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Engineering/Technical

DODGE®

Shafting

Table 1—Shafting Data

Recommended Shaft Diameters					
15/16	1-11/16	2-7/16	3-7/16	4-15/16	6-1/2
1-3/16	1-15/16	2-11/16	3-15/16	5-7/16	7
1-7/16	2-3/16	2-15/16	4-7/16	6	7-1/2

Diameter Tolerance—Steel Shafting s			
Shaft Size	**Type**	**Plus**	**Minus**
Up to 1-1/2″ Over 1-1/2 to 2-1/2″ Over 2-1/2 to 4″	Cold Drawn	.000 .000 .000	.002 .003 .004
Over 4 to 6″ Over 6 to 8″ Over 8 to 9″ Over 9″	Turned & Polished	.000 .000 .000 .000	.005 .006 .007 .008

s Cold finished low carbon bars. Ref.—A.I.S.I. Tables 8-5 and 8-6. (March 1986)

Recommended Shaft Diameters—Diameters shown above are recommended for general use. Standard collars, couplings, bearings, pulleys, sheaves, clutches and other transmission items having bores as recommended are carried in stock, at least up to 3-15/16″, in the principal trading centers.

Standard Shafting—Table 1, above, 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 failure of the shaft by fatigue.

Keyseats—For standard sizes see Tables 8 and 9, page B14–7.

Selection of Shaft Diameters

Tables 2 thru 5 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”. (page B14–5).

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 6, under heading “Factors for Shafting Other than Standard Shafting.”(page B14–4).

Table 2—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	.3	.7	1.1	1.5	1.9	2.3	2.6	3	3.4	3.8	4.2	4.6	5.3	6.1	7.7	9.2	10.7	12.3	13.8
1-3/16	.7	1.5	2.3	3.1	3.9	4.6	5.4	6.2	7	7.8	8.6	9.3	10.9	12.5	15.6	18.7	21.9	25	28.1
1-7/16	1.3	2.7	4.1	5.5	6.9	8.3	9.7	11.1	12.4	13.8	15.2	16.6	19.4	22.2	27.7	33.3	38.8	44.4	49.9
1-11/16	2.2	4.4	6.6	8.9	11.2	13.4	15.7	17.9	20.2	22.4	24.7	26.9	31.4	35.9	44.9	53.8	62.8	71.8	80.8
1-15/16	3.3	6.7	10.1	13.5	16.9	20.3	23.7	27.1	30.5	33.9	37.3	40.7	47.5	54.3	67.9	81.5	95.1	108	122
2-3/16	4.9	9.8	14.6	19.5	24.4	29.3	34.2	39.1	44	48.9	53.8	58.6	68.4	78.2	97.8	117	136	156	176
2-7/16	6.7	13.5	20.2	27	33.8	40.6	47.3	54.1	60.9	67.6	74.4	81.2	94.7	108	135	162	189	216	243
2-11/16	9	18.1	27.1	36.2	45.3	54.4	63.4	72.5	81.6	90.7	99.7	108	126	145	181	217	253	290	326
2-15/16	11.8	23.6	35.4	47.3	59.2	71	82.9	94.7	106	118	130	142	165	189	236	284	331	379	426
3-7/16	19	37.9	57	75.9	94.9	113	132	151	170	189	208	227	265	303	379	455	531	607	683
3-15/16	28.5	57	85.5	114	142	171	199	228	256	285	313	342	399	456	570	684	798	912	1026
4-7/16	40.8	81.6	122	163	204	245	286	327	367	408	449	490	572	653	816	980	1143	1306	1470

Selection of Shaft Diameters (Con't.)

Table 3—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	.2	.5	.7	1	1.2	1.5	1.7	2	2.3	2.5	2.8	3	3.5	4.1	5.1	6.1	7.1	8.2	9.2
1-3/16	.5	1	1.5	2	2.6	3.1	3.6	4.1	4.7	5.2	5.7	6.2	7.3	8.3	10.4	12.5	14.6	16.7	18.8
1-7/16	.9	1.8	2.7	3.7	4.6	5.5	6.4	7.4	8.3	9.2	10.1	11.1	12.9	14.8	18.5	22.2	25.9	29.6	33.3
1-11/6	1.4	2.9	4.3	5.9	7.4	8.9	10.4	11.9	13.4	14.9	16.4	17.9	20.9	23.9	29.9	35.9	41.9	47.9	53.9
1-15/16	2.2	4.5	6.7	9	11.3	13.6	15.8	18.1	20.4	22.6	24.9	27.2	31.7	36.2	45.3	54.4	63.4	72.5	81.6
2-3/16	3.2	6.5	9.7	13	16.3	19.5	22.8	26.1	29.3	32.6	35.8	39.1	45.6	52.2	65.2	78.3	91.3	104	117
2-7/16	4.5	9	13.5	18	22.5	27	31.6	36.1	40.6	45.1	49.6	54.1	63.2	72.2	90.2	108	126	144	162
2-11/16	6	12.1	18.1	24.2	30.2	36.3	42.3	48.4	54.4	60.5	66.5	72.6	84.7	96.8	121	145	169	193	217
2-15/16	7.9	15.8	23.7	31.6	39.5	47.4	55.3	63.2	71.1	79	86.9	94.8	110	126	158	189	221	252	284
3-7/16	12.6	25.3	37.9	50.6	63.3	75.9	88.6	101	113	126	139	151	177	202	253	303	354	405	455
3-15/16	19	38	57	76.1	94.1	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

Table 4—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	.8	1.7	2.5	3.5	4.4	5.3	6.2	7.1	8	8.9	9.8	10.7	12.5	14.3	17.9	21.5	25.1	28.7	32.3
1-15/16	1.3	2.7	4	5.4	6.7	8.1	9.5	10.8	12.2	13.5	14.9	16.3	19	21.7	27.1	32.6	38	43.5	48.9
2-3/16	1.9	3.9	5.8	7.8	9.7	11.7	13.7	15.6	17.6	19.5	21.5	23.4	27.4	31.3	39.1	46.9	54.8	62.6	70.4
2-7/16	2.7	5.4	8.1	10.8	13.5	16.2	18.9	21.6	24.3	27	29.7	32.4	37.9	43.3	54.1	64.9	75.8	86.6	97.4
2-11/16	3.6	7.2	10.8	14.5	18.1	21.7	25.4	29	32.6	36.2	39.9	43.5	50.8	58	72.5	87.1	101	116	130
2-15/16	4.7	9.4	14.1	18.9	23.6	28.4	33.1	37.9	42.6	47.3	52.1	56.8	66.3	75.8	94.7	113	132	151	170
3-7/16	7.5	15.1	22.6	30.3	37.9	45.5	53.1	60.7	68.3	75.9	83.5	91.1	106	121	151	182	212	243	273
3-15/16	11.4	22.8	34.2	45.6	57	68.4	79.9	91.3	102	114	125	136	159	182	228	273	319	365	410
4-7/16	16.3	32.6	48.9	65.3	81.6	98	114	130	147	163	179	196	228	261	326	392	457	522	588
4-15/16	22.5	45	67.5	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	78.5	157	235	315	394	473	552	631	709	788	867	946	1104	1262	1577	1893	2208	2524	2839
8	95.5	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 5—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	.4	.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	16.1
1-15/16	.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	24.4
2-3/16	.9	1.9	2.9	3.9	4.8	5.8	6.8	7.8	8.8	9.7	10.7	11.7	13.7	15.6	19.5	23.4	27.4	31.3	35.2
2-7/16	1.3	2.7	4	5.4	6.7	8.1	9.4	10.8	12.1	13.5	14.8	16.2	18.9	21.6	27	32.4	37.9	43.3	48.7
2-11/16	1.8	3.6	5.4	7.2	9	10.8	12.7	14.5	16.3	18.1	19.9	21.7	25.4	29	36.2	43.5	50.5	58	65
2-15/16	2.3	4.7	7	9.4	11.8	14.2	16.5	18.9	21.3	23.6	26	28.4	33.1	37.9	47.3	56.5	66	75.5	85
3-7/16	3.7	7.5	11.3	15.1	18.9	22.7	26.5	30.3	34.1	37.9	41.7	45.5	53	60.5	75.5	91	106	121	136
3-15/16	5.7	11.4	17.1	22.8	28.5	34.2	39.9	45.6	51	57	62.5	68	79.5	91	114	136	159	182	205
4-7/16	8.1	16.3	24.4	32.6	40.8	49	57	65	73.5	81.5	89.5	98	114	130	163	196	228	261	294
4-15/16	11.2	22.5	33.7	45	56	67.5	78.5	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	19.5	39	58.5	78	97.1	117	136	156	171	195	215	234	273	313	391	469	547	626	704
6-1/2	25.5	51	76.5	102.5	128	154	179	205	231	256	282	308	359	410	513	616	718	821	924
7	32	64.9	96	128	160	192	224	256	288	320	352	384	448	513	641	769	897	1026	1154
7-1/2	39.2	78.5	117	157	197	236	276	315	354	394	433	473	552	631	788	946	1104	1262	1419
8	47.7	95.5	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 (Continued)

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. Making the shaft diameter generous and the distance between bearing centers short usually prevents this trouble.

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 and 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, as otherwise a dangerous concentration of stress will occur at the fillet. See heading—"Turning Down Shaft Ends." (page B14–2).

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 bearings.

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. Shafting 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 page B14–6, 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 6 below.

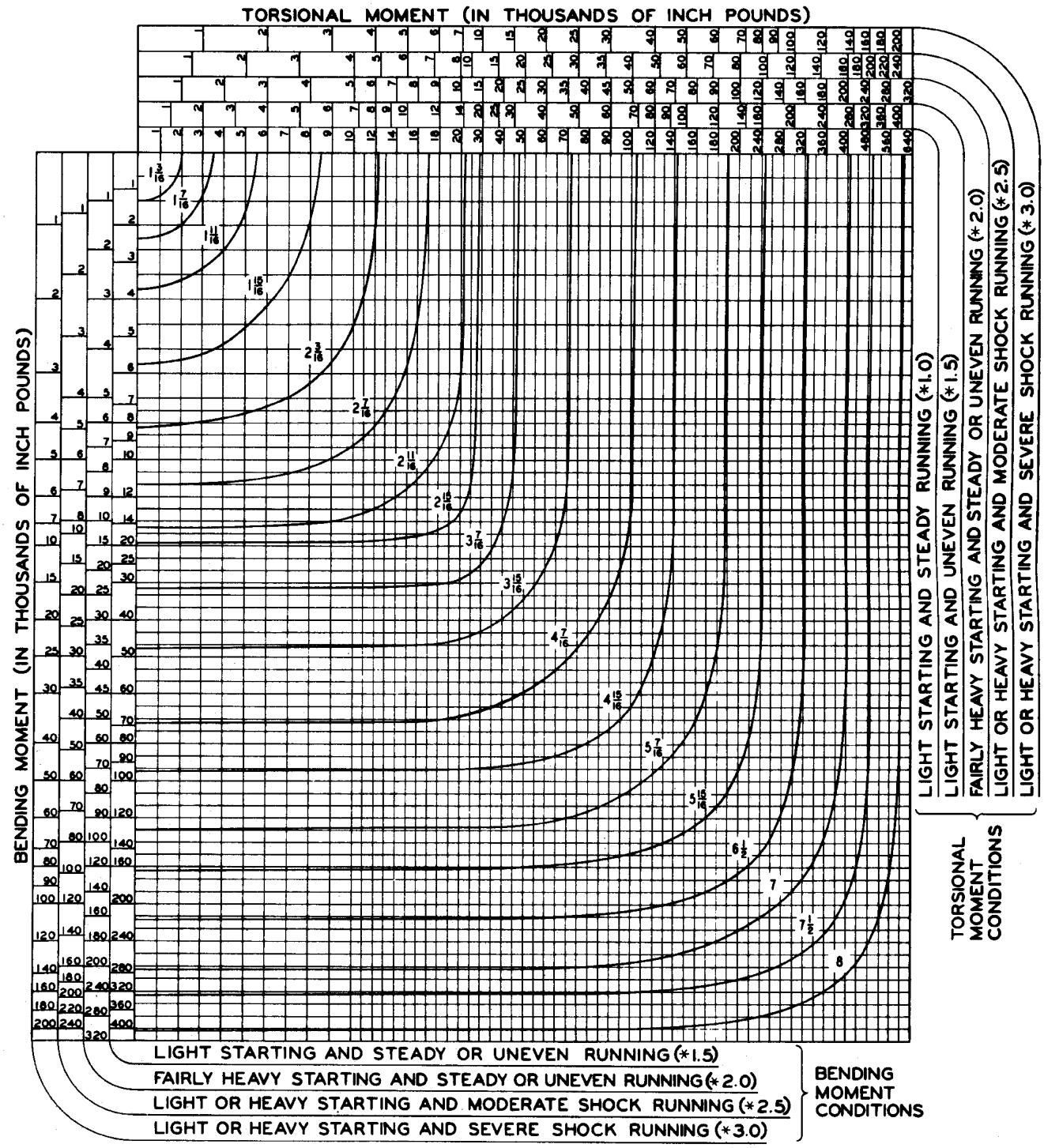
Standard keyseated shafting, using a safe shear stress of 6,000 PSI is the basis of shafting tables and chart. For safe shear stress of other materials, use 1/10 of nominal ultimate tensile strength. For example, use 8,000 for C1045 and 10,000 for 4140 keyseated shafting. When definite physical specifications 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 6 —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

Combined Torsion and Bending of Standard Shafts (Based on a Safe Shear Stress of 6,000 PSI for Keyseated Shafting)



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 B14–4.

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 shafting expansion is given in Table 7 below. For example, with a 100° 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 does 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 7 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 shafting expansion problems and the use of suitable bearings.

Table 7—Linear Expansion of Steel Shafting

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

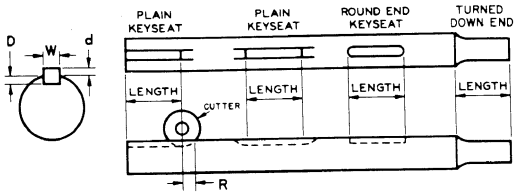
Length (Feet)	Temperature Increase—Degrees F.					Length (Feet)	Temperature Increase—Degrees F.				
	20°	40°	60°	80°	100°		20°	40°	60°	80°	100°
1	.0015″	.0030″	.0045″	.0060″	.0075″	40	.060″	.121″	.181″	.242″	.302″
2	.0030	.0060	.0091	.0121	.0151	45	.068	.136	.204	.272	.340
3	.0045	.0091	.0136	.0181	.0227	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	.159	.212	.265	150	.227	.454	.680	.907	1.134

Shaft Keyseats/Hub Keyways

Table 8—Standard Keyseats/Keyways

Shaft Size	W width	D, d Depth		R R Cutter Run-out
		Regular	Shallow	
5/16 to 7/16	3/32	3/64		1/2
1/2 to 3/16	1/8	1/16		9/16
5/8 to 7/8	3/16	3/32		11/16
13/16 to 1-1/4	1/4	1/8		13/16
1-5/16 to 1-3/8	5/16	3/32		15/16
1-7/16 to 1-3/4	3/8	3/16		1-1/16
1-13/16 to 2-1/4	1/2	1/4	1/8	1-3/16
2-5/16 to 2-3/4	5/8	5/16	3/16	1-5/16
2-15/16 to 3-l/4	3/4	3/8	3/16	1-9/16
3-5/16 to 3-3/4	7/8	7/16	1/4	1-11/16
3-13/16 to 4-1/2	1	1/2	1/4	1-3/4
4-9/16 to 5-1/2	1-1/4	5/8	1/4	1-15/16
5-9/16 to 6-1/2	1-1/2	3/4	1/4	2-1/8
6-9/16 to 7-1/2	1-3/4	3/4	1/4	2-1/8
7-9/16 to 9	2	3/4	3/8	2-1/8
9-1/16 to 11	2-1/2	7/8	3/8	2-5/16
11-1/16 to 13	3	1	3/8	2-7/16

Hub Keyways will normally be furnished to comply with the standard dimensions shown in Table 8. They will be straight unless tapered keyways are specified. Tapered keyways, available in hubs only, will be “d” depth at the large end of the bore; taper. 1/8″ per foot.



Shaft Keyseats are always straight and may be furnished plain or round end as required. They will be regular depth “D” even when shallow or special keyways are used in the hub.

Standard Keyseats/Keyways will be furnished in most DODGE products. Exceptions will be found in catalog listings herein. Some are shown under headings “Shallow Keyseats”, below and Taper–Lock bushing keyways referred to in Table 9.

Setscrews are furnished in hubs over straight keyways on practically all products. Setscrews over tapered keyways are not usually furnished.

Shallow Keyseats are furnished on the O.D. of most clutch sleeves. Hubs fitted thereon usually have shallow keyways. In other product lines, hubs with abnormally large bores may be furnished with shallow or special keyways when considered advisable.

Special Keyways should be avoided whenever possible.

Table 9—TAPER-LOCK Bushing Keyways

Bushing	Shaft Size	Bushing Wxd	Shaft WxD
1008	1/2 to 9/16	1/8x1/16	1/8x1/16
	5/8 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1	1/4x1/16s	1/4x1/8
1108	1/2 to 9/16	1/8x1/16	1/8x1/16
	5/8 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1	1/4x1/8	1/4x1/8
	1-1/16 to 1-1/8	1/4x1/16s	1/4x1/8
1210 and 1215	1/2 to 9/16	1/8x1/16	1/8x1/16
	5/8 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1-1/4	1/4x1/8	1/4x1/8
1310	1/2 to 9/16	1/8x1/16	1/8x1/16
	5/8 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1-1/4	1/4x1/8	1/4x1/8
	1-5/16 to 1-3/8	5/16x5/32	5/16x5/32
1610 and 1615	1/2 to 9/16	1/8x1/16	1/8x1/16
	5/8 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1-1/4	1/4x1/8	1/4x1/8
	1-5/16 to 1-3/8	5/16x5/32	5/16x5/32
	1-7/16 to 1-1/2	3/8x3/16	3/8x3/16
	1-9/16 to 1-5/8	3/8x1/8s	3/8x3/16
2012	1/2 to 9/16	1/8x1/16	1/8x1/16
	5/8 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1-1/4	1/4x1/8	1/4x1/8
	1-5/16 to 1-3/8	5/16x5/32	5/16x5/32
	1-7/16 to 1-3/4	3/8x3/16	3/8x3/16
	1-13/16 to 1-7/8	1/2x1/4	1/2x1/4
	1-15/16 to 2	1/2x3/16s	1/2x1/4
2517	1/2 to 9/16	1/8x1/16	1/8x1/16
	5/8 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1-1/4	1/4x1/8	1/4x1/8
	1-5/16 to 1-3/8	5/16x5/32	5/16x5/32
	1-7/16 to 1-3/4	3/8x3/16	3/8x3/16
	1-13/16 to 2-1/4	1/2x1/4	1/2x1/4
	2-5/16 to 2-1/2	5/8x3/16s	5/8x5/16
2525	3/4 to 7/8	3/16x3/32	3/16x3/32
	15/16 to 1-1/4	1/4x1/8	1/4x1/8
	1-5/16 to 1-3/8	5/16x5/32	5/16x5/32
	1-7/16 to 1-3/4	3/8x3/16	3/8x3/16
	1-13/16 to 2-1/4	1/2x1/4	1/2x1/4
	2-5/16 to 2-1/2	5/8x3/16s	5/8x5/16
3020 and 3030	7/8*	3/16x3/32	3/16x3/32
	15/16 to 1-1/4	1/4x1/8	1/4x1/8
	1-5/16 to 1-3/8	5/16x5/32	5/16x5/32
	1-7/16 to 1-3/4	3/8x3/16	3/8x3/16
	1-13/16 to 2-1/4	1/2x1/4	1/2x1/4
	2-5/16 to 2-3/4	5/8x5/16	5/8x5/16
	2-13/16 to 3	3/4x1/4s	3/4x3/8
3535	1-3/16 to 1-1/4	1/4x1/8	1/4x1/8
	1-5/16 to 1-3/8	5/16x5/32	5/16x5/32
	1-7/16 to 1-3/4	3/8x3/16	3/8x3/16
	1-13/16 to 2-1/4	1/2x1/4	1/2x1/4
	2-5/16 to 2-3/4	5/8x5/16	5/8x5/16
	2-13/16 to 3-1/4	3/4x3/8	3/4x3/8
	3-5/16 to 3-1/2	7/8x1/4s	7/8x7/16
4040	1-7/16 to 1-3/4	3/8x3/16	3/8x3/16
	1-13/16 to 2-1/4	1/2x1/4	1/2x1/4
	2-5/16 to 2-3/4	5/8x5/16	5/8x5/16
	2-13/16 to 3-1/4	3/4x3/8	3/4x3/8
	3-5/16 to 3-3/4	7/8x7/16	7/8x7/16
	3-13/16 to 4	1x1/4s	1x1/2
4545	1-15/16 to 2-1/4	1/2x1/4	1/2x1/4
	2-5/16 to 2-3/4	5/8x5/16	5/8x5/16
	2-13/16 to 3-1/4	3/4x3/8	3/4x3/8
	3-5/16 to 3-3/4	7/8x7/16	7/8x7/16
	3-13/16 to 4-1/4	1x1/2	1x1/2
	4-5/16 to 4-1/2	1x1/4s	1x1/2
5050	2-7/16 to 2-3/4	5/8x5/16	5/8x5/16
	2-13/16 to 3-1/4	3/4x3/8	3/4x3/8
	3-5/16 to 3-3/4	7/8x7/16	7/8x7/16
	3-13/16 to 4-1/2	1x1/2	1x1/2
	4-9/16 to 5	1-1/4x7/16s	1-1/4x5/8
6050	3-7/16 to 3-3/4	7/8x7/16	7/8x7/16
	3-13/16 to 4-1/2	1x1/2	1x1/2
	4-9/16 to 5-1/2	1-1/4x5/8	1-1/4x5/8
	5-9/16 to 6	1-1/2x3/4	1-1/2x3/4
7060	3-15/16 to 4-1/2	1x1/2	1x1/2
	4-9/16 to 5-1/2	1-1/4x5/8	1-1/4x5/8
	5-9/16 to 6-1/2	1-1/2x3/4	1-1/2x3/4
	6-9/16 to 7	1-3/4x3/4	1-3/4x3/4
8065	4-7/16 to 4-1/2	1x1/2	1x1/2
	4-9/16 to 5-1/2	1-1/4x5/8	1-1/4x5/8
	5-9/16 to 6-1/2	1-1/2x3/4	1-1/2x3/4
	6-9/16 to 7-1/2	1-3/4x3/4	1-3/4x3/4
	7-9/16 to 8	2x3/4	2x3/4
10085	7 to 7-1/2	1-3/4x3/4	1-3/4x3/4
	7-9/16 to 9	2x3/4	2x3/4
	9-1/16 to 10	2-1/2x7/8	2-1/2x7/8
120100	8 to 9	2x3/4	2x3/4
	9-1/16 to 11	2-1/2x7/8	2-1/2x7/8
	11-1/16 to 12	3x1	3x1

TAPER-L0CK bushing keyways and shaft key seats are the same as standard shown in table a top of page except that the depth in the bushing only is different in some cases. Special keyways should be avoided whenever possible. Taper key ways or set screws over keyways are never furnished in TAPER-LOCK bushings.

s Key furnished for these sizes only

* On 3020 size only

Weights and Properties of Steel Shafting

Table 10—Weight of Round Steel Shafting

Shaft Size	Weight of Shafting for Various Lengths in feet																	Weight Per Inc
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22	24	
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 11—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	.1250	.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

Table 11–Weight and Properties of Round Steel Shafting (Continued)

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
4-13/16	5.15	10.94	21.88	26.33	52.66	13-1/2	40.5	241.5	483.1	1630	3261
4-7/8	5.28	11.37	22.75	27.72	55.45	13-3/4	42.0	255.2	510.4	1755	3509
4-15/16	5.42	11.82	23.63	29.17	58.35	14	43.6	269.4	538.8	1886	3771
5	5.56	12.27	24.54	30.68	61.36	14-1/4	45.1	284.1	568.2	2024	4048
5-1/16	5.70	12.74	25.48	32.24	64.49	14-1/2	46.7	299.3	598.6	2170	4340
5-1/8	5.84	13.22	26.43	33.86	67.73	14-3/4	48.4	315.0	630.1	2324	4647
5-3/16	5.98	13.70	27.41	35.55	71.09	15	50.0	331.3	662.7	2485	4970
5-1/4	6.13	14.21	28.41	37.29	74.58	15-1/4	51.7	348.2	696.4	2655	5310
5-5/16	6.27	14.72	29.44	39.10	78.20	15-1/2	53.4	365.6	731.2	2833	5667
5-3/8	6.42	15.25	30.49	40.97	81.94	15-3/4	55.1	383.6	767.1	3021	6041
5-7/16	6.58	15.78	31.57	42.91	85.82	16	56.9	402.1	804.2	3217	6434
5-1/2	6.72	16.33	32.67	44.92	89.84	16-1/4	58.7	421.3	842.5	3422	6846
5-9/16	6.88	16.90	33.79	46.99	93.99	16-1/2	60.5	441.0	882.0	3638	7277
5-5/8	7.03	17.47	34.95	49.14	98.29	16-3/4	62.4	461.4	922.7	3864	7728
5-11/16	7.19	18.06	36.12	51.36	102.7	17	64.2	482.3	964.7	4100	8200
5-3/4	7.35	18.66	37.33	53.66	107.3	17-1/4	66.1	503.9	1008	4346	8693
5-13/16	7.51	19.28	38.56	56.03	112.1	17-1/2	68.1	526.2	1052	4604	9208
5-7/8	7.67	19.91	39.82	58.48	117.0	17-3/4	70.0	549.1	1098	4873	9745
5-15/16	7.84	20.55	41.10	61.01	122.0	18	72.0	572.6	1145	5153	10306
6	8.00	21.21	42.41	63.62	127.2	18-1/4	74.0	596.7	1193	5445	10891
6-1/16	8.17	21.88	43.75	66.31	132.6	18-1/2	76.1	621.6	1243	5750	11500
6-1/8	8.34	22.56	45.12	69.09	138.2	18-3/4	78.1	647.1	1294	6067	12134
6-3/16	8.51	23.26	46.51	71.95	143.9	19	80.2	673.4	1347	6397	12794
6-1/4	8.68	23.97	47.94	74.90	149.8	19-1/4	82.4	700.3	1401	6741	13481
6-5/16	8.86	24.69	49.39	77.94	155.9	19-1/2	84.5	728.0	1456	7098	14195
6-3/8	9.03	25.44	50.87	81.08	162.2	19-3/4	86.7	756.3	1513	7469	14937
6-7/16	9.21	26.19	52.38	84.30	168.6	20	88.9	785.4	1571	7854	15708
6-1/2	9.39	26.96	53.92	87.62	175.2	20-1/4	91.1	815.2	1630	8254	16508
6-5/8	9.76	28.55	57.09	94.56	189.1	20-1/2	93.4	845.8	1692	8669	17339
6-3/4	10.1	30.19	60.39	101.9	203.8	20-3/4	95.7	877.1	1754	9100	18200
6-7/8	10.5	31.90	63.80	109.7	219.3	21	98.0	909.2	1818	9547	19093
7	10.9	33:67	67.35	117.9	235.7	21-1/4	100.4	942.1	1884	10009	20019
7-1/8	11.3	35.51	71.02	126.5	253.0	21-1/2	102.7	975.7	1951	10489	20978
7-1/4	11.7	37.41	74.82	135.6	271.2	21-3/4	105.1	1010	2020	10985	21970
7-3/8	12.1	39.38	78.76	145.2	290.4	22	107.6	1045	2091	11499	22998
7-1/2	12.5	41.42	82.84	155.3	310.6	22-1/4	110.0	1081	2163	12031	24061
7-5/8	12.9	43.52	87.05	165.9	331.9	22-1/2	112.5	1118	2237	12581	25161
7-3/4	13.3	45.70	91.40	177.1	354.2	22-3/4	115.0	1156	2312	13149	26298
7-7/8	13.8	47.95	95.89	188.8	377.6	23	117.6	1194	2389	13737	27473
8	14.3	50.27	100.5	201.1	402.1	23-1/4	120.1	1234	2468	14344	28687
8-1/8	14.7	52.66	105.3	213.9	427.9	23-1/2	122.7	1274	2548	14971	29941
8-1/4	15.1	55.13	110.3	227.4	454.8	23-3/4	125.4	1315	2630	15618	31236
8-3/8	15.6	57.67	115.3	241.5	483.0	24	128.0	1357	2714	16286	32572
8-1/2	16.1	60.29	120.6	256.2	512.5	24-1/4	130.7	1400	2800	16975	33951
8-5/8	16.5	62.99	126.0	271.6	543.3	24-1/2	133.4	1444	2888	17686	35372
8-3/4	17.0	65.77	131.6	287.7	575.5	24-1/4	136.2	1488	2977	18419	36838
8-7/8	17.5	68.63	137.3	304.5	609.1	25	138.9	1534	3068	19175	38350
9	18.0	71.57	143.1	322.1	644.1	25-1/4	141.7	1580	3161	19954	39907
9-1/8	18.5	74.59	149.2	340.3	680.7	25-1/2	144.5	1628	3256	20755	41511
9-1/4	19.0	77.70	155.4	359.4	718.7	25-3/4	147.4	1676	3352	21581	43163
9-3/8	19.5	80.89	161.8	379.2	758.4	26	150.3	1726	3451	22432	44864
9-1/2	20.1	84.17	168.3	399.8	799.6	26-1/4	153.2	1776	3552	23307	46614
9-5/8	20.6	87.54	175.1	421.3	842.6	26-1/2	156.1	1827	3654	24208	48415
9-3/4	21.1	90.99	182.0	443.6	887.2	26-3/4	159.0	1879	3758	25134	50268
9-7/8	21.7	94.54	189.1	466.8	933.6	27	162.0	1932	3865	26087	52174
10	22.2	98.17	196.3	490.9	981.7	27-1/2	168.1	2042	4083	28074	56148
10-1/4	23.4	105.72	211.4	541.8	1084	28	174.3	2155	4310	30172	60344
10-1/2	24.5	113.65	227.3	596.7	1193	28-1/2	180.5	2273	4545	32385	64771
10-3/4	25.7	121.96	243.9	655.5	1311	29	186.9	2394	4789	34719	69437
11	26.9	130.67	261.3	718.7	1437	29-1/2	193.4	2520	5041	37176	74351
11-1/4	28.1	139.78	279.6	786.3	1573	30	200.0	2651	5301	39761	79522
11-1/2	29.4	149.31	298.6	858.5	1717	30-1/2	206.8	2785	5571	42479	84957
11-3/4	30.7	159.26	318.5	935.7	1871	31	213.6	2925	5849	45333	90666
12	32.0	169.65	339.3	1018	2036	31-1/2	220.5	3069	6137	48329	96659
12-1/4	33.4	180.47	360.9	1105	2211	32	227.6	3217	6434	51472	102944
12-1/2	34.7	191.75	383.5	1198	2397	32-1/2	234.8	3370	6740	54765	109530
12-3/4	36.1	203.48	407.0	1297	2594	33	242.1	3528	7056	58214	116428
13	37.6	215.69	431.4	1402	2804	34	256.9	3859	7717	65597	131194
13-1/4	39.0	228.37	456.7	1513	3026	35	272.3	4209	8418	73662	147324

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 12—Decimal and Millimeter Equivalents of Fractions

Inches		Millimeters	Inches		Millimeters	Inches		Millimeters
Fractions	Decimals		Fractions	Decimals		Fractions	Decimals	
1/64	.015625	.397	11/32	.34375	8.731	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	.421875	10.716	49/64	.765625	19.447
7/64	.109375	2.778	7/16	.4375	11.113	25/32	.78125	19.844
1/8	.125	3.175	29/64	.453125	11.509	51/64	.796875	20.241
9/64	.140625	3.572	15/32	.46875	11.906	13/16	.8125	20.638
5/32	.15625	3.969	31/64	.484375	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	.90625	23.019
1/4	.250	6.350	37/64	.578125	14.684	59/64	.921875	23.416
17/64	.265625	6.747	19/32	.59375	15.081	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	.640625	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 13—Millimeter-Inch Equivalents; 1 —254MM (.03937″—10.0″)

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	6.85039	225	8.85826
22	.86614	73	2.87401	124	4.88189	175	6.88976	226	8.89763
23	.90551	74	2.91338	125	4.92126	176	6.92913	227	8.93700
24	.94488	75	2.95275	126	4.96063	177	6.96850	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	5.07874	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	5.15748	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	3.30708	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	3.42519	138	5.43307	189	7.44094	240	9.44881
37	1.45669	88	3.46456	139	5.47244	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	3.58267	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	5.74803	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	3.81889	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	3.93700	151	5.94488	202	7.95275	253	9.96063
50	1.96850	101	3.97637	152	5.98425	203	7.99212	254	10.00000
51	2.00787	102	4.01574	153	6.02362	204	8.03149	...	.....

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.)

Measures 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 10^9 or one billion
mega	M	1,000,000 or 10^6 or one million
kilo	k	1,000 or 10^3 or one thousand
* hecto	h	100 or 10^2 or one hundred
* deka	da	10 or 10^1 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 sec2	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

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 H_20) 60F	2.301
atmospheres (atm), standard	psi	14.70
	lb per ft^2	2116.8
	Pa	101325
inch of water, 60F (in of H_20)	psi	0.03609
	lb per ft^2	5.197
	Pa	248.84
foot of water, 60F (ft of H_20)	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

To Convert From...	To	Multiply Col. A by
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-sec^2 per ft)	0.03106
pound-foot^2 (lb-ft^2)	kilogram-meters^2 (kg-m^2)	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

GRAVITATIONAL CONSTANT

g = 32.174 feet per second per second (ft per sec^2)
= 9.8067 meters per second per second (m per sec^2)

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, continued

	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
Indlan teak	0.66-0.88	48

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 rim. 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 14—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)	$\sqrt{\frac{.8681(D^2+d^2)}{1000}}$	$\sqrt{\frac{.8681(D^2+d^2)}{1000}}$	$\sqrt{\frac{.8681(D^2+d^2)}{1000}}$
WR2 Wt. X Sq. of Radius of Gyration (Lbs. X Ft.2)	$\frac{.1773F(D^4-d^4)}{1000}$	$\frac{.1929F(D^4-d^4)}{1000}$	$\frac{.6818FK(D^4-d^4)}{1000}$
Ts Tensile Load in Rim (Lbs.)	$\frac{.3078FN^2(D^3-d^3)}{1,000,000}$	$\frac{.3350FN^2(D^3-d^3)}{1,000,000}$	$\frac{1.184KFN^2(D^3-d^3)}{1,000,000}$

s 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).

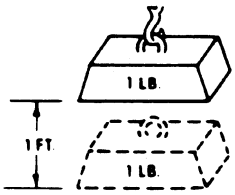
W = Weight of body (pounds).

Formulas and Constants†

1 HP = 33,000 Foot-pounds of work per minute.
1 HP = .746 K.W. = K.W.÷ 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 32°F.
1 Lb. per Sq. In. Pressure = 2.3095 feet fresh water at 62°F. = 2.0355 inches mercury at 32°F. = 2.0416 inches mercury at 62°F.
Water Pressure (pounds per sq. in.) = .433 X height of water in feet (Fresh water at 62°F.).
Weight of 1 cu. ft. fresh Water = 62.355 lbs. at 62°F. = 59.76 lbs. at 212°F.
Weight of 1 cu. ft. Air at 14.7 lbs. per sq. in. Pressure = .07608 lbs. at 62°F. = .08073 lbs. at 32°F.

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

Torque and Horsepower Equivalents

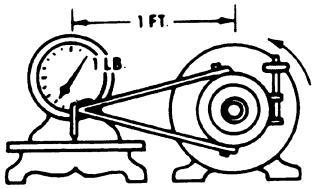


A foot-pound is the amount of energy expended in lifting a one-pound mass a distance of one foot against the pull of gravity.

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 foot long.

POUND-FEET INDICATE TORQUE

$$\text{Torque (in Pound-Inches)} = \frac{63,025 \times HP}{RPM}$$
$$= \text{Force} \times \text{Lever Arm (In Inches)}$$

$$\text{Torque (in Pound-Feet)} = \frac{5,252 \times HP}{RPM}$$
$$= \text{Force} \times \text{Lever Arm (In Feet)}$$

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

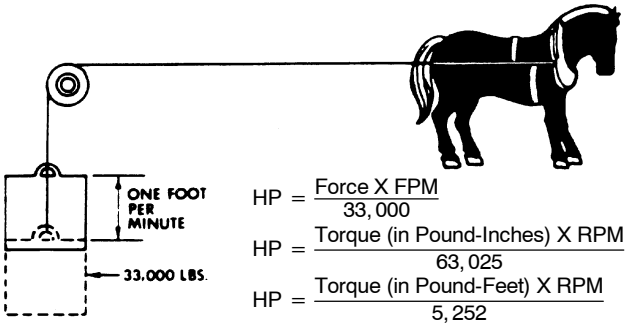
For other values of RPM move decimal point in RPM values to the left or right as desired, and in Torque values move to the right or left (opposite way) the same number of places.

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.



$$HP = \frac{\text{Force} \times FPM}{33,000}$$

$$HP = \frac{\text{Torque (in Pound-Inches)} \times RPM}{63,025}$$

$$HP = \frac{\text{Torque (in Pound-Feet)} \times RPM}{5,252}$$

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:

$$\text{O.H.L.} = \frac{63.000 \times HP \times F}{N \times R}$$

Where HP = Transmitted hp X service factor.
N = RPM of shaft.
R = Radius of sprocket, pulley. etc.
F = Factor.

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.

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:

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

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.
A side of a square multiplied by 1.128 equals diameter of an equal circle.
A side of a square multiplied by 3.547 equals circumference of an equal circle.
To find gallon capacity of tanks (given dimensions of a cylinder in inches): square the diameter of the cylinder, multiply by the length and by .0034.

Torque in Pound-inches for Horsepower at Different Revolutions Per Minute

Table 15—Torque for 1-50 hp @ 100-260 RPM

HP	Revolutions per Minute																
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260
1	630	572	525	484	450	420	393	370	350	331	315	300	286	274	262	252	242
2	1260	1145	1050	969	900	840	787	741	700	663	630	600	572	548	525	504	484
3	1890	1718	1575	1454	1350	1260	1181	1112	1050	995	945	900	859	822	787	756	727
4	2521	2291	2100	1939	1800	1680	1575	1482	1400	1326	1260	1200	1145	1096	1050	1008	969
5	3151	2864	2626	2424	2250	2100	1969	1853	1750	1658	1575	1500	1432	1370	1313	1260	1212
6	3781	3437	3151	2908	2701	2521	2363	2224	2100	1990	1890	1800	1718	1644	1575	1512	1454
7	4411	4010	3676	3393	3151	2941	2757	2595	2450	2321	2205	2100	2005	1918	1838	1764	1696
8	5042	4583	4201	3878	3601	3361	3151	2965	2801	2653	2521	2400	2291	2192	2100	2016	1939
9	5672	5156	4726	4363	4051	3781	3545	3336	3151	2985	2836	2701	2578	2466	2363	2268	2181
10	6302	5729	5252	4848	4501	4201	3939	3707	3501	3317	3151	3001	2864	2740	2626	2521	2424
11	6932	6302	5777	5332	4951	4621	4332	4078	3851	3648	3466	3301	3151	3014	2888	2773	2666
12	7563	6875	6302	5817	5402	5042	4726	4448	4201	3980	3781	3601	3437	3288	3151	3025	2908
13	8193	7448	6827	6302	5852	5462	5120	4819	4551	4312	4096	3901	3724	3562	3413	3277	3151
14	8823	8021	7352	6787	6302	5882	5514	5190	4901	4643	4411	4201	4010	3836	3676	3529	3393
15	9453	8594	7878	7272	6752	6302	5908	5561	5252	4975	4726	4501	4297	4110	3939	3781	3636
16	10084	9167	8403	7756	7202	6722	6302	5931	5602	5307	5042	4801	4583	4384	4201	4033	3878
17	10714	9740	8928	8241	7653	7142	6696	6302	5952	5639	5357	5102	4870	4658	4464	4285	4120
18	11344	10313	9453	8726	8103	7563	7090	6673	6302	5970	5672	5402	5156	4932	4726	4537	4363
19	11974	10886	9979	9211	8553	7983	7484	7044	6652	6302	5987	5702	5443	5206	4989	4789	4605
20	12605	11459	10504	9696	9003	8403	7878	7414	7002	6634	6302	6002	5729	5480	5252	5042	4848
21	13235	12032	11029	10181	9453	8823	8272	7785	7352	6965	6617	6302	6016	5754	5514	5294	5090
22	13865	12605	11554	10665	9903	9243	8665	8156	7703	7297	6932	6602	6302	6028	5777	5546	5332
23	14495	13178	12079	11150	10354	9663	9059	8526	8053	7629	7247	6902	6588	6302	6039	5798	5575
24	15126	13750	12605	11635	10804	10084	9453	8897	8403	7961	7563	7202	6875	6576	6302	6050	5817
25	15756	14323	13130	12120	11254	10504	9847	9268	8753	8292	7878	7503	7161	6850	6565	6302	6060
26	16386	14896	13655	12605	11704	10924	10241	9639	9103	8624	8193	7803	7448	7124	6827	6554	6302
27	17016	15469	14180	13089	12154	11344	10635	10009	9453	8956	8508	8103	7734	7398	7090	6806	6544
28	17647	16042	14705	13574	12605	11764	11029	10380	9803	9287	8823	8403	8021	7672	7352	7058	6787
29	18277	16615	15231	14059	13055	12184	11423	10751	10154	9619	9138	8703	8307	7946	7615	7310	7029
30	18907	17188	15756	14544	13505	12605	11817	11122	10504	9951	9453	9003	8594	8220	7878	7563	7272
31	19537	17761	16281	15029	13955	13025	12211	11492	10854	10283	9768	9303	8880	8494	8140	7815	7514
32	20168	18334	16806	15513	14405	13445	12605	11863	11204	10614	10084	9603	9167	8768	8403	8067	7756
33	20798	18907	17331	15998	14855	13865	12998	12234	11554	10946	10399	9903	9453	9042	8665	8319	7999
34	21428	19480	17857	16483	15306	14285	13392	12605	11904	11278	10714	10204	9740	9316	8928	8571	8241
35	22058	20053	18382	16968	15756	14705	13786	12975	12254	11609	11029	10504	10026	9590	9191	8823	8484
36	22689	20626	18907	17453	16206	15126	14180	13346	12605	11941	11344	10804	10313	9864	9453	9075	8726
37	23319	21199	19432	17937	16656	15546	14574	13717	12955	12273	11659	11104	10599	10138	9716	9327	8968
38	23949	21772	19958	18422	17106	15966	14968	14088	13305	12605	11974	11404	10886	10412	9978	9579	9211
39	24579	22345	20483	18907	17557	16386	15362	14458	13655	12936	12289	11704	11172	10686	10241	9831	9453
40	25210	22918	21008	19392	18007	16806	15756	14829	14005	13268	12605	12004	11459	10960	10504	10084	9696
41	25840	23491	21533	19877	18457	17226	16150	15200	14355	13600	12920	12304	11745	11234	10766	10336	9938
42	26470	24064	22058	20362	18907	17647	16544	15570	14705	13931	13235	12605	12032	11508	11029	10583	10181
43	27100	24637	22584	20846	19357	18067	16938	15941	15056	14263	13550	12905	12318	11782	11292	10840	10423
44	27731	25210	23109	21331	19807	18487	17331	16312	15406	14595	13865	13205	12605	12057	11554	11092	10665
45	28361	25783	23634	21816	20258	18907	17725	16683	15756	14927	14180	13505	12891	12331	11817	11344	10908
46	28991	26356	24159	22301	20708	19327	18119	17053	16106	15258	14495	13805	13177	12605	12079	11596	11150
47	29621	26928	24684	22786	21158	19747	18513	17424	16456	15590	14810	14105	13464	12879	12342	11848	11393
48	30252	27501	25210	23270	21608	20168	18907	17795	16806	15922	15126	14405	13750	13153	12605	12100	11635
49	30882	28074	25735	23755	22058	20588	19301	18166	17156	16253	15441	14705	14037	13427	12867	12352	11877
50	31512	28647	26260	24240	22509	21008	19695	18536	17507	16585	15756	15006	14323	13701	13130	12605	12120

Torque in Pound-inches for Horsepower at Different Revolutions Per Minute (Cont.)

Table 16 —Torque for 51-100 hp @ 100-260 RPM

HP	Revolutions per Minute																
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260
51	32142	29220	26785	24725	22959	21428	20089	18907	17857	16917	16071	15306	14610	13975	13392	12857	12362
52	32773	29793	27310	25210	23409	21848	20483	19278	18207	17249	16386	15606	14896	14249	13655	13109	12605
53	33403	30366	27836	25694	23859	22268	20877	19649	18557	17580	16701	15906	15183	14523	13918	13361	12847
54	34033	30939	28361	26179	24309	22689	21271	20019	18907	17912	17016	16206	15469	14797	14180	13613	13089
55	34663	31512	28886	26664	24759	23109	21664	20390	19257	18244	17331	16506	15756	15071	14443	13865	13332
56	35294	32085	29411	27149	25210	23529	22058	20761	19607	18575	17647	16806	16042	15345	14705	14117	13574
57	35924	32658	29937	27634	25660	23949	22452	21132	19957	18907	17962	17106	16329	15619	14968	14369	13817
58	36554	33231	30462	28118	26110	24369	22846	21502	20308	19239	18277	17406	16615	15893	15231	14621	14059
59	37184	33804	30987	28603	26560	24789	23240	21873	20658	19571	18592	17707	16902	16167	15493	14873	14301
60	37815	34377	31512	29088	27010	25210	23634	22244	21008	19902	18907	18007	17188	16441	15756	15126	14544
61	38445	34950	32037	29573	27461	25630	24028	22614	21358	20234	19222	18307	17475	16715	16018	15378	14786
62	39075	35523	32563	30058	27911	26050	24422	22985	21708	20566	19537	18607	17761	16989	16281	15630	15029
63	39705	36096	33088	30543	28361	26470	24816	23356	22058	20897	19852	18907	18048	17263	16544	15882	15271
64	40336	36669	33613	31027	28811	26890	25210	23727	22408	21229	20168	19207	18334	17537	16806	16134	15513
65	40966	37242	34138	31512	29261	27310	25604	24097	22759	21561	20483	19507	18621	17811	17069	16386	15756
66	41596	37815	34663	31997	29711	27731	25997	24468	23109	21892	20798	19807	18907	18085	17331	16638	15998
67	42226	38388	35189	32482	30162	28151	26391	24839	23459	22224	21113	20108	19194	18359	17594	16890	16241
68	42857	38961	35714	32967	30612	28571	26785	25210	23809	22556	21428	20408	19480	18633	17857	17142	16483
69	43487	39534	36239	33451	31062	28991	27179	25580	24159	22888	21743	20708	19766	18907	18119	17394	16725
70	44117	40106	36764	33936	31512	29411	27573	25951	24509	23219	22058	21008	20053	19181	18382	17647	16968
71	44747	40679	37289	34421	31962	29831	27967	26322	24859	23551	22373	21308	20339	19455	18644	17899	17210
72	45378	41252	37815	34906	32413	30252	28361	26693	25210	23883	22689	21608	20626	19729	18907	18151	17453
73	46008	41825	38340	35391	32863	30672	28755	27063	25560	24214	23004	21908	20912	20003	19170	18403	17695
74	46638	42398	38865	35875	33313	31092	29149	27434	25910	24546	23319	22208	21199	20277	19432	18655	17937
75	47268	42971	39390	36360	33763	31512	29543	27805	26260	24878	23634	22509	21485	20551	19695	18907	18180
76	47899	43544	39916	36845	34213	31932	29937	28176	26610	25210	23949	22809	21772	20825	19957	19159	18422
77	48529	44117	40441	37330	34663	32353	30330	28546	26960	25541	24264	23109	22058	21099	20220	19411	18665
78	49159	44690	40966	37815	35114	32773	30724	28917	27310	25873	24579	23409	22345	21373	20483	19663	18907
79	49789	45263	41491	38299	35564	33193	31118	29288	27661	26205	24894	23709	22631	21647	20745	19915	19149
80	50420	45836	42016	38784	36014	33613	31512	29658	28011	26536	25210	24009	22918	21921	21008	20168	19392
81	51050	46409	42542	39269	36464	34033	31906	30029	28361	26868	25525	24309	23204	22195	21271	20420	19634
82	51680	46982	43067	39754	36914	34453	32300	30400	28711	27200	25840	24609	23491	22469	21533	20672	19877
83	52310	47555	43592	40239	37365	34874	32694	30771	29061	27532	26155	24909	23777	22743	21796	20924	20119
84	52941	48128	44117	40724	37815	35294	33088	31141	29411	27863	26470	25210	24064	23017	22058	21176	20362
85	53571	48701	44642	41208	38265	35714	33482	31512	29761	28195	26785	25510	24350	23291	22321	21428	20604
86	54201	49274	45168	41693	38715	36134	33876	31883	30112	28527	27100	25810	24637	23565	22584	21680	20846
87	54831	49847	45693	42178	39165	36554	34269	32254	30462	28858	27415	26110	24923	23840	22846	21932	21089
88	55462	50420	46218	42663	39615	36974	34663	32624	30812	29190	27731	26410	25210	24114	23109	22184	21331
89	56092	50993	46743	43148	40066	37395	35057	32995	31162	29522	28046	26710	25496	24388	23371	22436	21574
90	56722	51566	47268	43632	40516	37815	35451	33366	31512	29854	28361	27010	25783	24662	23634	22689	21816
91	57352	52139	47794	44117	40966	38235	35845	33737	31862	30185	28676	27310	26069	24936	23897	22941	22058
92	57983	52712	48319	44602	41416	38655	36239	34107	32212	30517	28991	27611	26355	25210	24159	23193	22301
93	58613	53285	48844	45087	41866	39075	36633	34478	32563	30849	29306	27911	26642	25484	24422	23445	22543
94	59243	53857	49369	45572	42317	39495	37027	34849	32913	31180	29621	28211	26928	25758	24684	23697	22786
95	59873	54430	49895	46056	42767	39916	37421	35220	33263	31512	29936	28511	27215	26032	24947	23949	23028
96	60504	55003	50420	46541	43217	40336	37815	35590	33613	31844	30252	28811	27501	26306	25210	24201	23270
97	61134	55576	50945	47026	43667	40756	38209	35961	33963	32176	30567	29111	27788	26580	25472	24453	23513
98	61764	56149	51470	47511	44117	41176	38602	36332	34313	32507	30882	29411	28074	26854	25735	24705	23755
99	62394	56722	51995	47996	44567	41596	38996	36702	34663	32839	31197	29711	28361	27128	25997	24957	23998
100	63025	57295	52521	48481	45018	42016	39390	37073	35014	33171	31512	30012	28647	27402	26260	25210	24240

Torque in Pound-inches for Horsepower at Different Revolutions Per Minute (Cont.)

Table 17—Torque for 1-50 hp @ 270-1000 RPM

HP	Revolutions per Minute																	
	270	280	290	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
1	233	225	217	210	180	157	140	126	114	105	96	90	84	78	74	70	66	63
2	466	450	434	420	360	315	280	252	229	210	193	180	168	157	148	140	132	126
3	700	675	651	630	540	472	420	378	343	315	290	270	252	236	222	210	199	189
4	933	900	869	840	720	630	560	504	458	420	387	360	336	315	296	280	265	252
5	1167	1125	1086	1050	900	787	700	630	572	525	484	450	420	393	370	350	331	315
6	1400	1350	1303	1260	1080	945	840	756	687	630	581	540	504	472	444	420	398	378
7	1633	1575	1521	1470	1260	1102	980	882	802	735	678	630	588	551	519	490	464	441
8	1867	1800	1738	1680	1440	1260	1120	1008	916	840	775	720	672	630	593	560	530	504
9	2100	2025	1955	1890	1620	1418	1260	1134	1031	945	872	810	756	709	667	630	597	567
10	2334	2250	2173	2100	1800	1575	1400	1260	1145	1050	969	900	840	787	741	700	663	630
11	2567	2475	2390	2310	1980	1733	1540	1386	1260	1155	1066	990	924	866	815	770	729	693
12	2801	2701	2607	2521	2160	1890	1680	1512	1375	1260	1163	1080	1008	945	889	840	796	756
13	3034	2926	2825	2731	2340	2048	1820	1638	1489	1365	1260	1170	1092	1024	963	910	862	819
14	3267	3151	3042	2941	2521	2205	1960	1764	1604	1470	1357	1260	1176	1102	1038	980	928	882
15	3501	3376	3259	3151	2701	2363	2100	1890	1718	1575	1454	1350	1260	1181	1112	1050	995	945
16	3734	3601	3477	3361	2881	2521	2240	2016	1833	1680	1551	1440	1344	1260	1186	1120	1061	1008
17	3968	3826	3694	3571	3061	2678	2380	2142	1948	1785	1648	1530	1428	1339	1260	1190	1127	1071
18	4201	4051	3911	3781	3241	2836	2521	2268	2062	1890	1745	1620	1512	1418	1334	1260	1194	1134
19	4435	4276	4129	3991	3421	2993	2661	2394	2177	1995	1842	1710	1596	1496	1408	1330	1260	1197
20	4668	4501	4346	4201	3601	3151	2801	2521	2291	2100	1939	1800	1680	1575	1482	1400	1326	1260
21	4901	4726	4563	4411	3781	3308	2941	2647	2406	2205	2036	1890	1764	1654	1557	1470	1393	1323
22	5135	4951	4781	4621	3961	3466	3081	2773	2521	2310	2133	1980	1848	1733	1631	1540	1459	1386
23	5368	5177	4998	4831	4141	3623	3221	2899	2635	2415	2230	2070	1932	1811	1705	1610	1525	1449
24	5602	5402	5215	5042	4321	3781	3361	3025	2750	2521	2327	2160	2016	1890	1779	1680	1592	1512
25	5835	5627	5433	5252	4501	3939	3501	3151	2864	2626	2424	2250	2100	1969	1853	1750	1658	1575
26	6069	5852	5650	5462	4681	4096	3641	3277	2979	2731	2521	2340	2184	2048	1927	1820	1724	1638
27	6302	6077	5867	5672	4861	4254	3781	3403	3093	2836	2617	2430	2268	2127	2001	1890	1791	1701
28	6535	6302	6085	5882	5042	4411	3921	3529	3208	2941	2714	2521	2352	2205	2076	1960	1857	1764
29	6769	6527	6302	6092	5222	4569	4061	3655	3323	3046	2811	2611	2436	2284	2150	2030	1923	1827
30	7002	6752	6519	6302	5402	4726	4201	3781	3437	3151	2908	2701	2520	2363	2224	2100	1990	1890
31	7236	6977	6737	6512	5582	4884	4341	3907	3552	3256	3005	2791	2605	2442	2298	2170	2056	1953
32	7469	7202	6954	6722	5762	5042	4481	4033	3666	3361	3102	2881	2689	2520	2372	2240	2122	2016
33	7703	7427	7171	6932	5942	5199	4621	4159	3781	3466	3199	2971	2773	2599	2446	2310	2189	2079
34	7936	7653	7389	7142	6122	5357	4761	4285	3896	3571	3296	3061	2857	2678	2520	2380	2255	2142
35	8169	7878	7606	7352	6302	5514	4901	4411	4010	3676	3393	3151	2941	2757	2595	2450	2321	2205
36	8403	8103	7823	7563	6482	5672	5042	4537	4125	3781	3490	3241	3025	2836	2669	2521	2388	2268
37	8636	8328	8041	7773	6662	5829	5182	4663	4239	3886	3587	3331	3109	2913	2743	2591	2454	2331
38	8870	8553	8258	7983	6842	5987	5322	4789	4354	3991	3684	3421	3193	2993	2817	2661	2520	2394
39	9103	8778	8475	8193	7022	6144	5462	4915	4469	4096	3781	3511	3277	3072	2891	2731	2587	2457
40	9337	9003	8693	8403	7202	6302	5602	5042	4583	4201	3878	3601	3361	3151	2965	2801	2653	2521
41	9570	9228	8910	8613	7382	6460	5742	5168	4698	4306	3975	3691	3445	3230	3040	2871	2720	2584
42	9803	9453	9127	8823	7563	6617	5882	5294	4812	4411	4072	3781	3529	3308	3114	2941	2786	2647
43	10037	9679	9345	9033	7743	6775	6022	5420	4927	4516	4169	3871	3613	3387	3188	3011	2852	2710
44	10270	9903	9562	9243	7923	6932	6162	5546	5042	4621	4266	3961	3697	3466	3262	3081	2919	2773
45	10504	10129	9779	9453	8103	7090	6302	5672	5156	4726	4363	4051	3781	3545	3336	3151	2985	2836
46	10737	10354	9997	9963	8283	7247	6442	5798	5271	4831	4460	4141	3865	3623	3410	3221	3051	2899
47	10971	10579	10214	9873	8463	7405	6582	5924	5385	4936	4557	4231	3949	3702	3484	3291	3118	2962
48	11204	10804	10431	10084	8643	7563	6722	6050	5500	5042	4654	4321	4033	3781	3559	3361	3184	3025
49	11437	11029	10649	10294	8823	7720	6862	6176	5614	5147	4751	4412	4117	3860	3633	3431	3250	3088
50	11671	11254	10866	10504	9003	7878	7002	6302	5729	5252	4848	4501	4201	3939	3707	3501	3317	3151

Torque in Pound-inches for Horsepower at Different Revolutions Per Minute (Cont.)

Table 18—Torque for 51-100 hp @ 270-1000 RPM

HP	Revolutions per Minute																	
	270	280	290	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
51	11904	11479	11083	10714	9183	8035	7141	6428	5844	5357	4945	4591	4285	4017	3781	3571	3383	3214
52	12138	11704	11301	10924	9363	8193	7282	6554	5958	5462	5042	4681	4369	4096	3855	3641	3449	3277
53	12371	11929	11518	11134	9543	8350	7422	6680	6073	5567	5138	4771	4453	4175	3929	3711	3516	3340
54	12605	12154	11735	11344	9723	8508	7563	6806	6187	5672	5235	4861	4537	4254	4003	3781	3582	3403
55	12838	12379	11953	11554	9903	8665	7703	6932	6302	5777	5332	4951	4621	4332	4078	3851	3648	3466
56	13071	12605	12170	11764	10084	8823	7843	7058	6417	5882	5429	5042	4705	4411	4152	3921	3715	3529
57	13305	12830	12387	11974	10264	8981	7983	7184	6531	5987	5526	5132	4789	4490	4226	3991	3781	3592
58	13538	13055	12605	12184	10444	9138	8123	7310	6646	6092	5623	5222	4873	4569	4300	4061	3847	3655
59	13772	13280	12822	12394	10624	9296	9263	7436	6760	6197	5720	5312	4957	4648	4374	4131	3914	3718
60	14005	13505	13039	12605	10804	9453	8403	7563	6875	6302	5817	5402	5041	4726	4448	4201	3980	3781
61	14239	13730	13257	12815	10984	9611	8543	7689	6990	6407	5914	5492	5126	4805	4522	4271	4046	3844
62	14472	13955	13474	13025	11164	9768	8683	7815	7104	6512	6011	5582	5210	4884	4597	4341	4113	3907
63	14705	14180	13691	13235	11344	9926	8823	7941	7219	6617	6108	5672	5294	4963	4671	4411	4179	3970
64	14939	14405	13908	13445	11524	10084	8963	8067	7333	6722	6205	5762	5378	5041	4745	4481	4245	4033
65	15172	14630	14126	13655	11704	10241	9103	8193	7448	6827	6302	5852	5462	5120	4819	4551	4312	4096
66	15406	14855	14343	13865	11884	10399	9243	8319	7563	6932	6399	5942	5546	5199	4893	4621	4378	4159
67	15639	15081	14560	14075	12064	10556	9383	8445	7677	7037	6496	6032	5630	5278	4967	4691	4444	4222
68	15873	15306	14778	14285	12244	10714	9523	8571	7792	7142	6593	6122	5714	5357	5041	4761	4511	4285
69	16106	15531	14995	14495	12424	10871	9663	8697	7906	7247	6690	6212	5798	5435	5116	4831	4577	4348
70	16339	15756	15212	14705	12605	11029	9803	8823	8021	7352	6787	6302	5882	5514	5190	4901	4643	4411
71	16573	15981	15430	14915	12785	11186	9943	8949	8135	7457	6884	6392	5966	5593	5264	4971	4710	4474
72	16806	16206	15647	15126	12965	11344	10084	9075	8250	7563	6981	6482	6050	5672	5338	5042	4776	4537
73	17040	16431	15864	15336	13145	11502	10224	9201	8365	7668	7078	6572	6134	5751	5412	5112	4842	4600
74	17273	16656	16082	15546	13325	11659	10364	9327	8479	7773	7175	6662	6218	5829	5486	5182	4909	4663
75	17507	16881	16299	15756	13505	11817	10504	9453	8594	7878	7272	6752	6302	5908	5561	5252	4975	4726
76	17740	17106	16516	15966	13685	11974	10644	9579	8708	7983	7369	6842	6386	5987	5635	5322	5041	4789
77	17973	17331	16734	16176	13865	12132	10784	9705	8823	8088	7466	6932	6470	6066	5709	5392	5108	4852
78	18207	17557	16951	16386	14045	12289	10924	9831	8938	8193	7563	7022	6554	6144	5783	5462	5174	4915
79	18440	17782	17168	16596	14225	12447	11064	9957	9052	8298	7659	7112	6638	6223	5857	5532	5241	4978
80	18674	18007	17386	16806	14405	12605	11204	10084	9167	8403	7756	7202	6722	6302	5931	5602	5307	5042
81	18907	18232	17603	17016	14585	12762	11344	10210	9281	8508	7853	7292	6806	6381	6005	5672	5373	5105
82	19141	18457	17820	17226	14765	12920	11484	10336	9396	8613	7950	7382	6890	6460	6080	5742	5440	5168
83	19374	18682	18038	17436	14945	13077	11624	10462	9511	8718	8047	7472	6974	6538	6154	5812	5506	5231
84	19607	18907	18255	17647	15126	13235	11764	10588	9625	8823	8144	7563	7058	6617	6228	5882	5572	5294
85	19841	19132	18472	17857	15306	13392	11904	10714	9740	8928	8241	7653	7142	6696	6302	5952	5639	5357
86	20074	19357	18690	18067	15486	13550	12044	10840	9854	9033	8338	7743	7226	6775	6376	6022	5705	5420
87	20308	19582	18907	18277	15666	13707	12184	10966	9969	9138	8435	7833	7310	6853	6450	6092	5771	5483
88	20541	19807	19124	18487	15846	13865	12324	11092	10084	9243	8532	7923	7394	6932	6524	6162	5838	5546
89	20775	20033	19342	18697	16026	14023	12464	11218	10198	9348	8629	8013	7478	7011	6599	6232	5904	5609
90	21008	20258	19559	18907	16206	14180	12605	11344	10313	9453	8726	8103	7562	7090	6673	6302	5970	5672
91	21241	20483	19776	19117	16386	14338	12745	11470	10427	9558	8823	8193	7647	7169	6747	6372	6037	5735
92	21475	20708	19994	19327	16566	14495	12885	11596	10542	9663	8920	8283	7731	7247	6821	6442	6103	5798
93	21708	20933	20211	19537	16746	14653	13025	11722	10656	9768	9017	8373	7815	7326	6895	6512	6169	5861
94	21942	21158	20428	19747	16926	14810	13165	11848	10771	9873	9114	8463	7899	7405	6969	6582	6236	5924
95	22175	21383	20646	19957	17106	14968	13305	11974	10886	9978	9211	8553	7983	7484	7043	6652	6302	5987
96	22408	21608	20863	20168	17286	15126	13445	12100	11000	10084	9308	8643	8067	7562	7118	6722	6368	6050
97	22642	21833	21080	20378	17466	15283	13585	12226	11115	10189	9405	8733	8151	7641	7192	6792	6435	6113
98	22875	22058	21298	20588	17647	15441	13725	12352	11229	10294	9502	8823	8235	7720	7266	6862	6501	6176
99	23109	22283	21515	20798	17827	15598	13865	12478	11344	10399	9599	8913	8319	7799	7340	6932	6567	6239
100	23342	22509	21732	21008	18007	15756	14005	12605	11459	10504	9696	9003	8403	7878	7414	7002	6634	6302

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.

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

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*

$$T_1/T_2 = \frac{1}{1\text{–}0.8G}\ (\text{Also } T_1/T_2 = eK\emptyset)$$

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
$\emptyset$ = arc of contact in radians

Table 19—Arc of Contact Correction Factors G and R

D-d / C	Small Sheave Arc of Contact	Factor G	Factor R	D-d / C	Small Sheave Arc of Contact	Factor G	Factor R
.00	180°	1.00	1.000	.80	133°	.87	.917
.10	174°	.99	.999	.90	127°	.85	.893
.20	169°	.97	.995	1.00	120°	.82	.866
.30	163°	.96	.989	1.10	113°	.80	.835
.40	157°	.94	.980	1.20	106°	.77	.800
.50	151°	.93	.968	1.30	99°	.73	.760
.60	145°	.91	.954	1.40	91°	.70	.714
.70	139°	.89	.937	1.50	83°	.65	.661

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

$$T_1 = 41,250\left(\frac{HP}{GV}\right)$$

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

$$T_2 = 33,000\ (1.25\text{–}G)\left(\frac{HP}{GV}\right)$$

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 19, at left.

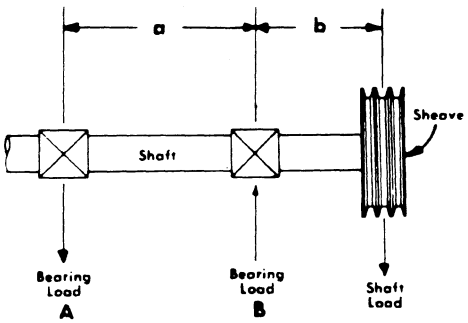
Table 20—Allowable Sheave Rim Speed

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:

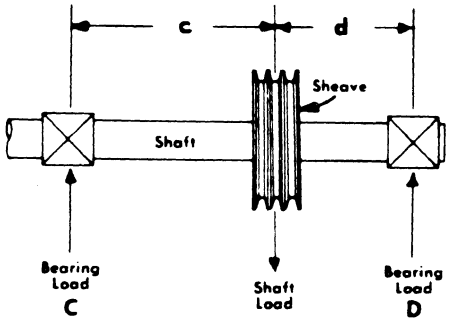


Overhung Sheave

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

$$\text{Load at A, lbs.} = \text{Shaft Load X } \frac{b}{a}$$

Where : a and b = Spacing, inches



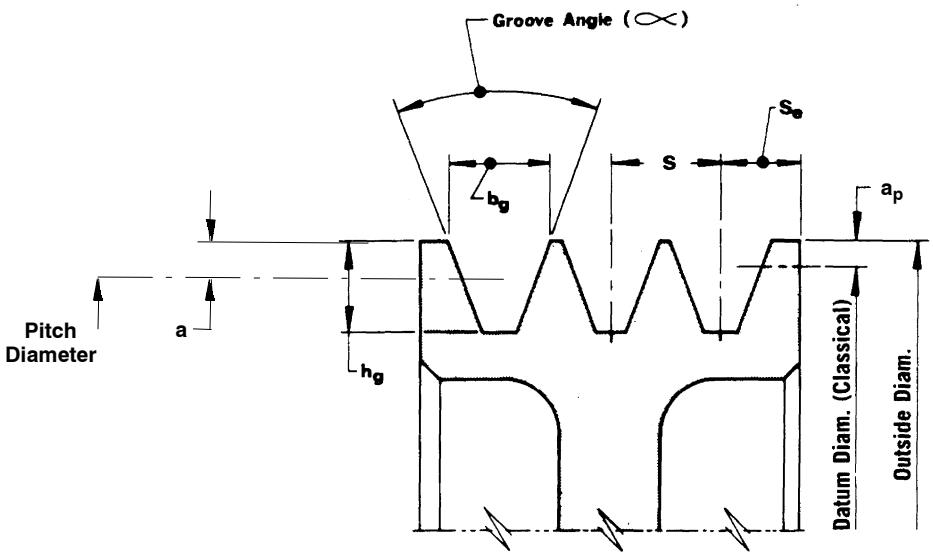
Sheave Between Bearings

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

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

Where : c and d = Spacing, inches

V-Belt Sheave Groove Dimensions



Narrow

Belt Section	Outside Diameter Range	∝ ±0.25°	b_g +.005	h_g Min.	a	S ±.015	Se	
3VX, 3V	LESS THAN 3.50 3.50 TO 6.00 6.01 to 12.00 Over 12.00	36° 38° 40° 42°	.350	0.340	0	.406	0.344	-+.094 -.000
5VX, 5V	Less than 10.00 10.00 to 16.00 Over 16.00	38° 40° 42°	.600	0.590	0	.688	0.500	+.125 -.000
8VX, 8V	Less than 16.00 16.00 to 22.40 Over 22.40	38° 40° 42°	1.000	0.990	0	1.125	0.750	-.000

Classical

Belt Section	Pitch Diameter		m ±0.33°	b_g		hg Min.	a_p *	S ±.025	Se		a
	Min. Recom.	Range									
AX, A	3.0	2.6 to 5.4 Over 5.4	34° 38°	.494 .504	±.005	.460	.125	.625	.375	+.090 -.062	0
BX, B	5.4	4.6 to 7.0 Over 7.0	34° 38°	.637 .650	±.006	.550	.175	.750	.500	+120 -.065	0
A, B AX, BX	-	To 7.0 Over 7.0	34° 38°	.612 .625	±.006	.612	.125 .175	.750	.500	+.120 -.065	A belt .37 B belt -.01
CX, C	9.0	7.0 to 7.99 8.0 to 12.0 Over 12.0	34° 36° 38°	.879 .887 .895	±.007	.750	.200	1.000	.688	+.160 -.070	0
DX, D	13.0	12.0 to 12.99 13.0 to 17.0 Over 17.0	34° 36° 38°	1.259 1.271 1.283	±.008	1.020	.300	1.438	.875	+.220 -.080	0
E	21.0	18.0 to 24.0 Over 24.0	36° 38°	1.527 1.542	±.010	1.300	.400	1.750	1.125	+.250 -.000	0

Note-For complete manufacturing tolerances-see RMA, MPTA Narrow/Classical V-belt Standards.
***Datum diameter, not pitch diameter.**

Nominal V-Belt Cross Sections

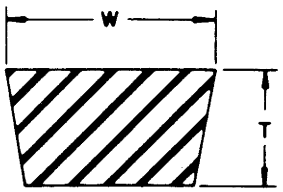


Table 21—Nominal V-Belt Cross Sections

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

* For industry standard sheave groove dimensions see opposite page.

Horsepower Required for Belt Conveyors

The horsepower required to operate a belt conveyor depends on the following:

1. Maximum tonnage to be handled.
2. Length of the conveyor.
3. Vertical distance material has to be lifted.

To determine horsepower required for a Horizontal conveyor use Table 22 only. To determine horsepower required for an Inclined Conveyor use both Table 22 and 23. Figure each one separately and add together to determine total horsepower required.

The table figures are based on average conditions with a uniformly fed conveyor running at normal operating speeds. If a mechanical feeder, tripper or other attachment is used, add the additional horsepower required. If tons are given as long tons, (2.240 lb.), multiply by 1.12 to convert to short (2,000 lb.) tons, before using tables.

Table 22—HP Required to 0perate Loaded Conveyer en the Level

Length of Conveyor in feet	Short Tons Per Hour (2000 Lbs.)												
	100	150	200	250	300	350	400	500	600	700	800	900	1000
25	2.0	2.3	2.5	2.7	3.0	3.3	3.5	4.0	4.5	5.0	5.5	6.0	6.5
50	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.8	5.4	6.0	6.6	7.2	7.8
75	2.8	3.1	3.5	3.8	4.1	4.5	4.8	5.5	6.2	6.9	7.6	8.3	9.0
100	3.0	3.4	3.8	4.2	4.5	4.9	5.3	6.0	6.8	7.5	8.3	9.0	9.8
125	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.6	7.4	8.2	9.0	9.8	10.6
150	3.7	4.1	4.6	5.0	5.5	5.9	6.3	7.2	8.1	9.0	9.9	10.8	11.5
175	4.0	4.5	5.0	5.5	6.0	6.5	7.0	8.0	9.0	10.0	11.0	12.0	13.0
200	4.3	4.8	5.3	5.8	6.4	7.0	7.5	8.6	9.7	10.8	11.9	13.0	14.1
225	4.6	5.1	5.7	6.2	6.8	7.3	8.0	9.2	10.4	11.6	12.8	14.0	15.2
250	4.9	5.5	6.2	6.8	7.5	8.0	8.8	10.1	11.4	12.7	14.0	15.3	16.6
300	5.6	6.2	7.0	7.6	8.4	9.0	9.8	11.2	12.6	14.0	15.4	16.8	18.2
350	6.2	6.9	7.7	8.4	9.2	10.0	10.7	12.2	13.7	15.2	16.7	18.2	19.7
400	6.8	7.6	8.5	9.2	10.2	11.0	11.9	13.6	15.3	17.0	18.7	20.4	22.1
450	7.3	8.3	9.2	10.2	11.1	12.0	13.0	14.9	16.8	18.7	20.6	22.5	24.4
500	8.0	9.0	10.1	11.1	12.2	13.2	14.3	16.4	18.5	20.6	22.7	24.8	26.9

Table 23—HP Required to Lift Load on Belt Conveyor

Lift in feet	Short Tons Per Hour (2000 Lbs.)												
	100	150	200	250	300	350	400	500	600	700	800	900	1000
10	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0	9.0	10.0
20	2.0	3.0	4.0	5.0	6.0	7.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
30	3.0	4.5	6.0	7.5	9.0	10.5	12.0	15.0	18.0	21.0	24.0	27.0	30.0
40	4.0	6.0	8.0	10.0	12.0	14.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0
50	5.0	7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	35.0	40.0	45.0	50.0
60	6.0	9.0	12.0	15.0	18.0	21.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0
70	7.0	10.5	14.0	17.5	21.0	24.5	28.0	35.0	42.0	49.0	56.0	63.0	70.0
80	8.0	12.0	16.0	20.0	24.0	28.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0
90	9.0	13.5	18.0	22.5	27.0	31.5	36.0	45.0	54.0	63.0	72.0	81.0	90.0
100	10.0	15.0	20.0	25.0	30.0	35.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0

Conveyor Belt FPM to RPM

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

Table 24—Recommended Maximum Conveyor Belt Speeds

Material being conveyed	Belt speeds (fpm)	Belt width (inches)
Grain or other free-flowing, nonabrasive material	500 700 800 1000	18 24-30 36-42 48-96
Coal, damp clay, soft ores, overburden and earth, fine-crushed stone	400 600 800 1000	18 24-36 42-60 72-96
Heavy, hard, sharp-edged ore, coarse-crushed stone	350 500 600	18 24-36 Over 36
Foundry sand, prepared or damp; shakeout sand with small cores, with or without small castings (not hot enough to harm belting)	350	Any width
Prepared foundry sand and similar damp (or dry abrasive) materials discharged from belt by rubber-edged plows	200	Any width
Nonabrasive materials discharged from belt by means of plows	200, except for wood pulp, where 300 to 400 is preferable	Any width
Feeder belts, flat or troughed, for feeding fine, nonabrasive, or mildly abrasive materials from hoppers and bins	50 to 100	Any width

Table 25—Material Characteristics

MATERIAL	DENSITY (LB/fT^3)	ANGLE OF REPOSE (DEG)	REC-OMMENDED MAXIMUM INCLINATION (DEG)
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	7.5	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°	
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°	

Table 26—Material Characteristics

MATERIAL	DENSITY (LB/fT³)	ANGLE OF REPOSE (DEG)	REC-OMMENDED MAXIMUM INCLINATION (DEG)
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°	
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°	
Taconite, Pellets	120 - 140	35°	13-15
Talc, 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°	

Table 27—Strength and Physical Properties of Various Metals

Metals and Alloys	Stress in Thousands of Pounds per Sq. Inch				Modulus of Elasticity Millions of PSI	Elongation %
	Tension Ultimate	Tension Yield Point	Compres-sion 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	10.2	30
Aluminum, Type 5052-H38, Hard	42	37	.....	24	10.2	8
Aluminum, Type 5056-0, Annealed	42	22	.....	26	10.3	35
Aluminum, Type 2014-0, Annealed	27	14	.....	18	10.6	18
Aluminum, Type 2014-T4, Heat Treated	62	42	.....	38	10.6	20
Aluminum, Type C4A, Casting. Solution Heat Treat	32	16	16s	24	.....	8.5
Aluminum, Type S5C, As Die Cast	30	16	16s	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	10-12s	.....	9.1-14.8	20-35
Brass, Red, Leaded, Cast, Grade 4B	30-38	12-17	11-12s	.....	.....	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	8-10s	.....	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†	15	33†
Bronze, Phosphor, Annealed	40-66	14-24	.....	.....	16-17	48-70
Bronze, Tin, High Leaded, Cast	23-38	11-22	12-16s	.....	8.5-13	7-20
Bronze, Tin, Leaded, Cast	33-48	16-26	9-15s	.....	10.6-16	15-40
Copper, Beryllium, Annealed	60-80	25-35†	.....	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	.....	.....	29.8	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	6.5	8-11
Magnesium Alloy, Extruded, ASTM AZ6IA-F	40-45	22-32	15-21	21	6.5	15-16
Magnesium Alloy, Cast, ASTM MIB	14	4.5	.....	11	6.5	5
Magnesium Alloy, Cast, ASTM AZ92A	24	14	.....	19	6.5	2
Magnesium Alloy, Cast, ASTM AZ9IA	36	23	.....	20	6.5	4
Monel, Cast	65-90	32-45	.....	.....	23	20-50
Monel, S, Cast	120-145	80-130	.....	.....	24.2	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	.....	.....	21.5	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	33s	45-54	29-30	21
Steel, Structural, High Strength, Low Alloy, ASTM A242	63-70	42-50	42-50s	47-53	29-30	18–24
Zinc, Die Cast Alloy XXIII	41	.....	60s	31	.....	10

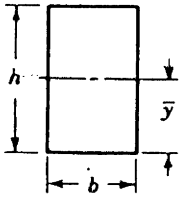
† When hardened, strength values are higher, elongation less

s Compression yield point.

Table 28—Properties of Sections

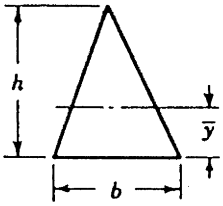
A = area
I = moment of inertia
J = polar moment of inertia
Z = section modulusπ
k = radius of gyration
$\bar{y}$= centroidal distance

Rectangle



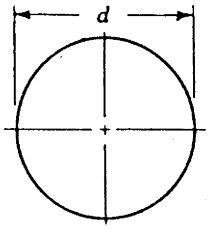
$A = bh$
$I = \frac{bh^3}{12}$
$Z = \frac{bh^2}{6}$
$k = 0.289h$
$\bar{y} = \frac{h}{2}$

Triangle



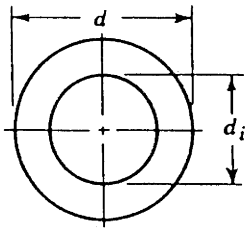
$A = \frac{bh}{2}$
$I = \frac{bh^3}{36}$
$Z = \frac{bh^2}{24}$
$k = 0.236h$
$\bar{y} = \frac{h}{3}$

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



$A = \frac{\pi}{4}(d^2 - d_i^2)$
$I = \frac{\pi}{64}(d^4 - d_i^4)$
$Z = \frac{\pi}{32d}(d^4 - d_i^4)$
$J = \frac{\pi}{32}(d^4 - d_i^4)$
$k = \sqrt{\frac{d^2 + d_i^2}{16}}$
$\bar{y} = \frac{d}{2}$

Table 29—Coefficients of Friction "f"

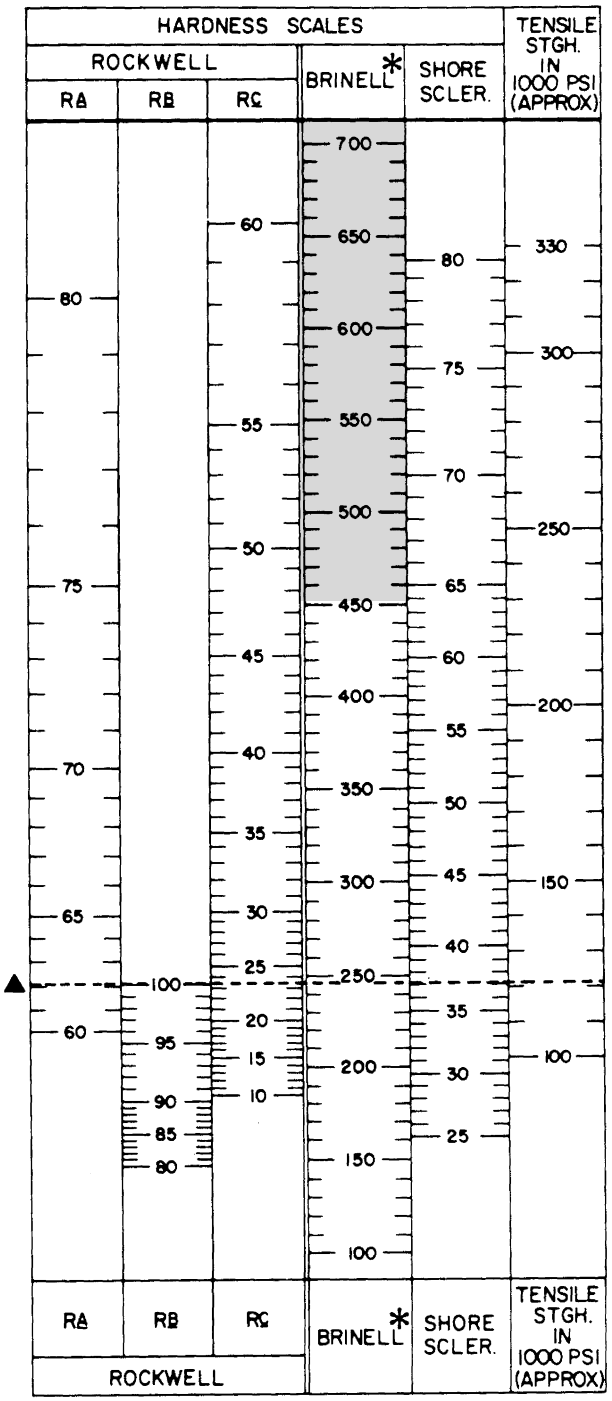
Material	Static		Sliding	
	Dry	Lubri-cated	Dry	Lubri-cated
Aluminum on aluminum	1.35	....	....	....
Canvas belt on rubber lagging	0.30	....	....	....
Canvas belt, stitched, on steel	....	....	0.20	0.10
Canvas belt, woven, on steel	....	....	0.22	0.10
Cast iron on asbestos, fabric	....	....	....	....
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	.6	....		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	0.133
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 30—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	.28125	20	.03590
2	.26562	21	.03290
3	.23910	22	.02990
4	.22420	23	.02690
5	.20920	24	.02390
6	.19430	25	.02090
7	.17930	26	.01790
8	.16440	27	.01640
9	.14950	28	.01490
10	.13450	29	.01350
11	.11960	30	.01200
12	.10460	31	.01094
13	.08970	32	.01016
14	.07470	33	.00938
15	.06730	34	.00859
16	.05980	35	.00781
17	.05380	36	.00703
18	.04780	37	.00664
19	.04180	38	.00625

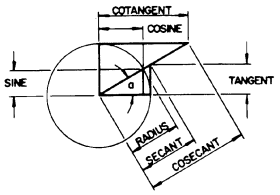
Hardness Comparison Chart



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

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

Trigonometric Formula



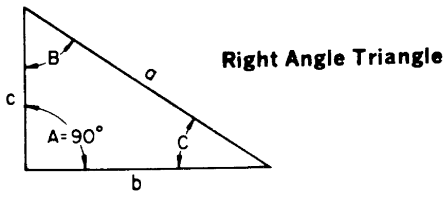


Table 31—Formulas for Finding Functions of Angles

$\frac{\text{Side opposite}}{\text{Hypotenuse}}$	=	SINE
$\frac{\text{Side adjacent}}{\text{Hypotenuse}}$	=	COSINE
$\frac{\text{Side opposite}}{\text{Side adjacent}}$	=	TANGENT
$\frac{\text{Side adjacent}}{\text{Side opposite}}$	=	COTANGENT
$\frac{\text{Hypotenuse}}{\text{Side adjacent}}$	=	SECANT
$\frac{\text{Hypotenuse}}{\text{Side opposite}}$	=	COSECANT

Table 32—Formulas for Finding Sides of Right Angle Triangles with an Angle and Side Known

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

Table 33—To Find Angles and Sides of Right Angle Triangles

To Find Angles		To Find Sides		
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	$\frac{b}{a}$ = 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	$\frac{c}{b}$ = 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	$\frac{b}{\text{Cotangent C}}$

Oblique Angle Triangle

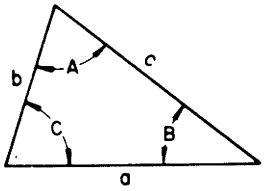


Table 34—To Find Angles and Sides of Oblique Angle Triangles

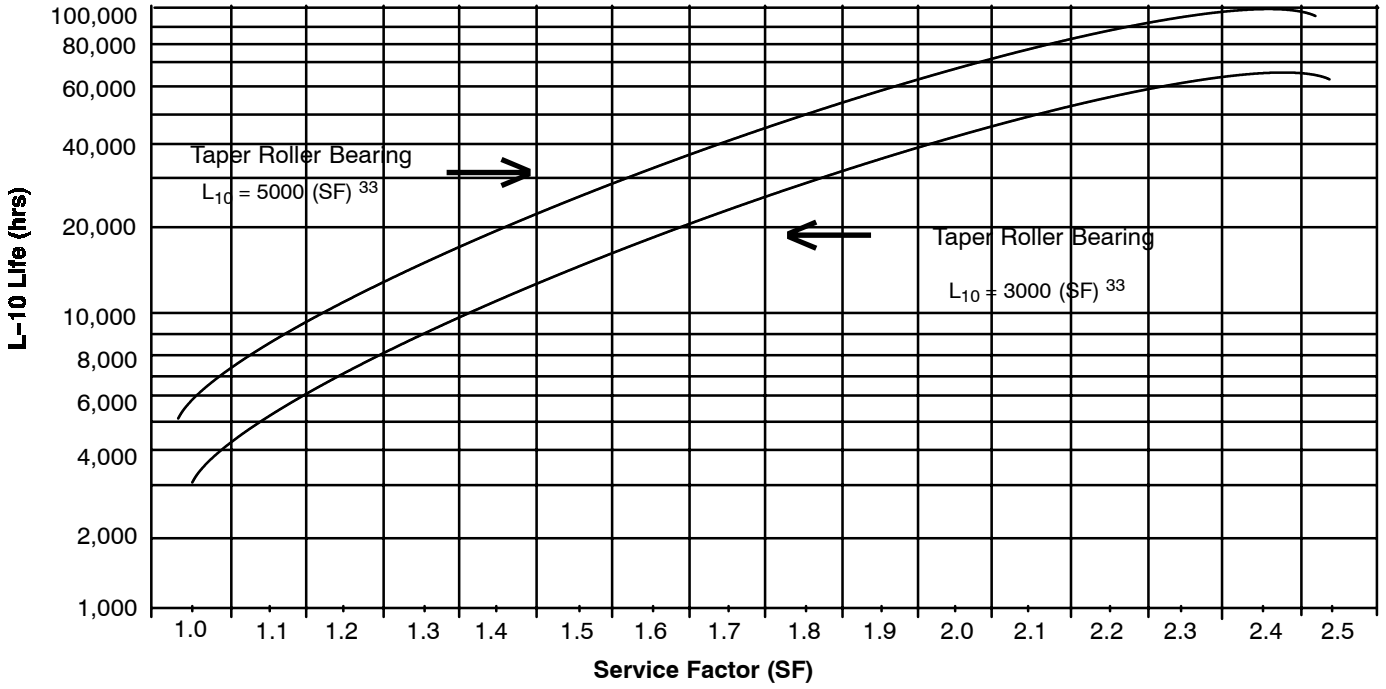
To find:	Known	Formulas	To Find:	Known	Formulas
C	A, B	180° - (A + B)	A	B, C	180° - (B + C)
b	a, B, A	$\frac{\text{a x Sin. B}}{\text{Sin. A}}$	Cos. A	a, b, c	$\frac{b^2 + c^2 - a^2}{2bc}$
c	a, A, C	$\frac{\text{a x Sin. C}}{\text{Sin. A}}$	Sin. C	c, A, a	$\frac{\text{c x Sin. A}}{\text{a}}$
Tan. A	a, C, b	$\frac{\text{a x Sin. C}}{\text{b} - (\text{a x Cos. C})}$	Cot. B	a, C, b	$\frac{\text{a x Cosec. C}}{\text{b}} - \text{Cot. C}$
B	A, C	180° - (A + C)	c	b, C, B	b x Sin. C x Cosec. B
Sin. B	b, A, a	$\frac{\text{b x Sin. A}}{\text{a}}$	. . . . .	. . . . .	. . . . .

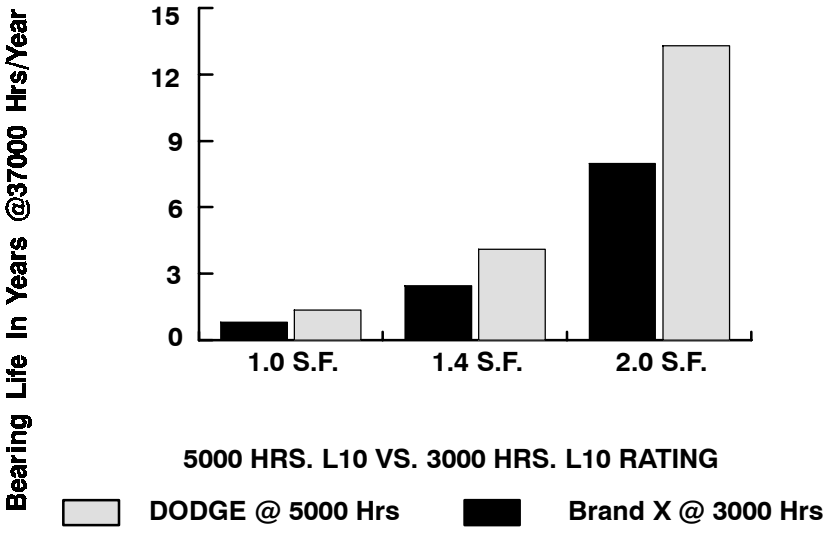
BEARING L-10 LIFE AS A FUNCTION OF SERVICE FACTOR

DODGE TORQUE-ARM and MAXUM Reducers are designed to provide a minimum L-10 bearing life of 5,000 hours for the most severe operating conditions. Since the probability of all maximum load conditions occurring in an application is remote, the actual L-10 life of an application is much greater. Remember, the L-50 average life would be approximately 25,000 hours.

The graph illustrates how bearing life varies with different service factors. For example, a DODGE TORQUE-ARM TXT625 Reducer with a 2.0 service factor has an average estimated life of about 50,000 hourse L–20 life.

Bearing Life vs. Service Factor (5,000 hr vs 3,000 hr)





AGMA Specifications

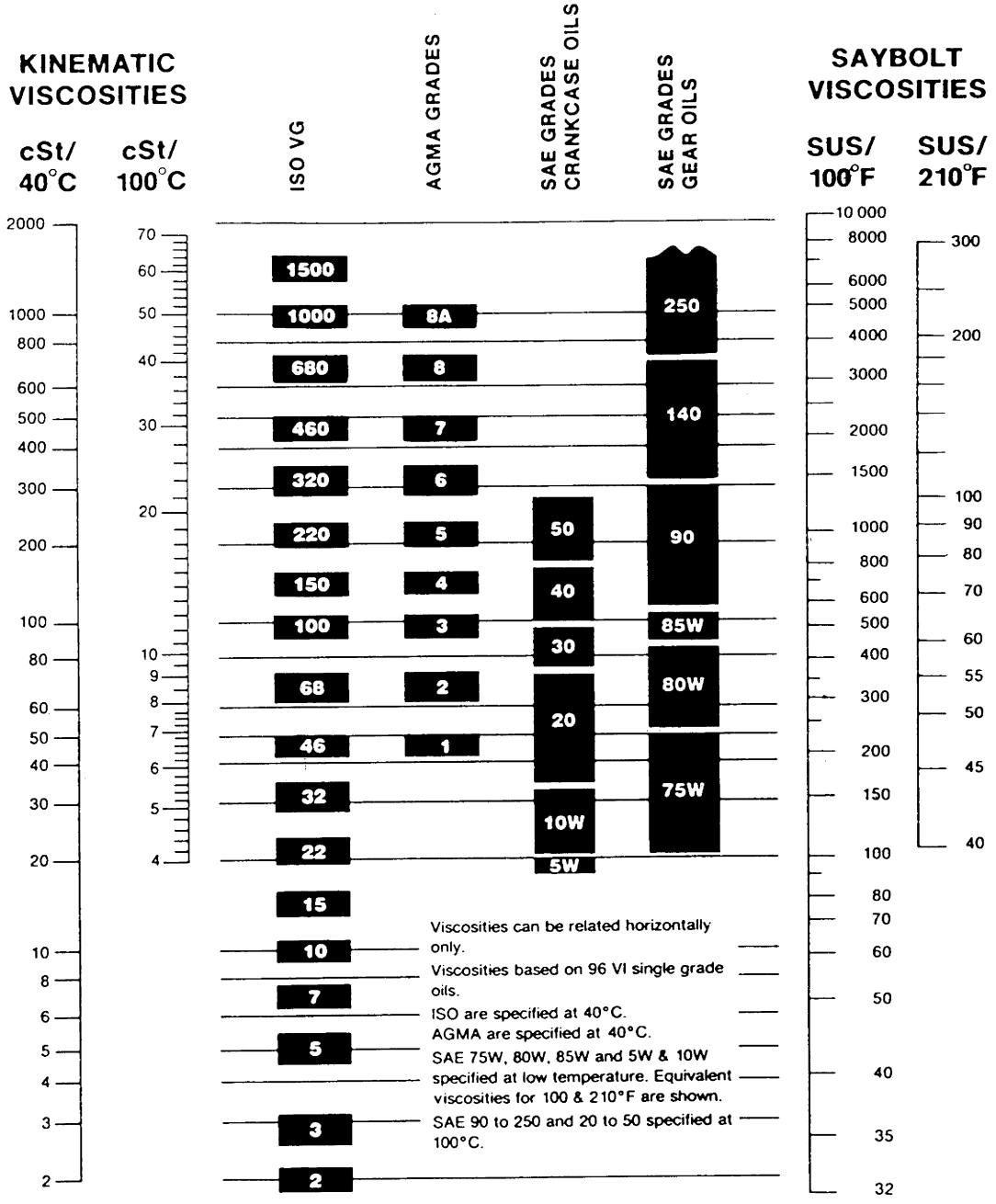
For Shaft Mounted Screw Conveyor Drives and MAXUM, using spur, helical and herringbone gears.

*** ANSI / AGMA 6021–G89**

*** ANSI / AGMA 6019–E89**

7.4 Roller and Ball Bearings. Roller and ball bearings shall be selected to provide not less than 5,000 hours L–10 life for class I service as calculated by the methods of the bearing manufacturer.

Viscosity Classification Equivalents



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

Electrical

Table 35—Electrical Formulas

To Find	Alternating Current	
	Single-Phase	Three-Phase
Amperes when horsepower is known	$\frac{\text{Hp X 746}}{\text{E X Eff X pf}}$	$\frac{\text{Hp X 746}}{\text{1.73 x E X Eff X pf}}$
Amperes when kilowatts are known	$\frac{\text{Kw X 1000}}{\text{E X pf}}$	$\frac{\text{Kw X 1000}}{\text{1.73 X E X pf}}$
Amperes when Kva are known	$\frac{\text{Kva X 1000}}{\text{E}}$	$\frac{\text{Kva X 1000}}{\text{1.73 x E}}$
Kilowatts	$\frac{\text{I X E X pf}}{\text{1000}}$	$\frac{\text{1.73 X I X E X pf}}{\text{1000}}$
Kva	$\frac{\text{I X E}}{\text{1000}}$	$\frac{\text{1.73 X I X E}}{\text{1000}}$
Horsepower = (Output)	$\frac{\text{I X E X Eff X pf}}{\text{746}}$	$\frac{\text{1.73 X I X E X Eff X pf}}{\text{746}}$

I - Amperes; E = Volts; Eff = Efficiency; pf = power factor; Kva = Kilovolt amperes; Kw = Kilowatts; R = Ohms.

To Find	Alternating or Direct Current
Amperes when voltage and resistance is known	$\frac{\text{E}}{\text{R}}$
Voltage when resistance and current are known	IR
Resistance when voltage and current are known	$\frac{\text{E}}{\text{I}}$

General Information (Approximation)

All Values At 100% Load:
- At 1800 rpm, a motor develops 36 lb.-in per hp
- At 1200 rpm, a motor develops 54 lb.-in per hp
- At 575 volts, a 3-phase motor draws 1 amp per hp
- At 460 volts, a 3-phase motor draws 1.25 amp per hp
- At 230 volts, a 3-phase motor draws 2.5 amp per hp
- At 230 volts, a single-phase motor draws 5 amp per hp
- At 115 volts, a single-phase motor draws 10 amp per hp

Temperature Conversion:
Deg C = (Deg F - 32) X 5/9
Deg F = (Deg C X 9/5) + 32

Table 36—AC Motor Recommended Wire Size

Volts	Motor Horsepower																					
	1-3	5	$7^1/_2$	10	15	20	25	30	40	50	60	75	100	125	150	200	250	300	350	400	450	500
230	14	12	10	8	6	4	3	1	0	000	000	300	500	...	...	...	...	...	...	...	...	...
460	14	14	14	12	10	8	6	6	4	3	2	0	000	0000	300	500	700	900	1500	600*	750*	900*
575	14	14	14	14	12	10	8	6	6	4	3	2	0	000	0000	250	500	600	800	1000	1500	600*

Insure that the requirements of the National Electric Code are fully met in all installations. This table is included as a guide only and is based on 3 phase, continuous duty, design B, standard efficiency motors using 600 volt Insulation, Type THW, with individual cooper conductors run in rigid conduit as defined in the 1987 NEC.

Table 37—Motor Amps @ Full Load†

HP	Alternating Current		DC	HP	Alternating Current		DC	HP	Alternating Current		DC	HP	Alternating Current		DC
	Single-phase	3-phase			Single-phase	3-phase			Single-phase	3-phase			Single-phase	3-phase	
1/2	4.9	2.0	2.7	5	28	14.4	20	25	....	60	92	75	....	180	268
1	8.0	3.4	4.8	7-1/2	40	21.0	29	30	....	75	110	100	....	240	355
1-1/2	10.0	4.8	6.6	10	50	26.0	38	40	....	100	146	125	....	300	443
2	12.0	6.2	8.5	15	....	38.0	56	50	....	120	180	150	....	360	534
3	17.0	8.6	12.5	20	....	50.0	74	60	....	150	215	200	....	480	712

† Values are for all speeds and frequencies @ 230 volts. Amperage other than 230 volts can be figured:

$$A = \frac{\text{230 X Amp from Table}}{\text{New Voltage}}$$

Example:

For 60 hp, 3 phase @ 550 volts : $\frac{(230 \text{ X } 150)}{550} = 62$ amps.

Power Factor estimated @ 80% for most motors. Efficiency is usually 80-90%.

Table 38—NEMA Electrical Enclosure Types

Type	Description	Type	Description
NEMA Type 1 (General Purposes)	For indoor use wherever oil, dust or water is not a problem.	NEMA Type 5 Dust Tight (Non-Hazardous)	Used for excluding dust. (All NEMA 12 enclosures are usually suitable for NEMA 5 use.)
NEMA Type 2 (Driptight)	Used indoors to exclude falling moisture and dirt.	NEMA Type 9 Dust Tight (Hazardous) ‡	For locations where combustible dusts are present.
NEMA Type 3 (Weatherproof)	Provides protection against rain, sleet and snow.		
NEMA Type 4 (Watertight) ◆	Needed when subject to great amounts of water from any angle—such as areas which are repeatedly hosed down.	NEMA Type 12 (Industrial Use)	Used for excluding oil, coolant, flying dust, lint, etc.

◆ Not designed to be submerged.

‡ Class II Groups E, F and G.

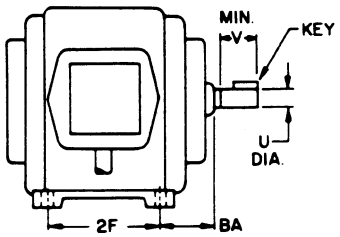
A-C MOTOR INFORMATION

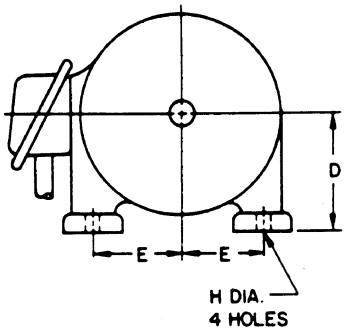
Table 39—Frame Assignments

HP	Motor Speed, rpm				HP	Motor Speed, rpm			
	3600	1800	1200	900		3600	1800	1200	900
1/8	. . .	48	. . .	. . .	15	254T,256U	254T,284U	284T,284TS,324U	286T,326U
1/6	. . .	48	. . .	. . .	20	256T,286U	256T,286U	286T,286TS,326U	324T,364U
1/4	48	48	48	56	25	284TS,324US	284T,284TS,324U	324T,324TS,364U	326T,365U
1/3	48	48,56	56	56	30	286TS,326US	286T,284TS,326U	326T,326TS,365U	364T,404U
1/2	48,56	48,56	56	56	40	324TS,364US	324T,324TS,364U	354T,404U	365T,405U
3/4	56	56	56,143T,182U	56,145T	50	326TS,365US	326T,326TS,365U	365T,405U	404T
1	56,143T,182U	56,143T,182U	56,143T,184U	182T	60	364TS	364T,364TS	404T	405T
1-1/2	56,143T,182U	56,145T,184U	145T,184U	184T	75	365TS	365T,365TS	405T	444T
2	56,145T,184U	56,145T,184U	184T,213U	213T	100	405TS	405T,405TS	444T	445T
3	56,145T,182T,184U	182T,213U	213T,215U	215T,254U	125	444TS	444T,444TS	445T	. . .
5	184T,213U	184T,215U	215T,254U	254T,256U	150	445TS	445T,445TS	. . .	. . .
7-1/2	213T,215U	213T,254U	254T,256U	256T,284U	200	445TS	445T,445TS	. . .	. . .
10	215T,254U	215T,256U	256T,284U	284T,286U	250	447TS	447T,447TS	. . .	. . .

Table 40—Motor Frame Dimensions

Frame Size	D	E	2F	H Dia. (4) Holes	U Dia.	BA	V Min.	Key
48	3	2-1/8	2-3/4	11/32	1/2	2-1/2	. . .	3/64 Flat
56	3-1/2	2-7/16	3	11/32	5/8	2-3/4	. . .	3/16 x 3/16 x 1-3/8
143T	3-1/2	2-3/4	4	11/32	7/8	2-1/4	2	3/16 x 3/16 x 1-3/8
145T	3-1/2	2-3/4	5	11/32	7/8	2-1/4	2	3/16 x 3/16 x 1-3/8
182T	4-1/2	3-3/4	4-1/2	13/32	1-1/8	2-3/4	2-1/2	1/4 x 1/4 x 1-3/4
184T	4-1/2	3-3/4	5-1/2	13/32	1-1/8	2-3/4	2-1/2	1/4 x 1/4 x 1-3/4
213T	5-1/4	4-1/4	5-1/2	13/32	1-3/8	3-1/2	3-1/8	5/16 x 5/16 x 2-3/8
215T	5-1/4	4-1/4	7	13/32	1-3/8	3-1/2	3-1/8	5/16 x 5/16 x 2-3/8
254U	6-1/4	5	8-1/4	17/32	1-3/8	4-1/4	3-1/2	5/16 x 5/16 x 2-3/4
254T	6-1/4	5	8-1/4	17/32	1-5/8	4-1/4	3-3/4	3/8 x 3/8 x 2-7/8
256U	6-1/4	5	10	17/32	1-3/8	4-1/4	3-1/2	5/16 x 5/16 x 2-3/4
256T	6-1/4	5	10	17/32	1-5/8	4-1/4	3-3/4	3/8 x 3/8 x 2-7/8
284U	7	5-1/2	9-1/2	17/32	1-5/8	4-3/4	4-5/8	3/8 x 3/8 x 3-3/4
284T	7	5-1/2	9-1/2	17/32	1-7/8	4-3/4	4-3/8	1/2 x 1/2 x 3-1/4
284TS	7	5-1/2	9-1/2	17/32	1-5/8	4-3/4	3	3/8 x 3/8 x 1-7/8
286U	7	5-1/2	11	17/32	1-5/8	4-3/4	4-5/8	3/8 x 3/8 x 3-3/4
286T	7	5-1/2	11	17/32	1-7/8	4-3/4	4-3/8	1/2 x 1/2 x 3-1/4
286TS	7	5-1/2	11	17/32	1-5/8	4-3/4	3	3/8 x 3/8 x 1-7/8
324U	8	6-1/4	10-1/2	21/32	1-7/8	5-1/4	5-3/8	1/2 x 1/2 x 4-1/4
324T	8	6-1/4	10-1/2	21/32	2-1/8	5-1/4	5	1/2 x 1/2 x 3-7/8
324TS	8	6-1/4	10-1/2	21/32	1-7/8	5-1/4	3-1/2	1/2 x 1/2 x 2
326U	8	6-1/4	12	21/32	1-7/8	5-1/4	5-3/8	1/2 x 1/2 x 4-1/4
326T	8	6-1/4	12	21/32	2-1/8	5-1/4	5	1/2 x 1/2 x 3-7/8
326TS	8	6-1/4	12	21/32	1-7/8	5-1/4	3-1/2	1/2 x 1/2 x 2
364U	9	7	11-1/4	21/32	2-1/8	5-7/8	6-1/8	1/2 x 1/2 x 5
364US	9	7	11-1/4	21/32	1-7/8	5-7/8	3-1/2	1/2 x 1/2 x 2
364T	9	7	11-1/4	21/32	2-3/8	5-7/8	5-5/8	5/8 x 5/8 x 4-1/4
364TS	9	7	11-1/4	21/32	1-7/8	5-7/8	3-1/2	1/2 x 1/2 x 2
365U	9	7	12-1/4	21/32	2-1/8	5-7/8	6-1/8	1/2 x 1/2 x 5
365US	9	7	12-1/4	21/32	1-7/8	5-7/8	3-1/2	1/2 x 1/2 x 2
365T	9	7	12-1/4	21/32	2-3/8	5-7/8	5-5/8	5/8 x 5/8 x 4-1/4
365TS	9	7	12-1/4	21/32	1-7/8	5-7/8	3-1/2	1/2 x 1/2 x 2
404U	10	8	12-1/4	13/16	2-3/8	6-5/8	6-7/8	5/8 x 5/8 x 5-1/2
404US	10	8	12-1/4	13/16	2-1/8	6-5/8	4	1/2 x 1/2 x 2-3/4
404T	10	8	12-1/4	13/16	2-7/8	6-5/8	7	3/4 x 3/4 x 5-5/8
404TS	10	8	12-1/4	13/16	2-1/8	6-5/8	4	1/2 x 1/2 x 2-3/4
405U	10	8	13-3/4	13/16	2-3/8	6-5/8	6-7/8	5/8 x 5/8 x 5-1/2
405US	10	8	13-3/4	13/16	2-1/8	6-5/8	4	1/2 x 1/2 x 2-3/4
405T	10	8	13-3/4	13/16	2-7/8	6-5/8	7	3/4 x 3/4 x 5-5/8
405TS	10	8	13-3/4	13/16	2-1/8	6-5/8	4	1/2 x 1/2 x 2-3/4
444U	11	9	14-1/2	13/16	2-7/8	7-1/2	8-3/8	3/4 x 3/4 x 7
444US	11	9	14-1/2	13/16	2-1/8	7-1/2	4	1/2 x 1/2 x 2-3/4
444T	11	9	14-1/2	13/16	3-3/8	7-1/2	8-1/4	7/8 x 7/8 x 6-7/8
444TS	11	9	14-1/2	13/16	2-3/8	7-1/2	4-1/2	5/8 x 5/8 x 3
445U	11	9	16-1/2	13/16	2-7/8	7-1/2	8-3/8	3/4 x 3/4 x 7
445US	11	9	16-1/2	13/16	2-1/8	7-1/2	4	1/2 x 1/2 x 2-3/4
445T	11	9	16-1/2	13/16	3-3/8	7-1/2	8-1/4	7/8 x 7/8 x 6-7/8
445TS	11	9	16-1/2	13/16	2-3/8	7-1/2	4-1/2	5/8 x 5/8 x 3





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 Tables 41-47 are vibration frequencies generated by bearing components defects. All frequencies are based on unity inner ring or cone rotation.

How to Use the Tables

If a 2-7/16 Type E pillow block is rotating at 1000 RPM, the vibration due to a failed component will show up at the following frequencies: (Table 42, 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 Tables 41-47 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 41
SC/SCM BALL BEARING PARAMETERS FOR VIBRATION ANALYSIS (1-RPS)

						RELATIVE SPEED WITH INNER RING ROTATION			RELATIVE SPEED WITH OUTER RING ROTATION		
SERIES	SC BORE	SCM BORE	NO. OF BALLS	DIA. OF BALLS	PITCH DIAMETER	Ni INNER	Nc CAGE	Nd BALL	No OUTER	Nc CAGE	Nd BALL
203	1/2-5/8		8	17/64	1.1506	1	0.36457	2.05057	1	0.61543	2.05057
204	1/2-3/4		8	5/16	1.3251	1	0.38208	2.00224	1	0.61792	2.00224
205	7/8- 1		9	5/16	1.5325	1	0.39804	2.35004	1	0.60196	2.35004
206	1-1/6-1-1/4	1	9	3/8	1.8230	1	0.39715	2.32781	1	0.60285	2.32781
207	1-1/4-1-7/16	1-3/16	9	7/16	2.1360	1	0.39759	2.33873	1	0.60241	2.33873
208	1-1/2- 1-5/8	1-7/16 - 1-1/2	9	1/2	2.3870	1	0.39527	2.28227	1	0.60473	2.28227
209	1-11/16-1-3/4	1-1/2	9	.520	2.5591	1	0.39840	2.35910	1	060159	2.35910
210	1-15/16-2	1-11/16-1-3/4	10	1/2	2.7645	1	0.40957	2.67407	1	0.59043	2.67407
211	2-2-1/4	1-15/16-2	10	9/16	3.0920	1	0.40904	2.65748	1	0.59096	2.65748
212	2-1/4-2-7/16	2-3/16-2-1/4	10	5/8	3.3850	1	0.40768	2.61568	1	0.59230	2.61568
214	2-11/16	2-7/16-2-1/2	10	11/16	3.7750	1	0.40894	2.65439	1	0.59106	2.65439
215	2-15/16	2-11/16	11	11/16	4.0850	1	0.41585	2.88676	1	0.58415	2.88675
216		2-15/16-3	11	3/4	4.3300	1	0.41339	2.80006	1	0.58661	2.80006
218		3-7/16-3-1/2	11	27/32	4.9199	1	0.41425	2.82981	1	0.58575	2.82981

TABLE 42
FUNDAMENTAL BEARING FREQUENCIES RELATIVE TO UNITY CONE SPEED (1-RPS)
TYPE E, K, DI, TAF

		RELATIVE SPEED (RPS)				COMPONENT IRREGULARITY FREQUENCIES				
								FLAW LOCATION (NICK OR SPALL)		
BORE	NO OF ROLLS PER ROW (A)	CONE TO CUP (N)	CAGE TO CUP (K)	CAGE TO CONE (C)	ROLLER TO CAGE (R)	CONE ECCENTRIC (N)	ROLL SIZE VAR. (K)	CUP (K.A.)	CONE (C.A.)	ROLLER 2(R)
1-3/16 - 1-1/4	19	1	.437	.563	3.774	1	.437	8.306	10.694	7.548
1-3/8-1-7/16	20	1	.432	.568	3.52	1	.432	8.650	11.350	7.040
1-1/2 -1-11/16	18	1	.430	.570	3.396	1	.430	7.739	10.261	6.792
1-3/4-2	17	1	.426	574	3.248	1	.426	7.242	9.758	6.496
2-3/16	19	1	.434	.566	3.648	1	.434	8.247	10.753	7.296
2-1/4 -2-1/2	21	1	.440	.560	4.034	1	.440	9.249	11.751	8.068
2-11/16-3	24	1	.450	.550	4.734	1	.450	10.769	13.211	9.468
3-3/16-3-1/2	26	1	.454	.546	5.118	1	.454	11.793	14.207	10.236
4-15/16-4	26	1	.452	.546	4.934	1	.452	11.745	14.255	9.868
4-7/16-4-1/2	25	1	451	.549	4.801	1	.451	11.269	13.731	9.602
4-15/16-5	25	1	.450	.550	4.760	1	.450	11247	13.753	9.520
5-7/16-6	32	1	.462	.536	6.290	1	.462	14.767	17.213	12.580
6-7/16-7	27	1	.455	.545	5.240	1	.455	12.282	14.718	10.480

TABLE 43
FUNDAMENTAL BEARING FREQUENCIES RELATIVE TO UNITY CONE SPEED (I-RPS)
TYPE C

		RELATIVE SPEED (RPS)				COMPONENT IRREGULARITY FREQUENCIES				
								FLAW LOCATION (NICK OR SPALL)		
BORE	NO OF ROLLS PER ROW (A)	CONE TO CUP (N)	CAGE TO CUP (K)	CAGE TO CONE (C)	ROLLER TO CAGE (R)	CONE ECCENTRIC (N)	ROLL SIZE VAR. (K)	CUP (K.A.)	CONE (C.A.)	ROLLER 2(R)
1-3/16-1-7/16	19	1	.433	.567	3.584	1	.433	8.232	10.768	7.168
1-1/2-1-3/4	21	1	.440	.560	4.018	1	.440	9.233	11.767	8.036
1-15/16	22	1	.443	.557	4.243	1	.443	9.755	12.245	8.486
2-2-1/4	21	1	.441	.559	4.070	1	.441	9.271	11.729	8.140
2-3/8-2-7/16	25	1	.452	.548	4.980	1	.452	11.307	13.693	9.960
2-1/2-2-11/16	23	1	.446	.554	4.447	1	.446	10.265	12.735	8.894
2-7/8-2-15/16	26	1	.452	.548	5.019	1	.452	11.761	14.239	10.038
3-3-3/16	22	1	.443	.557	4.179	1	.443	9.744	12.256	8.358
3-1/4-3-7/16	24	1	.448	.552	4.580	1	.448	10.748	13.252	9.160
3-1/2-4	25	1	.451	.549	4.801	1	.451	11.269	13.731	9.602
4-7/16-4-1/2	33	1	.463	.537	6.612	1	.463	15.281	17.719	13.224
4-15/16-5	26	1	.453	.547	5.067	1	.453	11.780	14.220	10.134

TABLE 44
FUNDAMENTAL BEARING FREQUENCIES RELATIVE TO UNITY CONE SPEED (1-RPS)
SPECIAL DUTY

		RELATIVE SPEED (RPS)				COMPONENT IRREGULARITY FREQUENCIES				
								FLAW LOCATION (NICK OR SPALL)		
BORE	NO OF ROLLS PER ROW (A)	CONE TO CUP (N)	CAGE TO CUP (K)	CAGE TO CONE (C)	ROLLER TO CAGE (R)	CONE ECCENTRIC (N)	ROLL SIZE VAR. (K)	CUP (K.A.)	CONE (C.A.)	ROLLER 2(R)
1-3/8-1-1/2	16	1	.422	.578	3.090	1	.422	6.756	9.244	6.180
1-9/16 - 1-3/4	18	1	.431	.569	3.467	1	.431	7.751	10.249	6.934
1-7/8-2	19	1	.434	.566	3.648	1	.434	8.247	10.753	7.296
2-1/6-2-1/4	22	1	.443	.557	4.191	1	.443	9.740	12.260	8.382
2-3/6-2-1/2	20	1	.439	.561	3.948	1	.439	8.783	11.217	7.896
2-5/8 - 3	22	1	.442	.558	4.162	1	.442	9.732	12.268	8.324
3-3/16 - 3-1/2	23	1	.446	.554	4.367	1	.446	10.247	12.753	8.734
3-11/16-4	23	1	.444	.556	4.296	1	.444	10.217	12.783	8.592
4-7/16-4-1/2	26	1	.453	.547	5.067	1	.453	11.780	14.220	10.134
415/16-5	24	1	.448	.552	4.580	1	.448	10.748	13.252	9.160
5-7/16-6	24	1	.451	.549	4.863	1	.451	10.824	13.176	9.726
6-1/2-7	29	1	.457	.543	5.443	1	.457	13.240	15.760	10.886
7-15/16-8	27	1	.452	.548	5.063	1	.452	12.205	14.795	10.126
8-1/2-10	41	1	.470	.530	8.004	1	.470	19.270	21.730	16.008
11, 12	37	1	.463	.537	6.629	1	.463	17.141	19.859	13.258

TABLE 45
FUNDAMENTAL BEARING FREOUENCIES RELATIVE TO UNITY CONE SPEED (1-RPS)
ALL STEEL

		RELATIVE SPEED (RPS)				COMPONENT IRREGULARITY FREQUENCIES				
								FLAW LOCATION (NICK OR SPALL)		
BORE	NO OF ROLLS PER ROW (A)	CONE TO CUP (N)	CAGE TO CUP (K)	CAGE TO CONE (C)	ROLLER TO CAGE (R)	CONE ECCEN-TRIC (N)	ROLL SIZE VAR. (K)	CUP (K.A.)	CONE (C.A.)	ROLLER 2(R)
2-11/16-3	27	1	0.437	0.543	5.599	1	0.457	12.340	14.660	11.198
31/4-3-1/2	26	1	0.452	0.548	4.934	1	0.452	11.745	14.255	9.868
315/16 - 4	33	1	0.459	0.541	5.998	1	0.459	15.161	17.639	11.996
4-1/4-41/2	29	1	0.455	0.545	5.378	1	0.455	13.191	15.809	10.756
4-15/16-5	32	1	0.459	0.541	5.998	1	0.459	14.702	17.298	11.996
5-7/16	27	1	0.450	0.550	4.875	1	0.450	12.154	14.846	9.750
5-15/16-6	26	1	0.450	0.550	4.875	1	0.450	11.704	14.296	9.750
6-7/16-7	32	1	0.459	0.541	5.998	1	0.459	14.702	17.298	11.996
7-1/2-8	27	1	0.452	0.548	5.063	1	0.452	12.205	14.795	10.126
9-10	32	1	0.455	0.545	5.436	1	0.455	14.563	17.432	10.876

TABLE 46
USAF SAF-XT SDAF S2000 & UNISPHERE II BEARING FUNDAMENTAL FREQUENCIES (1-RPS)

BEARING NUMBER	TYPES		Z				FREQUENCIES			
	USAF BORE	S2000 & UNISPHERE II BORE	ROLLS/ ROW	DW IN	PD IN	ALPHA DEG.	RPFO HZ	RPFI HZ	FTF HZ	RSF HZ
22207ESK			15	0.3937	2.166	11°45′	6.162	8.820	0.411	2.664
22208ESK		1-1/8 - 1-1/2	15	0.4468	2.449	10°35′	6.102	8.880	0.407	2.566
22209ESK	1-7/16	1-5/6-1-3/4	17	0.4291	2.665	9°45′	7.128	9.840	0.419	2.982
22210ESK	1-11/16	1-7/8-2	18	0.4331	2.858	9°05′	7.632	10.380	0.424	3.180
22211ESK	1-15/16	2-3/16-2-1/4	19	0.4648	3.169	8°45′	8.112	10.860	0.427	3.318
22213ESK	2-3/16	2-3/6-2-1/2	18	0.5827	3.795	9°05′	7.614	10.380	0.423	3.138
22215ESK	2-7/16 - 2-1/2	2-11/16-3	20	0.5746	4.197	8°15′	8.628	11.340	0.431	3.546
22216ESK	2-11/16-2-3/4		19	0.6535	4.480	8°10′	8.112	10.860	0.427	3.318
22217ESK	2-15/16-3		18	0.7323	4.764	8°25′	7.614	10.380	0.423	3.138
22218ESK	3-3/16	3-3/16-3-1/2	18	0.7795	5.079	8°50′	7.614	10.380	0.423	3.138
22220ESK	3-7/16-3-1/2	3-11/16-4	18	0.8760	5.705	9°00′	7.614	10.380	0.423	3.138
22222ESK	3-15/16-4	**4-7/16*-4-1/2***	17	1.0197	6.287	9°25′	7.116	9.900	0.419	2.958
22224ESK	4-3/16		18	1.0472	6.819	9°25′	7.614	10.380	0.423	3.138
22226ESK	4-7/16-4-1/2	**4-15/16*-5***	18	1.1181	7.307	9°45′	7.620	10.380	0.424	3.144
22228ESK	4-15/16-5		18	1.2165	7.933	9°35′	7.614	10.380	0.423	3.138
22230ESK	5-3/16		18	1.3150	8.559	9°30′	7.614	10.360	0.423	3.138
22232ESK	5-7/16 - 5-1/2		18	1.4094	9.189	9°40′	7.614	10.360	0.423	3.138
22234ESK	5-15/16-6		17	1.5827	9.740	9°50′	7.116	9.900	0.419	2.952
22236ESK	6-7/16 - 6-1/2		18	1.5591	10.157	9°25′	7.614	10.380	0.423	3.138
22238KMB	6-15/16-7		20	1.4961	10.669	10°40′	8.592	11.480	0.430	3.432
22244KMB	7-1/2, 7-15/16, 8		19	1.8504	12.480	10°50′	8.088	10.920	0.425	3.240
23048KMB	8-7/16, 8-1/2, 8-15/16, 9		29	1.1417	12.008	9°20′	13.116	15.900	0.452	5.142
23052KMB	9-7/16, 9-1/2		27	1.3780	13.228	9°40′	12.090	14.880	0.448	4.680
23056KMB	9-15/16, 10, 10-7/16, 10-1/2		28	1.3780	13.976	9°20′	12.612	15.360	0.451	4.956
23060KMB	10-15/16-11		27	1.5748	15.276	9°30′	12.102	14.880	0.446	4.728
23064KMB	11-7/16, 11-1/2, 11-15/16, 12		28	1.5748	16.063	9°20′	12.624	15.360	0.451	4.980
23072KMB	12-15/16, 13, 13-7/16, 13-1/2		28	1.7323	18.031	9°20′	12.648	15.360	0.452	5.088
23076KMB	13-15/16, 14		30	1.7323	18.819	9°00′	13.614	16.380	0.454	5.316

* ONLY S2000

TABLE 47
SPLIT-SPHERE BEARING FUNDAMENTAL FREQUENCIES (1-RPS)

BORE SIZE	BEARING DESCRIPTION	ROLLERS PER ROW	ROLLER SIZE VARIATION (FTF)	FLAW LOCATION (NICK OR SPALL)		
				OUTER (RPFO)	INNER (RPFI)	ROLLER (RSF)
2-3/16	22213SS	17	0.420	7.128	9.876	5.946
2-7/16	22215SS	18	0.423	7.614	10.380	3.138
2-11/18	22216SS	19	0.426	8.124	10.878	6.684
2-15/16	22217SS	20	0.431	8.628	11.340	3.546
3-3/16	22218SS	19	0.427	8.112	10.860	3.318
3-7/16	22220SS	18	0.423	7.614	10.380	3.138
3-15/16-4	22222SS	18	0.423	7.614	10.380	3.138
4-3/18	22224SS	17	0.419	7.116	9.900	2.958
4-7/16-4-1/2	22226SS	18	0.423	7.614	10.380	3.132
4/15/18	22228SS	18	0.424	7.620	10.380	3.144
5-3/16	22230SS	18	0.423	7.614	10.380	3.138
5-7/16	22232SS	18	0.423	7.614	10.380	3.138
5-15/16-6	22234SS	18	0.423	7.614	10.380	3.138
6-7/16-6-1/2	22236SS	18	0.423	7.614	10.380	3.138
6-15/16-7	22238SS	18	0.426	7.620	10.380	6.276
7-3/16	22240SS	16	0.426	6.640	9.162	6.642
7-1/2-8	22244SS	16	0.426	6.774	9.228	6.276
8-1/2-9	22248SS	20	0.420	8.844	11.154	8.448
9-1/2	22252SS	22	0.444	9.780	12.222	8.814
10	22256SS	20	0.444	8.844	11.154	8.442

RPFO=ROLL PASS FREQUENCY, OUTER RACER, HZ
RPFI=ROLL PASS FREQUENCY, INNER RACE, HZ
FTF=FUNDAMENTAL TRAIN (CAGE) FREQUENCY, HZ
RSF=ROLL SPIN FREQUENCY, HZ

AT 1-RPS
RPFO=8.33*Z*(1-(DW*COS ALPHA)/PD), HZ
RPFI=8.33*Z*(1+(DW*COS ALPHA)/PD), HZ
FTF=8.33*Z*(1-DW*COS ALPHA)/PD, HZ
RSF=8.333*(PD/DW)*1(1-DW*COS ALPHA/PD)**2, HZ
WHERE Z=NO ROLLS; DW=ROLL DIAMETER; PD=PITCH DIAMETER

Mounted Bearings Life Adjustment Factors

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 from the Selection Procedure) the L10 must be adjusted by a factor a_1, such that $L_n = a_1 \times L10$.

The life adjustment factors for reliability of Table 48 are recommended.

Table 48
Life Adjustment Factors For Reliability

Reliability %	L_n	Life Adjustment Factor for Reliability a_1
90	L_{10} (Rating Life)	1
95	L_5	0.62
96	L_4	0.53
97	L_3	0.44
98	L_2	0.33
99	L_1	0.21

1.3 LIFE ADJUSTMENT FACTOR FOR MATERIAL. For bearings, which incorporate improved materials and processing, the L10 (as previously calculated in Selection Procedure) must be adjusted by a 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.

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 Nd_m (rpm times bore diameter in mm); e.g., Nd_m 1000.
   b) Lubricant viscosity less than 20.4 centistokes (100 SSU) at operating temperature.
   c) Excessively high operating temperatures.

   When a_3 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 embodying the foregoing life adjustment factors is:

For Ball Bearings:

$$L_n = a_1 \times a_2 \times a_3 \left(\frac{C*}{P}\right)^3 \times \frac{(16,667)}{RPM}$$

For Tapered Roller Bearings:

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

For 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