = 1.132 foot of water = 13.58 inches of water = 0.491 pound per square inch.

Column of water 12 in. high, 1 in. dia. = .341 lbs.

Cubic Measure

1 cubic yard = 27 cubic feet.
1 cubic foot = 1728 cubic inches.
The following measures are also used for wood and masonry:
1 cord of wood = 4 X 4 X 8 feet = 128 cubic feet.
1 perch of masonry = 16-1/2 X 1-1/2 X 1 foot = 24-3/4 cubic feet.

Shipping Measure

For measuring entire internal capacity of a vessel: 1 register ton = 100 cubic feet.
For measurement of cargo:
1 U.S. shipping ton = 40 cubic feet = 32.143 U.S. bushels = 31.16 Imperial bushels.
British shipping ton = 42 cubic feet = 33.75 U.S. bushels = 32.72 Imperial bushels.

Troy Weight, Used for Weighing Gold and Silver

1 pound = 12 ounces = 5760 grains.
1 ounce = 20 pennyweights = 480 grains.
1 pennyweight = 24 grains.
1 carat (used in weighing diamonds) = 3.086 grains.
1 grain Troy = 1 grain avoirdupois = 1 grain apothecaries' weight.

Measure Used for Diameters and Areas of Electric Wires

1 circular inch = area of circle 1 inch in diameter = 0.7854 square inch.
1 circular inch = 1,000,000 circular mils.
1 square inch = 1.2732 circular inch = 1,273,239 circular mils.
A circular mil is the area of a circle 0.001 inch in diameter.

Board Measure

One foot board measure is a piece of wood 12 inches square by 1 inch thick, or 144 cubic inches. 1 cubic foot therefore equals 12 feet board measure

TABLE 28: Decimal and Millimeter Equivalents of Fractions

Inches			Milli-	Inches			Milli-	Inches			Milli-
Fractions		Decimals	meters	Fractions		Decimals	meters	Fractions		Decimals	meters
1/64		.015625	.397		11/32	.34375	8.7319		11/16	.6875	17.463
	1/32	.03125	.794	23/64		.359375	9.128	45/64		.703125	17.859
3/64		.046875	1.191		3/8	.375	9.525		23/32	.71875	18.256
	1/16	.0625	1.588	25/64		.390625	9.922	47/64		.734375	18.653
5/64		.078125	1.984		13/32	.40625	10.319		3/4	.750	19.050
	3/32	.09375	2.381	27/64		4.21875	10.716	49/64		.765625	19.447
7/64		.109375	2.778		7/16	4.375	11.113		25/32	.78125	19.844
	1/8	.125	3.175	29/64		4.53125	11.509	51/64		.796875	20.241
9/64		.140625	3.582		15/32	.46875	11.906		13/16	.8125	20.638
	5/32	.15625	3.969	31/64		.48376	12.303	53/64		.828125	21.034
11/64		.171875	4.366		1/2	.500	12.700		27/32	.84375	21.431
	3/16	.1875	4.763	33/64		.515625	13.097	55/64		.859375	21.828
13/64		.203125	5.159		17/32	.53125	13.494		7/8	.875	22.225
	7/32	.21875	5.556	35/64		.546875	13.891	57/64		.890625	22.622
15/64		.234375	5.953		9/16	.5625	14.288		29/32	.90524	23.019
	1/41	.250	6.350	37/64		.578125	14.684	59/64		.921875	23.416
7/64		.265625	6.747		19/32	.59375	14.081		15/16	.9375	23.813
	9/32	.28125	7.144	39/64		.609375	15.478	61/64		.953125	24.209
19/64		.296875	7.541		5/8	.625	15.875		31/32	.96875	24.606
	5/16	.3125	7.938	41/64		.60625	16.272	63/64		.984375	25.003
21/64		.328125	8.334		21/32	.65625	16.669		1	1.000	25.400
				43/64		.671875	17.066				

Table 29: Millimeter-Inch Equivalents: 1" = 25.4mm (.03937" = 1mm)

Millimeter	Decimal	Millimeter	Decimal	Millimeter	Decimal	Millimeter	Decimal	Millimeter	Decimal
1	.03937	52	2.04724	103	4.05511	154	6.06299	205	8.07086
2	.07874	53	2.08661	104	4.09448	155	6.10236	206	8.11023
3	.11811	54	2.12598	105	4.13385	156	6.14173	207	8.14960
4	.15748	55	2.16535	106	4.17322	157	6.18110	208	8.18897
5	.19685	56	2.20472	107	4.21259	158	6.22047	209	8.22834
6	.23622	57	2.24409	108	4.25196	159	6.25984	210	8.26771
7	.27559	58	2.28346	109	4.29133	160	6.29921	211	8.30708
8	.31496	59	2.32283	110	4.33070	161	6.33858	212	8.34645
9	.35433	60	2.36220	111	4.37007	162	6.37795	213	8.38582
10	.39370	61	2.40157	112	4.40944	163	6.41732	214	8.42519
11	.43307	62	2.44094	113	4.44881	164	6.45669	215	8.46456
12	.47244	63	2.48031	114	4.48818	165	6.49606	216	8.50393
13	.51181	64	2.51968	115	4.52755	166	6.53543	217	8.54330
14	.55118	65	2.55905	116	4.56692	167	6.57480	218	8.58267
15	.59055	66	2.59842	117	4.60629	168	6.61417	219	8.62204
16	.62992	67	2.63779	118	4.64566	169	6.65354	220	8.66141
17	.66929	68	2.67716	119	4.68503	170	6.69291	221	8.70078
18	.70866	69	2.71653	120	4.72440	171	6.73228	222	8.74015
19	.74803	70	2.75590	121	4.76378	172	6.77165	223	8.77952
20	.78740	71	2.79527	122	4.80315	173	6.81102	224	8.81889
21	.82677	72	2.83464	123	4.84252	174	.685039	225	8.85826
22	.86614	73	2.87401	124	4.88189	175	6.88976	226	8.897.63
23	.90551	74	2.91338	125	4.92126	176	6.92913	227	8.93700
24	.94488	75	2.95275	126	4.96063	177	.696850	228	8.97637
25	.98425	76	2.99212	127	5.00000	178	7.00787	229	9.01574
26	1.02362	77	3.03149	128	5.03937	179	7.04724	230	9.05511
27	1.06299	78	3.07086	129	5.07875	180	7.08661	231	9.09448
28	1.10236	79	3.11023	130	5.11811	181	7.12598	232	9.13385
29	1.14173	80	3.14960	131	5.15749	182	7.16535	233	9.17322
30	1.18110	81	3.18897	132	5.19685	183	7.20472	234	9.21259
31	1.22047	82	3.22834	133	5.23622	184	7.24409	235	9.25196
32	1.25984	83	3.26771	134	5.27559	185	7.28346	236	9.29133
33	1.29921	84	.303708	135	5.31496	186	7.32283	237	9.33070
34	1.33858	85	3.34645	136	5.35433	187	7.36220	238	9.37007
35	1.37795	86	3.38582	137	5.39370	188	7.40157	239	9.40944
36	1.41732	87	.342519	138	.543307	189	7.44094	240	9.44881
37	1.45669	88	3.46456	139	.547244	190	7.48031	241	9.48818
38	1.49606	89	3.50393	140	5.51181	191	7.51968	242	9.52755
39	1.53543	90	3.54330	141	5.55118	192	7.55905	243	9.56692
40	1.57480	91	.358267	142	5.59055	193	7.59842	244	9.60629
41	1.61417	92	3.62204	143	5.62992	194	7.63779	245	9.64566
42	1.65354	93	3.66141	144	5.66929	195	7.67716	246	9.68503
43	1.69291	94	3.70078	145	5.70866	196	7.71653	247	9.72440
44	1.73228	95	3.74015	146	5.748.4	197	7.75590	248	9.76378
45	1.77165	96	3.77952	147	5.78740	198	7.79527	249	9.80315
46	1.81102	97	3.81899	148	5.82677	199	7.83464	250	9.84252
47	1.85039	98	3.85826	149	5.86614	200	7.87401	251	9.88189
48	1.88976	99	3.89763	150	5.90551	201	7.91338	252	9.92126
49	1.92913	100	3.93710	151	5.94488	202	795275	253	9.96063
50	1.96850	101	3.97637	152	5.98425	203	799221	254	10.00000
51	2.00787	102	4.01574	153	6.02362	204	8.03149	-	-

FEATURES/BENEFITS	SPECIFICATION	MODIFICATION/ACCESSORIES	RENEWAL PARTS
PAGE G2-2	PAGE G2-9	PAGE G2-120	PAGE G2-166

Metric System of Measurements

Measures of Length

10	millimeters (mm.)	=	1 centimeter (cm.)
10	centimeters	=	1 decimeter (dm.)
10	decimeters	=	1 meter (m.)
1000	meter	=	1 kilometer (km.)

Measure of Weight

10	milligrams (mg.)	=	1 centigram (cg.)
10	centigrams	=	1 decigram (dg.)
10	decigrams	=	1 gram (g.)
10	grams	=	1 decagram (Dg.)
10	decagrams	=	1 hectogram (Hg.)
10	hectograms	=	1 Kilogram (Kg.)
1000	kilograms	=	1 (metric) ton (T.)

Surveyor's Square Measure

100	square meters (m.2)	=	1 are (ar.)
100	acres	=	1 hectare (har.)
100	hectares	=	1 sq. kilometer (Km.2)

Square Measure

100	sq. millimeters (mm.2)	=	1 sq. centimeter (cm.2)
100	sq. centimeters	=	1 sq. decimeter (dm.2)
100	sq. decimeters	=	1 sq. meter (m.2)

Cubic Measure

1000	cu. millimeters (mm.3)	=	1 cu. centimeter (cm.3)
1000	cu. centimeters	=	1 cu. decimeter (dm.3)
1000	cu. decimeters	=	1 cu. meter (m.3)

Dry and Liquid Measure

10	milliliters (ml.)	=	1 centiliter (cl.)
10	centiliters	=	1 deciliter (dl.)
10	deciliters	=	1 liter (l.)
100	liters	=	1 hectoliter (Hl.)

1 liter = 1 cubic decimeter = the volume of 1 kilogram of pure water at a temperature of 39.2 degrees F.

Length Conversion Constants for Metric and U.S. Units

Millimeters X.039370 = inches.
Meters x 39.370 = inches.
Meters X 3.2808 = feet.
Meters X 1.09361 = yards.
Kilometers X 3,280.8 = feet.
Kilometers X.62137 = Statute Miles.
Kilometers x.53959 = Nautical Miles.

Inches X 25.4001 = millimeters.
Inches X.0254 = meters.
Feet x.30480 = meters.
Yards X.91440 = meters.
Feet x.0003048 = kilometers.
Statute Miles X 1.60935 = kilometers.
Nautical Miles x 1.85325 = kilometers.

Weight Conversion Constants for Metric and U.S. Units

Grams X 981 = dynes.
Grams X 15.432 = grains.
Grams X.03527 = ounces (Avd.).
Grams x.033818 = fluid ounces (water).
Kilograms X 35.27 = ounces (Avd.).
Kilograms X 2.20462 = pounds (Avd.).
Metric Tons (1000 Kg.) X 1.10231 = Net Ton (2000 lbs.).
Metric Tons (1000 Kg.) X.98421 = Gross Ton (2240 lbs.).

Dynes X.0010193 = grams.
Grains X.0648 = grams.
Ounces (Avd.) X 28.35 = grams.
Fluid Ounces (Water) X 29.57 = grams.
Ounces (Avd.) X.02835 = kilograms.
Pounds (Avd.) X.45359 = kilograms.
Net Ton (2000 lbs.) X.90719 = Metric Tons (1000 Kg.).
Gross Ton (2240 lbs.) X 1.01605 = Metric Tons (1000 Kg.).

Area Conversion Constants for Metric and U.S. Units

Square Millimeters X.00155 = square inches.
Square centimeters X.155 = square inches.
Square Meters X 10.76387 = square feet.
Square Meters X 1.19599 = square yards.
Hectares X 2.47104 = acres.
Square Kilometers X 247.104 = acres.
Square Kilometers X.3861 = square miles.

Square Inches X 645.163 = square millimeters.
Square Inches x 6.45163 = square centimeters.
Square Feet x.0929 = square meters.
Square Yards X.83613 = square meters.
Acres X.40469 = hectares.
Acres X.0040469 = square kilometers.
Square Miles X 2.5899 = square kilometers.

Volume Conversion Constants for Metric and U.S. Units

Cubic centimeters X.033818 = fluid ounces.
Cubic centimeters X.061023 = cubic inches.
Cubic centimeters X.271 = fluid drams.
Liters X 61.023 = cubic inches.
Liters X 1.05668 = quarts.
Liters X .26417 = gallons.
Liters X.035317 = cubic feet.
Hectoliters X 26.417 = gallons.
Hectoliters X 3.5317 = cubic feet.
Hectoliters X 2.83794 = bushel (2150.42 cu. in.).
Hectoliters X.1308 = cubic yards.
Cubic Meters x 264.17 = gallons.
Cubic Meters x 35.317 = cubic feet.
Cubic Meters X 1.308 = cubic yards.

Fluid Ounces X 29.57 = cubic centimeters.
Cubic Inches X 16.387 = cubic centimeters.
Fluid Drams x 3.69 = cubic centimeters.
Cubic Inches X.016387 = liters.
Quarts x.94636 = liters.
Gallons x 3.78543 = liters.
Cubic Feet x 28.316 = liters.
Gallons x.0378543 = hectoliters.
Cubic Feet x.28316 = hectoliters.
Bushels (2150.42 cu. in.) X.352379 = hectoliters.
Cubic Yards x 7.645 = hectoliters.
Gallons x.00378543 = cubic meters.
Cubic Feet x.028316 = cubic meters.
Cubic Yards x.7645 = cubic meters.

Power and Heat Conversion Constants for Metric and U.S. Units

Calorie x 0.003968 = B.T.U.
Joules X.7373 = pound-feet.
Newton-Meters X 8.851 = pound-inches
Cheval Vapeur X.9863 = Horsepower.
Kilowatts X 1.34 = Horsepower.
Kilowatt Hours X 3415 = B.T.U.
(Degrees Cent. X 1.8) +32 = degrees Fahr.
(Degrees Reamur X 2.25) + 32 = degrees Fahr.

B.T.U. X 252 = calories.
Pound-Feet X 1.3563 = joules.
Pound-inches X.11298 = Newton-meters.
Horsepower X 1.014 = Cheval Vapeur.
Horsepower X.746 = kilowatts.
B.T.U. X.00029282 = kilowatt hours.
(Degrees Fahr. - 32) x.555 = degrees Cent.
(Degrees Fahr. - 32) x.444 = degrees Reamur.

COMMON CONVERSION FACTORS
USEFUL IN MECHANICAL POWER TRANSMISSION

Symbols and Abbreviations Used in Conversion Factors

Symbols and abbreviations found in this section are those currently used in many texts and product publications. Considerable effort is underway to standardize on abbreviations for metric and English units of measurement. Recently, ASTM (American Society for Testing and Materials) and IEEE (Institute of Electrical and Electronic Engineers) published a standard practice on the metric system. † This publication consolidates a great deal of the current thinking and provides a system of abbreviations and symbols that differ somewhat from those used here.

This Handbook has retained use of familiar abbreviations consistent with existing product and trade literature rather than the abbreviations found in current publications of technical and scientific societies.

Prefixes Used in the Metric System

Common prefixes and symbols used in the metric system are listed below. An example of use is 1000 meters is equivalent to 1 kilometer, and 1/1000 of one meter is equivalent to 1 millimeter.

Prefix	Symbol	Multiplication Factor-Decimal and Power of 10
giga	G	1,000,000,000 or 109 or one billion
mega	M	1,000,000 or 106 or one million
kilo	k	1,000 or 103 or one thousand
*hecto	h	100 or 102 or one hundred
*deka	da	10 or 101 or ten
**deci	d	0.1 or 10-1 or one tenth
**centi	c	0.01 or 10-2 or one hundredth
mill	m	0.001 or 10-3 or one thousandth
micro	µ	0.000,001 or 10-6 or one millionth
nano	n	0.000,000,001 or 10-9 or one billionth

* Not commonly used.

** Not commonly used except for special situations.
The centimeter as a unit of length is in common use.
The decibel is a unit in both electrical and acoustical work.

† ASTM/IEEE Standard Metric Practice, ASTM E 380-75, IEEE Std. 268-1976.

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Symbol or Abbreviation	Term
atm	atmosphere
avdp	avoirdupois
bbl	barrels
bu	bushels
C	degrees Centigrade or Celsius
cc	cubic centimeters
cfm	cubic feet per minute
cfs	cubic feet per second
cm	centimeter
cu	cubic
deg	degrees
F	degrees Fahrenheit
fps	feet per second
ft	feet
ft-lb	foot-pounds (work or energy)
ft per sec	feet per second (alternate)
ft per sec^2	feet per second per second
g	acceleration due to gravity
g	grams
gal	gallons
gpm	gallons per minute
hp	horsepower
hr	hour
in	inches
in-lb	inch-pounds (work or energy)
K	degrees Kelvin
kg	kilograms
km	kilometers
kn	knots
kW	kilowatts

Symbol or Abbreviation	Term
l	liters
lb	pounds
lb-ft	pound-feet (torque)
m	meters
m per sec^2	meters per second per second
mi	miles
mm	millimeters
mph	miles per hour
MGD	millions of gallons per day
N	Newtons
oz	ounces
oz-in	ounce-inches (torque)
Pa	Pascals
psi	pounds per square inch
psia or psig	pounds per square inch "absolute" or gauge
pt	pint
qt	quart
R	degrees Rankine (Fahrenheit, absolute)
rad	radians
rev	revolutions
rpm	revolutions per minute
sec	seconds
sq	square
std	standard
temp	temperature
wt	weight
yd	yard
yr	year

Rounding of Numbers

A minimum of four significant figures are used in conversion factors presented here. Where the conversion factor is exact (for example, 1 foot contains 12 inches), decimal fractions are not necessary. Also, where large whole numbers are used (for example, 1 square kilometer contains 1195990 square yards), decimal fractions are not used unless justified by the accuracy of ordinary computations.

1195990	(sq yd in a sq km)
4389.12	(cc in a cu ft)
448.86	(gpm in a liter per sec)
14.70	(psi in an atmosphere)
0.4331	(psi in a ft of water)
0.0625	(lb-in in an oz-in)

VELOCITY

centimeters per second (cm per sec)	feet per second (fps or ft per sec)	0.3281
feet per second (fps)	centimeters per second (cm per sec)	30.48
	meters per second (m per sec)	0.3048
	kilometers per hour (km per hr)	1.097
	miles per hour (mph)	0.6818
kilometers per hour (km per hr)	knots (kn)	0.5396
	feet per second (fps)	1.467
	kilometers per hour (km per hr)	1.609
	feet per minute (ft per min.)	88
knots (kn)	miles per hour (mph)	1.152
	kilometers per hour (km per hr)	1.853
radians per second (rad per sec)	revolutions per minute (rpm)	9.55
	degrees per minute (deg per min.)	3437.7
revolutions per minute (rpm)	radians per second (rad per sec)	0.1047
	degrees per minute (deg per min.)	360

ACCELERATION

COLUMN A

To Convert From...	To...	Multiply Col. A by
feet per second per second (ft per sec^2)	meters per second per second (m per sec^2)	0.3048
m per sec^2	ft per sec^2	3.281
revolutions per minute per second (rpm per sec)	radians per second per second (rad per sec^2)	0.1047
rad per sec^2	rpm per sec	9.55

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VOLUMETRIC FLOW RATES

gallons per minute, US (gpm)	liters per second (l per sec)	0.008434
	cubic feet per minute (cfm)	0.1337
	cubic feet per hour (cu ft per hr)	8.022
gallons per minute, UK or Canadian (gpm)	liters per second (l per sec)	0.0101
	cubic feet per minute (cfm)	0.1606
	cubic feet per hour (cu ft per hr)	9.634
cubic feet per second (cfs)	gpm (UK or Canadian)	373.77
	gpm (US)	448.86
	liters per second (l per sec)	1699.2
liters per second (l per sec)	cubic feet per minute (cfm)	2.119
	gpm (UK or Canadian)	13.20
	gpm (US)	15.85
millions of gallons per day, US (MGD)	liters per second (l per sec)	43.81
	cubic feet per minute (cfm)	92.85
	gallons per minute, US (gpm)	694.44

PRESSURE

pascals (Pa)	pounds per square inch (psi)	0.0001450
	pounds per square foot (lb per ft^2)	0.02089
	newtons per square meter	1
pounds per square inch (psi)	atmospheres, std. (atm)	0.0680
	pounds per square foot (lb per ft^2)	144
	pascals (Pa)	6894.8
	foot of water (ft of H20) 60F	2.301
atmospheres (atm), standard	psi	14.70
	lb per ft^2	2116.8
	Pa	101325
inch of water, 60F (in of H20)	psi	0.03609
	lb per ft^2	5.197
	Pa	248.84
foot of water, 60F (ft of H20)	psi	0.4331
	lb per ft^2	62.36
	Pa	2985.9

WEIGHT, MASS, INERTIA

pounds (lb)*	kilograms (kg)	0.4536
	ounces (oz)	16
kilograms (kg)	pounds (lb)	2.205
	ounces (oz)	35.27

WEIGHT, MASS, INERTIA, continued

COLUMN A

Convert From	To	Multiply Col A By This Factor
tons (short)	metric tons	0.9072
	kilograms (kg)	907.2
	pounds (lb)	2000
metric tons	tons (short)	1.102
	kilograms	1000
	pounds	2205
pounds, weight (lb)	slugs, mass (lb-sec2 per ft)	0.03106
pound-foot2 (lb-ft2)	kilogram-meters2 (kg-m2)	0.04214

*pounds and ounces are avoirdupois

FORCE AND TORQUE

pounds (lb)	newtons(N)	4.448
newtons (N)	pounds (lb)	0.2248
newton-meters (N-m)	pound-feet (lb-ft)	0.7376
	pound-inches (lb-in)	8.851
	ounce-inches (oz-in)	141.60
ounce-inches (oz-in)	lb-ft.	0.005208
	N-m	0.007062
	lb-in	0.0625
pound-inches (lb-in)	lb-ft.	0.0833
	N-m	0.1298
	oz-In	16
pound-feet (lb-ft)	N-m	1.356
	lb -in	12
	oz-In	192

POWER

horsepower (hp)	kilowatts (kW)	0.7457
	foot-pounds per second (ft-lb per sec)	550
	foot-pounds per minute (ft-lb per min.)	33000
kilowatts (kW)	horsepower (hp)	1.341

TEMPERATURE

		Use This Relationship
degrees Fahrenheit (F)	degrees Celsius (C)	C =5/9 (F-32)
degrees Celsius (C)	degrees Fahrenheit (F)	F=9/5C+32
degrees Fahrenheit (F)	degrees Rankine (R)	R =F+459.69
degrees Celsius (C)	degrees Kelvin (K)	K=C+273.16

Examples:

1. Convert 12F to C. C = 5/9 (F-32) = 5/9 (12-32) = 5/9 (-20)
   Answer = -11.1C
2. Convert 40C to F. F = 9/5C + 32 = 9/5 (40) + 32 = 72 + 32
   Answer = 104F

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GRAVITATIONAL CONSTANT

g = 32.174 feet per second per second (ft per sec2)
= 9.8067 meters per second per second (m per sec2)

APPROXIMATE DENSITIES OF COMMON MATERIALS

	REPRESENTATIVE DENSITIES Grams per cc	lb per cu ft
GASES @ 68F, std atm		
Air	1.30 grams per liter	0.07528
Oxygen	1.45 grams per liter	0.08305
Hydrogen	0.09 grams per liter	0.005234
Nitrogen	1.25 grams per liter	0.07274
	All Other Materials grams per cc	
LIQUIDS		
Water @ 4C	1.000 grams per cc	62.43
20C	0.998	62.32
40C	0.992	61.94
SeaWater	1.02-1.03	64.00
Ethyl alcohol 100%	0.789	49.2
Kerosene	0.78-0.82	50
Gasoline	0.70-0.75	45
METALS		
Aluminum (95% Al)	2.70	169
Bronze (90% Cu, 10% Zn)	8.80	549
Copper (Annealed, ACS)	8.89	555
Gold	19.32	1206
Iron, gray cast	7.10	443
Lead	11.36	709
Magnesium	1.74	109
Steel (0.4-0.5% Carbon)	7.80	487
Steel, 410 stainless	7.70	480
ENGINEERING PLASTICS		
ABS, general purpose	1.01-1.05	64
Acrylics, cast sheet	1.19	74
Nylon 6/6	1.13-1.15	71
Phenolic, general purpose	1.35-1.46	87
Polycarbonates, general purpose	1.2	75
Polyesters, thermoplastic, unreinforced	1.31 - 1.43	86
Polyehtylene, medium density	0.926-0.940	58
Polyvinyl Chloride	1.30-1.58	89

APPROXIMATE DENSITIES OF COMMON MATERIALS

	REPRESENTATIVE DENSITIES Grams per cc	lb per cu ft
OTHER MATERIALS		
Concrete (stone and sand)	2.2-2.4	144
Limestone	1.5	94
Anthracite coal, not piled	1.4-1.8	100
Bituminous coal, not piled	1.2-1.5	83
Lignite coal, not piled	1.1-1.4	78
Wood, air dried:		
Douglas fir	0.48-0.55	32
White oak	0.77	48
White maple	0.53	33
Oregon pine	0.51	32
Hickory	0.74-0.80	48
Mahogany	0.56-0.85	44
African teak	0.99	62
Indian teak	0.66-0.88	48

Formulas and Constants

1 HP = 33,000 Foot-pounds of work per minute.

1 HP =.746 K.W. = K.W.P 1.341.

1 HP = 2547 B.T.U. per hour.

1 B.T.U. = Heat required to raise 1 lb. water 1-F.

1 B.T.U. = 777.6 Foot-pounds work.

1 Kilowatt Hour = 3415 B.T.U.

Heat Value of Carbon = 14,600 B.T.U. per pound.

Latent Heat of Fusion of Ice = 143.15 B.T.U. per pound.

Latent Heat of Evaporation of Water at 212° F. = 970.4 B.T.U. per pound.

Total Heat of Saturated Steam at atmospheric pressure = 1,150.4 B.T.U. per pound.

1 Ton of Refrigeration = 288,000 B.T.U. per 24 hours.

g = Acceleration of Gravity (commonly taken as 32.16 feet per second per second).

1 Radian = 57.296 degrees.

1 Meter = 100 cm. = 39.37 inches.

1 Kilometer =.62137 miles.

1 Gallon = 231 cubic inches.

1 Barrel = 31.5 gallons.

Atmospheric Pressure = 14.7 pounds per sq. in. = 29.92 inches mercury at 32º F.

1 Lb. per Sq. In. Pressure = 2.3095 feet fresh water at 62º F. = 2.0355 inches mercury at 32º F. = 2.0416 inches mercury at 62º F.

Water Pressure (pounds per sq. in.) =.433 X height of water in feet (Fresh water at 62ºF.).

Weight of 1 cu. ft. fresh Water = 62.355 lbs. at 62ºF. = 59.76 lbs. at 212º F.

Weight of 1 cu. ft. Air at 14.7 lbs. per sq. in. Pressure = .07608 lbs. at 62º F. =.08073 lbs. at 32º F.

† Also look in the General Index under Weights, Measures, or the subject material required.

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Flywheel Formulas

Flywheels are used on some machines, for example air compressors, to even out load pulsations. The following formulas are useful in designing entire flywheels and flywheel rims. A V-belt sheave may also be used as a flywheel eliminating the need for a separate flywheel in the system.

Formulas for Entire Flywheel

Kinetic energy of rotation of a flywheel (foot pounds) $= .0001705\ N^2(WR^2)^*$.

Torque to uniformly accelerate or decelerate a flywheel

$$= \frac{.03908\ (N_2 - N_1)\ (WR^2),\ ^*\text{ pound-inches}}{t}$$

where N_2 = final R.P.M. and N_1 = initial R.P.M.
Velocity at outside diameter (feet per minute) = 0.2618 ND.

W = weight (pounds).

R = radius of gyration (feet).

N = speed (R.P.M.)

t = time to change from N_1 to N_2 (seconds).

F = face of rim (inches).

D = outside diameter of rim (inches).

d = inside diameter of rim (inches).

K = weight per cubic inch of material (pounds).

*WR^2 = flywheel effect (pounds X feet^2). See table to the right for WR^2 of rims. Ordinarily the WR^2 of the rim only is considered. In unusual instances the relatively small WR^2 values of the hub and arms or web can be added directly to the WR^2 of the rim if desired. To find the WR^2 of a hub or web use the WR^2 formula for rims, substituting the hub or web outside diameter, inside diameter, and width for D, d and F respectively. When arms are used instead of a web an approximate WR^2 value of the arms is the total weight of the arms in pounds times the square of the radius in feet from the shaft center line to the mid point of the arms between hub and rim.

Table 30: Formulas for Flywheel Rims

Property	Cast Iron Rim (Based on.26 lbs. per cu. in.)	Steel Rim (Based on .283 lbs. per cu. in.)	Rim of any material weighing K pounds per cubic inch
Volume (Cubic Inches)	$.7854F(D^2-d^2)$	$.7854F(D^2-d^2)$	$.7854F(D^2-d^2)$
W Weight (Pounds)	$.2042F(D^2-d^2)$	$.2223F(D^2-d^2)$	$.7854FK(D^2-d^2)$
R Radius of Gyration (Feet)	$\sqrt{\frac{.8681\ (D^2-d^2)}{1000}}$	$\sqrt{\frac{0.8681\ (D^2-d^2)}{1000}}$	$\sqrt{\frac{.8681\ (D^2-d^2)}{1000}}$
WR^2 Wt X Sq. of Radius of Gyration (Lbs. X Ft.^{2})	$\frac{.1773F(D^4-d^4)}{1000}$	$\frac{.1929F(D^4-d^4)}{1000}$	$\frac{.6818FK(D^4-d^4)}{1000}$
T ▲ Tensile Load in rim (Lbs.)	$\frac{.3078FN2(D^3-d^3)}{1000000}$	$\frac{.3350FN2(D^3-d^3)}{1000000}$	$\frac{1,184FKN2(D^3-d^3)}{1000000}$

▲ Centrifugal force causes this tensile load at each and every section of the rim. Hence, on rims split into two or more sections the fastening at each joint should be designed to take the full load as calculated from the formula here given.

Centrifugal Force

R = Distance from the axis of rotation to the center of gravity of the body (feet).

N = Revolutions per minute.

v = Velocity of the center of gravity of the body (feet per second).

g = Acceleration due to gravity (32.16 commonly).

$$F = \frac{Wv^2}{gR} = \frac{WRN^2}{2933} = .000341\ WRN^2$$

F = Centrifugal force tending to move the body outward from the axis of rotation (pounds).

W = Weight of body (pounds).

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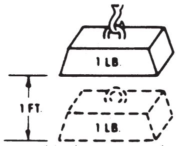
Torque and Horsepower Equivalents

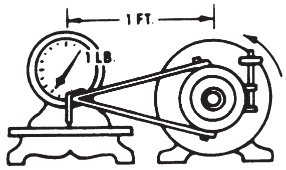


A foot-pound is the amount of energy expended in lifting a one-pound mass a distance of one foot against the pull of gravity

FOOT-POUNDS INDICATE ENERGY

TORQUE

It is: a turning moment or twisting effort.
Is it expressed in foot-pounds? or pound-feet?



A pound-foot is the moment created by a force of one pound applied to the end of a lever arm one

POUND-FEET INDICATE TORQUE

Torque (in Pound-Inches) $= \dfrac{63025 \text{ X HP}}{\text{RPM}}$

= Force X Lever Arm (In Inches)

Torque (in Pound-Feet) $= \dfrac{5252 \text{ X HP}}{\text{RPM}}$

= Force X Lever Arm (In Feet)

Force = Working Load in Pounds.
FPM = Feet Per Minute.
RPM = Revolutions Per Minute.
Lever Arm = Distance from the Force to the center of rotation in Inches or Feet.

Example:

25 HP at 150 RPM = 10504 Pound-Inches Torque
2.5 HP at 150 RPM = 1050.4 Pound-Inches Torque

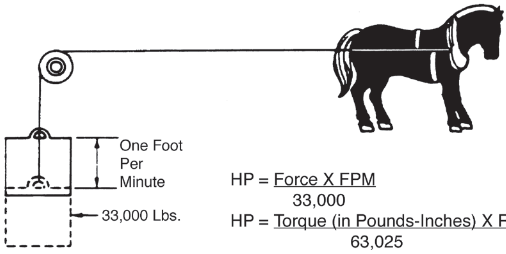
For other values of RPM move decimal point in RPM values to the left or right as desired, and in Torque values move to the right or left (opposite way) the same number of places.

Example:

25 HP at 150 RPM = 10504 Pound-Inches Torque
25 HP at 1.50 RPM = 1050400 Pound-Inches Torque
2.5 HP at 1.50 RPM = 105040 Pound-Inches Torque

HORSEPOWER

Common Unit of Mechanical power - (HP)
One HP is the rate of work required to raise 33,000 pounds one foot in one minute



HP $= \dfrac{\text{Force X FPM}}{33{,}000}$

HP $= \dfrac{\text{Torque (in Pounds-Inches) X RPM}}{63{,}025}$

HP $= \dfrac{\text{Torque (in Pounds-Feet) X RPM}}{5{,}252}$

Overhung Loads

An overhung load is a bending force imposed on a shaft due to the torque transmitted by V-drives, chain drives and other power transmission devices, other than flexible couplings.

Most motor and reducer manufacturers list the maximum values allowable for overhung loads. It is desirable that these figures be compared with the load actually imposed by the connected drive.

Overhung loads may be calculated as follows:

$$\text{O.H.L.} = \frac{63{,}000 \text{ X HP X F}}{\text{N X R}}$$

Where HP = Transmitted hp X service factor
N = RPM of shaft
R = Radius of sprocket, pulley. etc. (inches)
F = Factor (See chart to right)

Weights of the drive components are usually negligible. The formula is based on the assumption that the load is applied at a point equal to one shaft diameter from the bearing face. Factor F depends on the type of drive used:

F= {
1.00 for single chain drives.
1.3 for TIMING Belt Drives and HTD belt Drives.
1.25 for spur or helical gear or double chain drives.
1.50 for V-belt drives. 2.50 for flat belt drives.
2.50 for flat belt drives.

Example: Find the overhung load imposed on a reducer by a double chain drive transmitting 7 hp @ 30 RPM. The pitch diameter of the sprocket is 10"; service factor is 1.3.
Solution:

$$\text{O.H.L.} = \frac{(63{,}000)\ (7 \times 1.3)\ (1.25)\ = 4{,}780 \text{ lbs.}}{(30)\ (5)}$$

Mathematical Equations

To find circumference of a circle, multiply diameter by 3.1416.
To find diameter of a circle, multiply circumference by .31831.
To find area of a circle, multiply square of diameter by .7854.
To find area of a rectangle, multiply length by breadth.
To find area of a triangle, multiply base by 1/2 perpendicular height.
To find area of ellipse, multiply product of both diameters by .7854.
To find area of parallelogram, multiply base by altitude.
To find side of an inscribed square, multiply diameter by 0.7071 or multiply circumference by 0.2251 or divide circumference by 4.4428.
To find side of inscribed cube, multiply radius of sphere by 1.1547.
To find side of an equal square, multiply diameter by .8862.
To find the surface of a sphere, square the diameter and multiply by 3.1416.
To find the volume of a sphere, cube the diameter and multiply by .5236.
A side of a square multiplied by 1.4142 equals diameter of its circumscribing circle.
A side of a square multiplied by 4.443 equals circumference of its circumscribing circle.

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Table 31: Strength and Physical Properties of Various Metals

Metals and Alloys	Stress in Thousands of Pounds per Sq. Inch				Modulus of Elasticity Millions	Elongation%
	Tension Ultimate	Tension Yield Point	Compression Ultimate	Shear Ultimate		
Aluminum, Type 1100.0, Annealed	13	5	. . . . . .	9	10	45
Aluminum, Type 1100-H18, Hard	24	22	. . . . . .	13	10	15
Aluminum. Type 3003-0, Annealed	16	6	. . . . . .	11	10	40
Aluminum, Type 3003-H18, Hard	29	27	. . . . . .	16	10	10
Aluminum, Type 5052-0, Annealed	28	13	. . . . . .	18	10.20	30
Aluminum, Type 5052-H38, Hard	42	37	. . . . . .	24	10.20	8
Aluminum, Type 5056-0, Annealed	42	22	. . . . . .	26	10.30	35
Aluminum, Type 2014-0, Annealed	27	14	. . . . . .	18	10.60	18
Aluminum, Type 2014-T4, Heat Treated	62	42	. . . . . .	38	10.60	20
Aluminum, Type C4A, Casting. Solution Heat Treat	32	16	16▲	24	. . . . . .	8.50
Aluminum, Type S5C, As Die Cast	30	16	16▲	19	. . . . . .	9
Brass, Admiralty, Annealed	53	22	. . . . . .	. . . . . .	16	65
Brass, Aluminum, Annealed	60	27	. . . . . .	. . . . . .	16	55
Brass, Cartridge, 30% Zn, Annealed	44	11	. . . . . .	32	16	66
Brass, Cartridge, 30% Zn, Hard	76	63	. . . . . .	44	16	8
Brass, Naval, Annealed	57†	25†	. . . . . .	40 †	15	47†
Brass, Naval, Leaded, Annealed	57†	25†	. . . . . .	36 †	15	40†
Brass, Red, 15% Zn, Annealed	39	10	. . . . . .	31	17	48
Brass, Red, 15% Zn, Hard	70	57	. . . . . .	42	17	5
Brass, Red, Leaded, Cast, Grade 4A	33-46	17-24	10-12▲	. . . . . .	9.1-14.8	20-35
Brass, Red, Leaded, Cast, Grade 4B	30-38	12-17	11-12▲	. . . . . .	. . . . . .	15-27
Brass, Semi-Red, Leaded, Cast, Grade 5A	29-39	13-17	. . . . . .	. . . . . .	7.7-14.3	18-30
Brass, Semi-Red, Leaded, Cast, Grade 5B	30-40	12-16	8-10▲	. . . . . .	10-14	20-35
Brass, Yellow, 35% Zn, Annealed	46	14	. . . . . .	32	15	65
Brass, Yellow, 35% Zn, Hard	74	60	. . . . . .	43	15	8
Bronze, Aluminum, As Cast	67-95	27-45	. . . . . .	. . . . . .	15-18	5-35
Bronze, Commercial, 10% Zn, Annealed	37†	10†	. . . . . .	28 †	17	45=
Bronze, Manganese, Annealed	65†	30†	. . . . . .	42 v	15	33=
Bronze, Phosphor, Annealed	40-66	14-24	. . . . . .	. . . . . .	16-17	48-70
Bronze, Tin, High Leaded, Cast	23-38	11-22	12-16▲	. . . . . .	8.5-13	7-20
Bronze, Tin, Leaded, Cast	33-48	16-26	9-15▲	. . . . . .	10.6-16	15-40
Copper, Beryllium, Annealed	60-80	25-35v	. . . . . .	50-60 †	19	35-50†
Copper, Electrolytic, Tough Pitch, Annealed	32†	10†	. . . . . .	22 †	17	45†
Inconel, Cast	65-90	. . . . . .	. . . . . .	. . . . . .	23	10-20
Inconel, S, Cast	90-120	80-100	. . . . . .	. . . . . .	25	1-3
Inconel, Shapes, Plate, Etc., Annealed	80-100†	30-45†	. . . . . .	. . . . . .	31	35-55†
Inconel, X, Shapes, Plate, Etc., Annealed	110-130†	45-65†	. . . . . .	. . . . . .	31	40-55†
Iron, Cast, Class 30	30-34	. . . . . .	115	44	15	. . . . . .
Iron, Cast, Class 35	35-40	. . . . . .	125	43	16	. . . . . .
Iron, Ingot, Hot Rolled	44	23	. . . . . .	. . . . . .	29.80	47
Iron, Malleable, Class 32510	50	33	90	46	25	10-18
Iron, Malleable, Class 35018	55	37	90	51	25	18-25
Iron, Nodular (Ductile) Class 60-45-10	60	45	120	. . . . . .	22-25	10-25
Iron, Nodular (Ductile) Class 80-60-3	80	60	160	. . . . . .	22-25	3-10
Iron, Pearlitic, Malleable	60-90	40-70	. . . . . .	. . . . . .	28	3-12
Iron, Wrought, Hot Rolled	34-47	23-24	. . . . . .	. . . . . .	29	7-35
Lead, Hard, Rolled	4.0-4.6	. . . . . .	. . . . . .	. . . . . .	. . . . . .	31-48
Magnesium Alloy, Extruded, ASTM MIA	26-28	23-28	10-13	16	6.50	8-11
Magnesium Alloy, Extruded, ASTM AZ6IA-F	40-45	22-32	15-21	21	6.50	15-16
Magnesium Alloy, Cast, ASTM MIB	14	4.50	. . . . . .	11	6.50	5
Magnesium Alloy, Cast, ASTM AZ92A	24	14	. . . . . .	19	6.50	2
Magnesium Alloy, Cast, ASTM AZ9IA	36	23	. . . . . .	20	6.50	4

Table 31: Strength and Physical Properties of Various Metals

Metals and Alloys	Stress in Thousands of Pounds per Sq. Inch				Modulus of Elasticity Millions	Elongation%
	Tension Ultimate	Tension Yield Point	Compression Ultimate	Shear Ultimate		
Monel, Cast	65-90	32-45	......	......	23	20-50
Monel, S, Cast	120-145	80-130	......	......	24.20	1-4
Monel, Shapes, Plate, Etc., Annealed	70-85†	25-45†	......	......	26	35-50†
Monel, K, Shapes, Plate, Etc., Annealed	90-105†	40-65†	......	26	25-45	35-55†
Muntz Metal, Cu 59.63%, Zn balance	54	21	......	40	15	45
Nickel, Cast .	50-65	15-30	......	......	21.50	15-30
Nickel, Silver, Annealed	49-63†	18-30†	......	......	17-18	35-60†
Steel, Cast Carbon, Class 70,000 Normalized	70	38	......	......	30	28
Steel, Cast Low Alloy, Class 100,000, Normalized and Tempered	100	68	......	......	29-30	20
Steel, Cast Low Alloy, Class 120,000, Quenched and Tempered	120	95	......	......	29-30	16
Steel, Cast Low Alloy, Class 200,000, Quenched and Tempered	200	170	......	......	29-30	5
Steel, Sheets	48	25	......	......	29-30	18-27
Steel, Stainless, Austenitic, Types 304, 316	85	35	......	......	28	55-60
Steel, Stainless, Martensitic, Type 416	75	40	......	......	29	30
Steel, Structural, Bridge and Building, ASTM A7	60-72	33	33▲	45-54	29-30	21
Steel, Structural, High Strength, Low Alloy, ASTM A242	63-70	42-50	42-50▲	47-53	29-30	18-24
Zinc, Die Cast Alloy XXIII	41	......	60▲	31	......	10

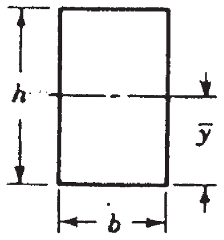
† When hardened, strength values are higher, elongation less

▲ Compression yield point

Table 32: Properties of Sections

A = area
I = moment of inertia
J = polar moment of inertia
Z = section modulus π
k = radius of gyration
y = centroidal distance

Rectangle



$A = bh$

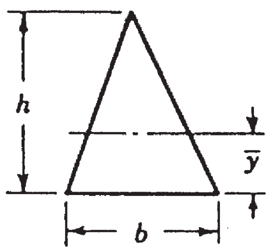
$I = \frac{bh^3}{12}$

$Z = \frac{bh^2}{6}$

$k = 0.289h$

$\bar{y} = \frac{h}{2}$

Triangle



$A = \frac{bh}{2}$

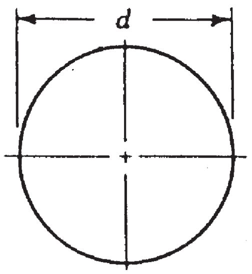
$I = \frac{bh^3}{36}$

$Z = \frac{bh^2}{24}$

$k = 0.236h$

$\bar{y} = \frac{h}{3}$

Circle



$A = \frac{\pi d^2}{4}$

$I = \frac{\pi d^4}{64}$

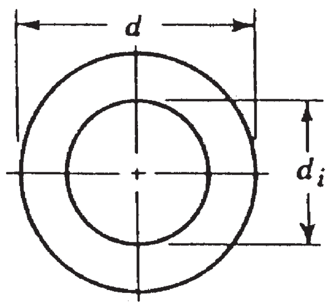
$Z = \frac{\pi d^3}{32}$

$J = \frac{\pi d^4}{32}$

$k = \frac{d}{4}$

$\bar{y} = \frac{d}{2}$

Hollow Circle



$A = \frac{\pi d}{4} (d^2 - d_i^2)$

$I = \frac{\pi}{64} (d^4 - d_i^4)$

$Z = \frac{\pi}{32d} (d^4 - d_i^4)$

$J = \frac{\pi}{32} (d^4 - d_i^4)$

$k = \sqrt{\frac{d^2 - d_i^2}{16}}$

$\bar{y} = \frac{d}{2}$

Engineering
System-1
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Table 33: Coefficients of Friction "f"

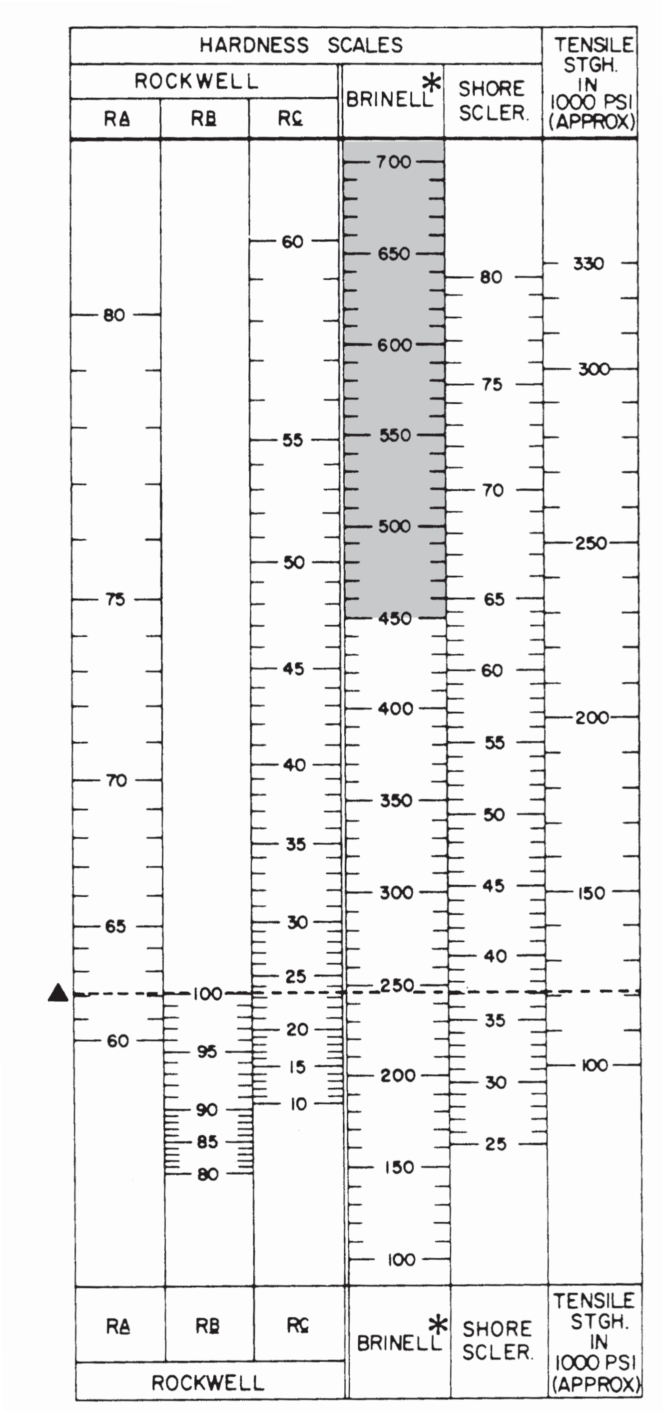
Material	Static Dry	Static Lubricated	Sliding Dry	Sliding Lubricated
Aluminum on aluminum	1.35	....	....	....
Canvas belt on rubber lagging	0.30	....	....	....
Canvas belt, stitched, on steel	....	....	0.20	0.10
Canvas belt, woven, on steel	....	....	0.22	0.10
Cast iron on asbestos, fabric	....	....	....	....
brake material	....	....	0.35-0.40	....
Cast iron on brass	....	....	0.30	....
Cast iron on bronze	....	....	0.22	0.07-0.08
Cast iron on cast iron	1.10	....	0.15	0.06-0.10
Cast iron on copper	1.05	....	0.29	....
Cast iron on lead	....	....	0.43	....
Cast iron on leather	0.60	....		0.13-0.36
Cast iron on oak (parallel)	....	....	0.30-0.50	0.07-0.20
Cast iron on magnesium	....	....	0.25	....
Cast iron on steel, mild	....	0.18	0.23	1/0/00 3:11
Cast iron on tin	....	....	0.32	....
Cast iron on zinc	0.85	....	0.21	....
Earth on earth	0.25-1.0	....	....	....
Glass on glass	0.94	....	0.40	....
Hemp rope on wood	0.50-0.80	....	0.40-0.70	....
Nickel on nickel	1.10	....	0.53	0.12
Oak on leather (parallel)	0.50-0.60	....	0.30-0.50	....
Oak on oak (parallel)	0.62	....	0.48	0.16
Oak on oak (perpendicular)	0.54	....	0.32	0.07
Rubber tire on pavement	0.8-0.9	0.6-0.7 *	0.75-0.85	0.5-0.7*
Steel on ice	0.03	....	0.01	....
Steel, hard, on babbit	0.42-0.70	0.08-0.25	0.33-0.35	0.05-0.16
Steel, hard. on steel, hard	0.78	0.11-0.23	0.42	0.03-0.12
Steel, mild, on aluminum	0.61	....	0.47	....
Steel, mild, on brass	0.51	....	0.44	....
Steel, mild, on bronze	....	....	0.34	0.17
Steel, mild, on copper	0.53	....	0.36	0.18
Steel, mild, on steel, mild	0.74	....	0.57	0.09-0.19
Stone masonry on concrete	0.76	....	....	....
Stone masonry on ground	0.65	....	....	....
Wrought iron on bronze	0.19	0.07-0.08	0.18	....
Wrought iron on wrought iron	....	0.11	0.44	0.08-0.10

* Wet pavement

Table 34: U.S. Standard Sheet Metal Gages

Gage No.	Thickness in Decimal Parts of an Inch	Gage No.	Thickness in Decimal Parts of an Inch
1	.2813	20	.0359
2	.2656	21	.0329
3	.2391	22	.0299
4	.2242	23	.0269
5	.2092	24	.0239
6	.1943	25	.0209
7	.1793	26	.0179
8	.1644	27	.0164
9	.1495	28	.0149
10	.1345	29	.0135
11	.1196	30	.0120
12	.1046	31	.0109
13	.0897	32	.0102
14	.0747	33	.0094
15	.0673	34	.0086
16	.0598	35	.0078
17	.0538	36	0070
18	.0478	37	.0066
19	.0418	38	.0063

Hardness Comparison Chart



* Shaded area indicates values may vary depending on type of ball used.

▲ Example: A Brinell number of 245 is equal to 62 Rockwell "A", 100 Rockwell "B", 23 Rockwell "C", 37 Shore with a tensile of approximately 120,000 psi.

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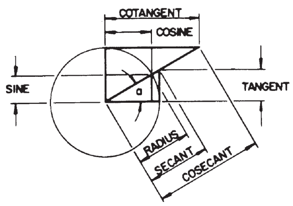
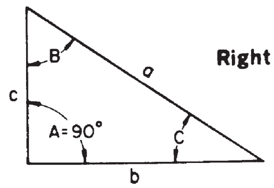
Trigonometric Formula





Right Angle Triangle

Table 35: Formulas for Finding Functions of Angles

Side opposite / Hypotenuse	=	SINE
Side adjacent / Hypotenuse	=	COSINE
Side opposite / Side adjacent	=	TANGENT
Side adjacent / Side opposite	=	COTANGENT
Hypotenuse / Side adjacent	=	SECANT
Hypotenuse / Side opposite	=	COSECANT

Table 36: Formulas for Finding Sides of Right Angle Triangles with an Angle and Side Known

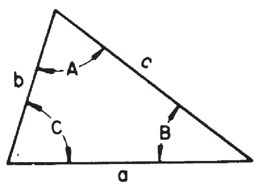
To find: Length of side opposite	Hypotenuse x Sine Hypotenuse ÷ Coscant Side adjacent x Tangent Side adjacent ÷ Cotangent
To find: Length of side adjacent	Hypotenuse X Cosine Hypotenuse ÷ Secant Side opposite X Cotangent Side opposite ÷ Tangent
To find: Length of Hypotenuse	Side opposite X Cosecant Side opposite ÷ Sine Side adjacent X Secant Side adjacent ÷ Cosine

Table 37: To Find Angles and Sides of Right Angle Triangles

To Find Angles				To Find Angles		
To Find:	**Formulas**			**To Find:**	**Formulas**	
C	$\frac{c}{a}$	=	Sine C	a	$\sqrt{b^2 + c^2}$	- - -
C	$\frac{b}{a}$	=	Cosine C	a	c x Cosec. C	$\frac{c}{\text{Sine C}}$
C	$\frac{c}{b}$	=	Tan. C	a	c x Secant B	$\frac{c}{\text{Cosine B}}$
C	$\frac{b}{c}$	=	Cotan C	a	b x Cosec. B	$\frac{b}{\text{Sine B}}$
C	$\frac{a}{b}$	=	Secant C	a	b x Secant C	$\frac{b}{\text{Cosine C}}$
C	$\frac{a}{c}$	=	Cosec. C	b	$\sqrt{a^2 - c^2}$	- - -
B	$\frac{c}{a}$	=	Sine B	b	a x Sine B	$\frac{a}{\text{Cosecant B}}$
B	$\frac{c}{a}$	=	Cosine B	b	a x Cos. C	$\frac{a}{\text{Secant C}}$
B	$\frac{b}{c}$	=	Tan. B	b	c x Tan. B	$\frac{c}{\text{Cotangent B}}$
B	$\frac{c}{d}$	=	Cotan. B	b	c x Cot. C	$\frac{c}{\text{Tangent C}}$
B	$\frac{a}{c}$	=	Secant B	c	$\sqrt{a^2 - b^2}$	- - -
B	$\frac{a}{b}$	=	Cosec. B	c	a x Cos. B	$\frac{a}{\text{Secant B}}$
				c	a x Sine C	$\frac{a}{\text{Cosecant C}}$
				c	b x Cot. B	$\frac{b}{\text{Tangent B}}$
				c	b x Tan. C	$\frac{b}{\text{Cotangent C}}$

Table 38: To Find Angles and Sides of Oblique Angle Triangle

Oblique Angle Triangle



To Find Angles and Sides of Oblique Angle Triangle					
To find:	**Known**	**Formulas**	**To Find:**	**Known**	**Formulas**
C	A, B	180˚ (A + B)	A	B, C	180˚- (B + C)
b	a, B, A	$\frac{\text{a x Sin. B}}{\text{Sin A}}$	Cos. A	a, b, c	$\frac{b^2 + c^2 - a^2}{2bc}$
c	a, A, C	$\frac{\text{a x Sin. C}}{\text{Sin. A}}$	Sin. C	c, A, a	$\frac{\text{c x Sin. A}}{\text{a}}$
Tan. A	a, C, b	$\frac{\text{a x Sin. C}}{\text{b - (a x Cos. C)}}$	Cot. B	a, C, b	$\frac{\text{a x Cosec. C}}{\text{b}}$
B	A, C	180˚ - (A + C)	c	b, C, B	b x Sin. C x Cosec. B
Sin. B	b, A, a	$\frac{\text{b x Sin. A}}{\text{a}}$	- - -	- - -	- - - - -

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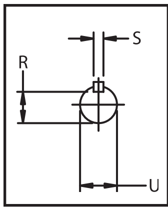
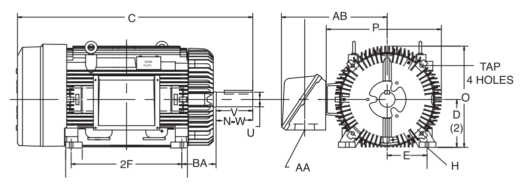
NEMA QUICK REFERENCE CHART

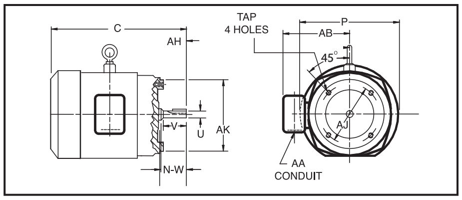
- Dimensions are for reference only
- Drawings represent standard TEFC general purpose motors

Contact your local DODGE/Reliance Sales Office at 1-864-284-5700 for "C" dimensions.



FRAME		NEMA SHAFT	KEYSEAT DIMENSIONS		FRAME		NEMA SHAFT	KEYSEAT DIMENSIONS	
		U	R	S			U	R	S
48	48	1/2	29/64	FLAT	284T	286T	1-7/8	1-19/32	1/2
56	56	5/8	33/64	3/16	324T	326T	2-1/8	1-27/32	1/2
143T	145T	7/8	49/64	3/16	364T	365T	2-3/8	2-1/64	5/8
182T	184T	1-1/8	63/64	1/4	404T	405T	2-7/8	2-29/64	3/4
213T	215T	1-3/8	1-13/64	5/16	444T	445T	3-3/8	2-7/8	7/8
254T	256T	1-5/8	1-13/32	3/8	447T	449T	3-3/8	2-7/8	7/8





NEMA C-FACE	BA Dimensions
143TC - 145TC	2-3/4
182TC - 184 TC	3-1/2
213TC - 215TC	4-1/4
254TC- 256TC	4-3/4

NEMA Frame	D	E	2F	H	N-W	O	P	U	Keyway	V	AA	AB	AH	AJ	AK	BA	Tap Size
48	3	2-1/8	2-3/4	11/32 SLOT	1-1/2	5-13/16	5-5/8	1/2		1-1/2	1/2	-	1-11/16	3-3/4	3	2-1/2	1/4-20
56	3-1/2	2-7/16	3	11/32	1-7/8	8-9/16	7-9/32	5/8	3/16x3/32	1-7/8	1/2	-	2-1/16	5-7/8	4-1/4	2-3/4	3/8-16
56H	3-1/2	2-7/16	5	SLOT	1-7/8	8-9/16	7-9/32	5/8	3/16x3/32	1-7/8	1/2	-	2-1/16	5-7/8	4-1/2	2-3/4	3/8-16
143T	3-1/2	2-7/16	4	11/32	2-1/4	8-9/16	7-9/32	7/8	3/16x3/32	2-1/4	3/4	-	2-1/8	5-7/8	4-1/2	2-1/4	3/8-16
145T	3-1/2	2-3/4	5	11/32	2-1/4	8-9/16	7-9/32	7/8	3/16x3/32	2-1/4	3/4	-	2-1/8	5-7/8	4-1/2	2-1/4	3/8-16
182	4-1/2	3-3/4	4-1/2	13/32	2-1/4	9-7/8	9-1/4	7/8	3/16x3/32	2-1/4	3/4	8-7/16	2-1/8	5-7/8	4-1/2	2-3/4	3/8-16
184	4-1/2	3-3/4	5-1/2	13/32	2-1/4	9-7/8	9-1/4	7/8	3/16x3/32	2-1/4	3/4	8-7/16	2-1/8	5-7/8	4-1/2	2-3/4	3/8-16
182T	4-1/2	3-3/4	4-1/2	13/32	2-3/4	9-7/8	9-1/4	1-1/8	1/4x1/8	2-3/4	3/4	7-13/16	2-5/8	7-1/4	8-1/2	2-3/4	1/2-13
184T	4-1/2	3-3/4	5-1/2	13/32	2-3/4	9-7/8	9-1/4	1-1/8	1/4x1/8	2-3/4	3/4	7-13/16	2-5/8	7-1/4	8-1/2	2-3/4	1/2-13
213	5-1/4	4-1/4	5-1/2	13/32	3	11-1/4	10-1/2	1-1/8	1/4x1/8	3	1	9-5/16	2-3/4	7-1/4	8-1/2	3-1/2	1/2-13
215	5-1/4	4-1/4	7	13/32	3	11-1/4	10-1/2	1-1/8	1/4x1/8	3	1	9-5/16	2-3/4	7-1/4	8-1/2	3-1/2	1/2-13
213T	5-1/4	4-1/4	5-1/2	13/32	3-3/8	11-1/4	10-1/2	1-3/8	5/16x5/32	3-3/8	1	8-11/16	3-1/8	7-1/4	8-1/2	3-1/2	1/2-13
215T	5-1/4	4-1/4	7	13/32	3-3/8	11-1/4	10-1/2	1-3/8	5/16x5/32	3-3/8	1	8-11/16	3-1/8	7-1/4	8-1/2	3-1/2	1/2-13
254U	6-1/4	5	8-1/4	17/32	3-3/4	13-1/4	13-1/4	1-3/8	5/16x5/32	3-3/4	1-1/4	10-13/16	3-1/2	7-1/4	8-1/2	4-1/4	1/2-13
256U	6-1/4	5	10	17/32	3-3/4	13-1/4	13-1/4	1-3/8	5/16x5/32	3-3/4	1-1/4	10-13/16	3-1/2	7-1/4	8-1/2	4-1/4	1/2-13
254T	6-1/4	5	8-1/4	17/32	4	13-1/4	13-1/4	1-5/8	3/8x3/16	4	1-1/4	10-3/4	3-3/4	7-1/4	8-1/2	4-1/4	1/2-13
256T	6-1/4	5	10	17/32	4	13-1/4	13-1/4	1-5/8	3/8x3/16	4	1-1/4	10-3/4	3-3/4	7-1/4	8-1/2	4-1/4	1/2-13
284U	7	5-1/2	9-1/2	17/32	4-7/8	14-3/4	14-7/8	1-5/8	3/8x3/16	4-7/8	1-1/2	12-5/8	4-5/8	9	10-1/2	4-3/4	1/2-13
286U	7	5-1/2	11	17/32	4-7/8	14-3/4	14-7/8	1-5/8	3/8x3/16	4-7/8	1-1/2	12-5/8	4-5/8	9	10-1/2	4-3/4	1/2-13
284T	7	5-1/2	9-1/2	17/32	4-5/8	14-3/4	14-7/8	1-7/8	1/2x1/4	4-5/8	1-1/2	12-3/4	4-3/8	9	10-1/2	4-3/4	1/2-13
286T	7	5-1/2	11	17/32	4-5/8	14-3/4	14-7/8	1-7/8	1/2x1/4	4-5/8	1-1/2	12-3/4	4-3/8	9	10-1/2	4-3/4	1/2-13
284TS	7	5-1/2	9-1/2	17/32	3-1/4	14-3/4	14-7/8	1-5/8	3/8x3/16	3-1/4	1-1/2	12-3/4	3	9	10-1/2	4-3/4	1/2-13
286TS	7	5-1/2	11	17/32	3-1/4	14-3/4	14-7/8	1-5/8	3/8x3/16	3-1/4	1-1/2	12-3/4	3	9	10-1/2	4-3/4	1/2-13
324U	8	6-1/4	10-1/2	21/32	5-5/8	16-11/16	17	1-7/8	1/2x1/4	5-5/8	2	15-7/16	5-3/8	11	12-1/2	5-1/4	5/8-11
326U	8	6-1/4	12	21/32	5-5/8	16-11/16	17	1-7/8	1/2x1/4	5-5/8	2	15-7/16	5-3/8	11	12-1/2	5-1/4	5/8-11
324T	8	6-1/4	10-1/2	21/32	5-1/4	16-11/16	17	2-1/8	1/2x1/4	5-1/4	2	15-3/16	5	11	12-1/2	5-1/4	5/8-11
326T	8	6-1/4	12	21/32	5-1/4	16-11/16	17	2-1/8	1/2x1/4	5-1/4	2	15-3/16	5	11	12-1/2	5-1/4	5/8-11
324TS	8	6-1/4	10-1/2	21/32	3-3/4	16-11/16	17	1-7/8	1/2x1/4	3-3/4	2	15-3/16	3-1/2	11	12-1/2	5-1/4	5/8-11
326TS	8	6-1/4	12	21/32	3-3/4	16-11/16	17	1-7/8	1/2x1/4	3-3/4	2	15-3/16	3-1/2	11	12-1/2	5-1/4	5/8-11
364U	9	7	11-1/4	21/32	6-3/8	18-1/2	19-1/2	2-1/8	1/2x1/4	6-3/8	2-1/2	18	6-1/8	11	12-1/2	5-7/8	5/8-11
365U	9	7	12-1/4	21/32	6-3/8	18-1/2	19-1/2	2-1/8	1/2x1/4	6-3/8	2-1/2	18	6-1/8	11	12-1/2	5-7/8	5/8-11
364T	9	7	11-1/4	21/32	5-7/8	18-1/2	19-1/2	2-3/8	5/8x5/16	5-7/8	2-1/2	18-1/16	5-5/8	11	12-1/2	5-7/8	5/8-11
365T	9	7	12-1/4	21/32	5-7/8	18-1/2	19-1/2	2-3/8	5/8x5/16	5-7/8	2-1/2	18-1/16	5-5/8	11	12-1/2	5-7/8	5/8-11
364TS	9	7	11-1/4	21/32	3-3/4	18-1/2	19-1/2	1-7/8	1/2x1/4	3-3/4	2-1/2	18-1/16	3-1/2	11	12-1/2	5-7/8	5/8-11
365TS	9	7	12-1/4	21/32	3-3/4	18-1/2	19-1/2	1-7/8	1/2x1/4	3-3/4	2-1/2	18-1/16	3-1/2	11	12-1/2	5-7/8	5/8-11
404U	10	8	12-1/4	13/16	7-1/8	21-5/16	22-1/2	2-3/8	5/8x5/16	7-1/8	3	19-1/4	6-7/8	11	12-1/2	6-5/8	5/8-11
405U	10	8	13-3/4	13/16	7-1/8	21-5/16	22-1/2	2-3/8	5/8x5/16	7-1/8	3	19-1/4	6-7/8	11	12-1/2	6-5/8	5/8-11
404T	10	8	12-1/4	13/16	7-1/4	21-5/16	22-1/2	2-7/8	3/4x3/8	7-1/4	3	19-5/16	7	11	12-1/2	6-5/8	5/8-11
405T	10	8	13-3/4	13/16	7-1/4	21-5/16	22-1/2	2-7/8	3/4x3/8	7-1/4	3	19-5/16	7	11	12-1/2	6-5/8	5/8-11
404TS	10	8	12-1/4	13/16	4-1/4	21-5/16	22-1/2	2-1/8	1/2x1/4	4-1/4	3	19-5/16	4	11	12-1/2	6-5/8	5/8-11
405TS	10	8	13-3/4	13/16	4-1/4	21-5/16	22-1/2	2-1/8	1/2x1/4	4-1/4	3	19-5/16	4	11	12-1/2	6-5/8	5/8-11
444U	11	9	14-1/2	13/16	8-5/8	23-3/8	25-1/4	2-7/8	3/4x3/8	8-5/8	3	22-3/16	8-3/8	14	16	7-1/2	5/8-11
445U	11	9	16-1/2	13/16	8-5/8	23-3/8	25-1/4	2-7/8	3/4x3/8	8-5/8	3	22-3/16	8-3/8	14	16	7-1/2	5/8-11
444T	11	9	14-1/2	13/16	8-1/2	23-3/8	25-1/4	3-3/8	7/8x7/16	8-1/2	3	23-3/8	8-1/4	14	16	7-1/2	5/8-11
445T	11	9	16-1/2	13/16	8-1/2	23-3/8	25-1/4	3-3/8	7/8x7/16	8-1/2	3	23-3/8	8-1/4	14	16	7-1/2	5/8-11
447T	11	9	20	13/16	8-1/2	23-5/8	26	3-3/8	7/8x7/16	8-1/2	3	23-7/8	8-1/4	14	16	7-1/2	5/8-11
449T	11	9	25	13/16	8-1/2	23-5/8	26	3-3/8	7/8x7/16	8-1/2	3	23-7/8	8-1/4	14	16	7-1/2	5/8-11
444TS	11	9	14-1/2	13/16	4-3/4	23-3/8	25-1/4	2-3/8	5/8x5/16	4-3/4	3	23-3/8	4-1/2	14	16	7-1/2	5/8-11
445TS	11	9	16-1/2	13/16	4-3/4	23-3/8	25-1/4	2-3/8	5/8x5/16	4-3/4	3	23-3/8	4-1/2	14	16	7-1/2	5/8-11
447TS	11	9	20	13/16	4-3/4	23-5/8	26	2-3/8	5/8x5/16	4-3/4	4 NPT	23-7/8	4-1/2	14	16	7-1/2	5/8-11
449TS	11	9	25	13/16	4-3/4	23-5/8	26	2-3/8	5/8x5/16	4-3/4	4 NPT	23-7/8	4-1/2	14	16	7-1/2	5/8-11

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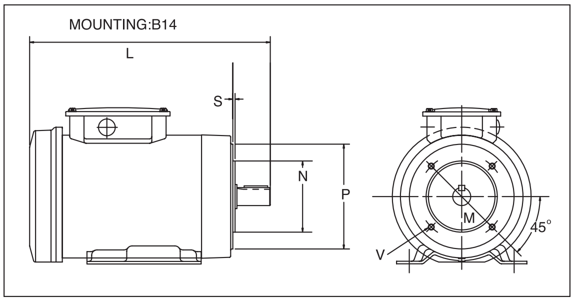
DODGE®

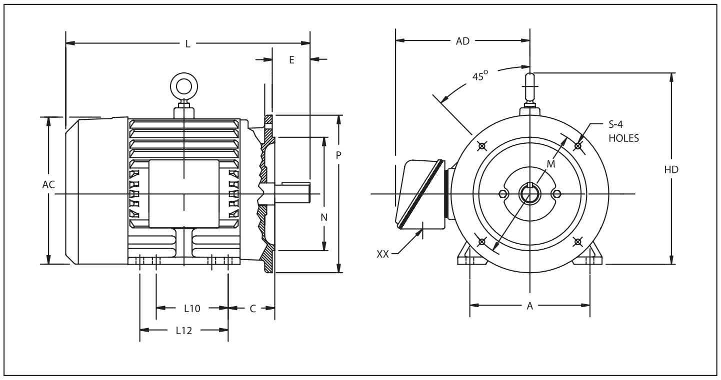
ENGINEERING

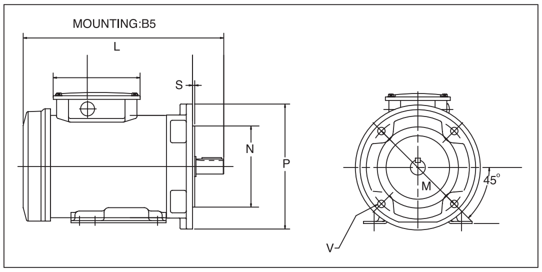
IEC QUICK REFERENCE CHART

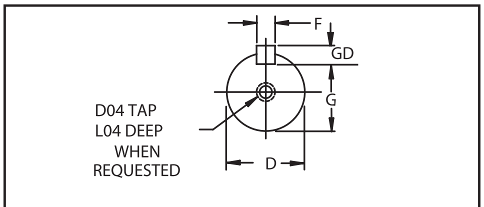
- Dimensions are for reference only
- Drawings represent standard TEFC general purpose motors

Contact your local DODGE/Reliance Sales Office at 1-864-284-5700 for "C" dimensions.









SHAFT DETAIL

KEY AND KEYSEAT DIMENSIONS

FRAME	D	G	F	GD	FRAME	D	G	F	GD
71	14	11	5	5	160	37	42	12	8
80	19	15.5	6	6	180	48	42.5	14	9
90	24	20	8	7	200	55	49	16	10
100	28	24	8	7	225	60	53	18	11
112	28	24	8	7	250	70	67.5	20	12
132	38	33	10	8	280	80	71	22	14

Frame	B3 RIGID BASE					SHAFT		B5 FLANGE					B14 FACE					GENERAL		
	A	L10	L12	HD	C	E	D	N	M	P	S	V	N	M	P	S	V	AC	AD	XX
71	–	–	–	–	–	–	–	110	130	160	"3,5"	"9,5"	70	85	105	2.5	M6	143	–	13
80	125	100	–	188	50	40	19	130	165	200	"3,5"	"11,5"	80	100	120	3	M6	143	–	13
90	140	100	125	208	56	50	24	130	165	200	"3,5"	"11,5"	95	115	140	3	M8	163	–	13
100	160	112	140	229	63	60	28	180	215	250	4	14	110	130	160	3.5	M8	175	–	19
112S	190	114	–	301.8	71.4	60	28	180	215	250	4	14	110	130	160	3.5	M8	243	210	32
112M	190	–	140	301.8	71.4	60	28	180	215	250	4	14	110	130	160	3.5	M8	243	210	32
132S	216	140	–	336.6	88.9	80	38	230	265	300	4	14	130	165	200	3.5	M8	286	243	32
132M	216	–	178	336.6	88.9	80	38	230	265	300	4	14	130	165	200	3.5	M8	286	243	32
160M	254	210	–	399	108	110	42	250	300	350	5	18	180	215	250	4	M12	324	320	40
160L	254	–	254	399	108	110	42	250	300	350	5	18	180	215	250	4	M12	324	320	40
180M	279	241	–	436	121	110	48	250	300	350	5	18	398	355	40			398	355	40
180L	279	–	279	436	121	110	48	250	300	350	5	18	398	355	40			398	355	40
200M	318	267	–	486	133	110	55	300	350	400	5	18	442	445	50			442	445	50
200L	318	–	305	486	133	110	55	300	350	400	5	18	442	445	50			442	445	50
225S	356	286	–	545	149	140	60	350	400	450	5	18	490	470	50			490	470	50
225M	356	–	311	545	149	140	60	350	400	450	5	18	490	470	50			490	470	50
250S	406	311	–	616	168	140	65											600	510	63
250M	406	–	349	616	168	140	65											600	535	63
280S	457	368	-	677	190	140	75											650	535	63
280M	457	-	419	677	190	140	75											650	535	63
280K	457	500	-	677	190	140	75											650	535	63
280H	457	630	-	677	190	140	75											650	535	63
L280H	457	635	-	677	202	205	75											650	535	63

LEGEND
Metric Dimensions in MM
1 mm = .03937"