General Engineering Information

BEV

- **Tensioning Drives**
- **Idler Usage**
- **V-Flat Drive Design**
- **Quarter Turn Drive Design**
- **Belt Pull & Bearing Loads**

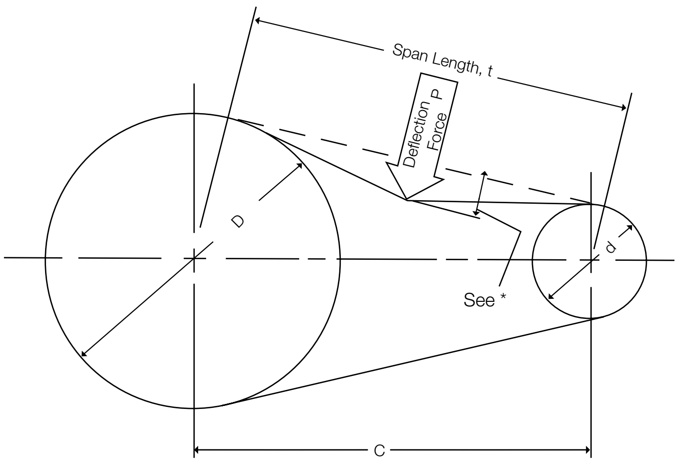
Below are some terms and abbreviations used on the following pages.

HP	=	Horsepower	**A**	=	Arc Correction Factor
DHP	=	Design Horsepower	**Lc**	=	Length Correction Factor
RPM	=	Revolutions Per Minute	**C**	=	Center Distance
D	=	Large Diameter Wheel	**d**	=	Small Diameter Wheel

Tensioning V-Belt Drives

Force Deflection Method

This method of tensioning should be used only for drives on which the grade of belt, rated belt capacity, service factor, design horsepower, etc. are known. If the drive has been designed in accordance with this catalog, or others with current horsepower ratings, the method outlined here is valid. When replacing belts on an older design, it would be recommended to review the capacity of the drive per current belt ratings. Due to the progressive development of belt horsepower ratings over time, older drives which were designed properly when new may now be drastically overdesigned. This could lead to excessive bearing load or excessive shaft deflection.



$$t = \sqrt{C^2 - \left(\frac{D-d}{2}\right)^2}$$

$$h = \frac{t}{64}$$

where t = Span length, inches
C = Center distance, inches
D = Larger sheave diameter, inches
d = Smaller sheave diameter, inches

* Deflection height h = 1/64 per inch of span

Figure 2

Step 1: Install belts per Step 1 of General Method above. Measure span length (t) in inches as shown in figure 2, or calculate using formula.

Step 2: From figure 2 the deflection height (h) is always 1/64” per inch of span length (t). For example, a 32” span length would require a deflection of 32/64” or 1/2”.

Step 3: Determine the minimum, maximum, and initial recommended pounds force using table 1 or calculate based on the required Static Strand Tension (T_S). Note: The initial recommended force is used only for installing new belts which have not seated themselves into the sheave grooves and where initial belt stretch has not taken place.

Step 4: Using a spring scale, apply a perpendicular force to any ONE of the belts at the mid point of the span as shown in figure 2. Compare this deflection force with the values found in Step 3.

a. If the deflection force is below the minimum, the belts are too loose and the tension should be increased by increasing the center distance.

b. If the deflection force is higher than the maximum, the belts are too tight and the tension should be decreased.

When new V-belts are installed on a drive the INITIAL tension will drop rapidly during the first few hours. Check tension during the first 24 hours of operation. Subsequent retensioning should fall between the minimum and maximum force.

To determine the deflection distance from normal position, use a straightedge or stretch a cord from sheave to sheave to use as a reference line. On multiple-belt drives an adjacent undeflected belt can be used as a reference.

Minimum deflection force values shown in table 1 are based on assumed average static tensions for drives having multiple belts or more than one V-band, thus eliminating calculations. (For drives using only one belt or one V-band, deflection force must be determined by use of engineering formulas.)

Find the minimum recommended deflection force for the belt section and type based upon the small sheave diameter, speed and drive ratio. For intermediate sheave diameters and/or drive ratio combinations, the minimum deflection force may be interpolated.

MAXIMUM Deflection Force = Minimum times 1.5

INITIAL Deflection Force = Minimum times 2.0

For Narrow Banded, Classical Banded, and Classical Cog Banded belts, multiply the minimum deflection force from table 1 by the number of belts in the band. Where larger values make use of the Force Deflection Method impractical, use the Elongation Method to tension V-bands.

Table 2. K FACTORS AND ARC OF CONTACT

D – d / C	Arc Contact Degree	Factor	
		Ac	K
0.000	180	1.000	24.750
0.025	179	0.997	24.883
0.050	177	0.994	25.019
0.075	176	0.990	25.158
0.100	174	0.987	25.300
0.125	173	0.983	25.444
0.150	171	0.980	25.591
0.175	170	0.977	25.742
0.200	169	0.973	25.896
0.225	167	0.969	26.053
0.250	166	0.966	26.213
0.275	164	0.962	26.377
0.300	163	0.958	26.545
0.325	161	0.954	26.717
0.350	160	0.951	26.892
0.375	158	0.947	27.072
0.400	157	0.943	27.257
0.425	155	0.939	27.445
0.450	154	0.935	27.639
0.475	153	0.930	27.837
0.500	151	0.926	28.040
0.525	150	0.922	28.249
0.550	148	0.917	28.463
0.575	147	0.913	28.684
0.600	145	0.908	28.910
0.625	144	0.904	29.142
0.650	142	0.899	29.381
0.675	141	0.894	29.627
0.700	139	0.889	29.881
0.725	137	0.884	30.142
0.750	136	0.879	30.411
0.775	134	0.874	30.688
0.800	133	0.869	30.975
0.825	131	0.864	31.270
0.850	130	0.858	31.576
0.875	128	0.852	31.892
0.900	127	0.847	32.219
0.925	125	0.841	32.558
0.950	123	0.835	32.909
0.975	122	0.829	33.273
1.000	120	0.823	33.652
1.025	118	0.816	34.045
1.050	117	0.810	34.454
1.075	115	0.803	34.879
1.100	113	0.796	35.323
1.125	112	0.789	35.786
1.150	110	0.782	36.270
1.175	108	0.774	36.777
1.200	106	0.767	37.307
1.225	104	0.759	37.864
1.250	103	0.751	38.448
1.275	101	0.742	39.064
1.300	99	0.734	39.713
1.325	97	0.725	40.398
1.350	95	0.716	41.123
1.375	93	0.706	41.892
1.400	91	0.697	42.709
1.425	89	0.687	43.580

Table 1. RECOMMENDED MINIMUM FORCE PER BELT

Belt Section		Small Sheave		Drive Ratio			
		Speed Range	Dia.	1.0	1.5	2.0	4.0 & Over
Narrow	3V	1200-3600	2.65	2.0	2.4	2.6	3.0
		1200-3600	3.65	2.8	3.6	3.8	4.2
		1200-3600	4.75	3.8	4.2	4.4	4.8
		1200-3600	5.60	4.2	4.6	4.8	5.4
		1200-3600	6.90	4.6	5.0	5.2	5.6
	5V	900-1800	7.1	8.5	9.5	10	11
		900-1800	9.0	10	11	12	13
		900-1800	14.0	12	13	14	15
		700-1200	21.2	14	15	16	17
	8V	900-1800	12.5	18	21	23	25
		900-1800	14.0	21	23	24	28
		700-1500	17.0	24	26	28	30
		700-1200	21.2	28	30	32	34
		400-1000	24.8	31	32	34	36
Narrow Cog	3VX	1200-3600	2.20	2.2	2.5	2.7	3.0
		1200-3600	2.50	2.6	2.9	3.1	3.6
		1200-3600	3.00	3.1	3.5	3.7	4.2
		1200-3600	4.12	3.9	4.3	4.5	5.1
		1200-3600	5.30	4.6	4.9	5.1	5.7
		1200-3600	6.9	5.0	5.4	5.6	6.2
	5VX	1200-3600	4.4	6.5	7.5	8.0	9.0
		1200-3600	5.2	8.0	9.0	9.5	10
		1200-3600	6.3	9.5	10	11	12
		1200-3600	7.1	10	11	12	13
		900-1800	9.0	12	13	14	15
		900-1800	14.0	14	15	16	17
Classical	AP	1800-3600	3.0	2.0	2.3	2.4	2.6
		1800-3600	4.0	2.6	2.8	3.0	3.3
		1800-3600	5.0	3.0	3.3	3.4	3.7
		1800-3600	7.0	3.5	3.7	3.8	4.3
	BP	1200-1800	4.6	3.7	4.3	4.5	5.0
		1200-1800	5.0	4.1	4.6	4.8	5.6
		1200-1800	6.0	4.8	5.3	5.5	6.3
		1200-1800	8.0	5.7	6.2	6.4	7.2
	CP	900-1800	7.0	6.5	7.0	8.0	9.0
		900-1800	9.0	8.0	9.0	10	11
		900-1800	12.0	10	11	12	13
		700-1500	16.0	12	13	13	14
	DP	900-1500	12.0	13	15	16	17
		900-1500	15.0	16	18	19	21
		700-1200	18.0	19	21	22	24
		700-1200	22.0	22	23	24	26
Classical Cog	AX	1800-3600	3.0	2.5	2.8	3.0	3.3
		1800-3600	4.0	3.3	3.6	3.8	4.2
		1800-3600	5.0	3.7	4.1	4.3	4.6
		1800-3600	7.0	4.3	4.6	4.8	5.3
	BX	1200-1800	4.6	5.2	5.8	6.0	6.9
		1200-1800	5.0	5.4	6.0	6.3	7.1
		1200-1800	6.0	6.0	6.4	6.7	7.7
		1200-1800	8.0	6.6	7.1	7.5	8.2
	CX	900-1800	7.0	10	11	12	13
		900-1800	9.0	11	12	13	14
		900-1800	12.0	12	13	13	14
		700-1500	16.0	13	14	14	15
	DX	900-1500	12.0	16	18	19	20
		900-1500	15.0	19	21	22	24
		700-1200	18.0	22	24	25	27
		700-1200	22.0	25	27	28	30

Tensioning V-Belt Drives

Force Deflection Engineering Formulas

For a more precise method, or where a V-drive combination is not within specified limits, table 1, use the following engineering formulas to determine force deflection values.

Step 1: Determine Span Length (t) and Deflection Height (h). Reference figure 2.

Step 2: Calculate the Static Strand Tension (Ts).

$$Ts = \frac{K \times DHP}{N \times S} + \frac{MS^2}{2}$$

Step 3: Calculate the recommended Deflection Forces (P) for drives using multiple belts or more than one V-band.

$$P_{Minimum} = \frac{Ts + Y}{16}$$

$$P_{Maximum} = \frac{1.5\,(Ts) + Y}{16}$$

$$P_{Initial} = 1.33 \text{ times } P_{Maximum}$$

Explanation of Symbols

A_C	=	Arc of contact – smaller sheave, degrees
C	=	Center distance, inches
D	=	Larger sheave pitch diameter, inches
d	=	Smaller sheave pitch diameter, inches
DHP	=	Design horsepower based upon the recommended application service factor
h	=	Deflection height, inches (Refer. figure 2)
K	=	Value from table 2 depending on $\frac{D-d}{C}$ or $K = 16.5\left(\frac{2.5 - A_c}{A_c}\right)$
L	=	Belt length, inches
M	=	Centrifugal constant table 3
N	=	Number of belts or V-band ribs
P	=	Deflection force, pounds
S	=	Belt speed, FPM/1000
t	=	Span length, inches (Refer. figure 2)
Y	=	Belt constant table 3

Note: For drives using only one belt or one V-band, and at least one shaft free to rotate use the following to determine the recommended Deflection Forces (P).

$$P_{Minimum} = \frac{Ts + Y\left(\frac{t}{L}\right)}{16} \qquad P_{Maximum} = \frac{1.5\,(Ts) + Y\left(\frac{t}{L}\right)}{16} \qquad P_{Initial} = 1.33 \text{ times } P_{Maximum}$$

Table 3. BELT CONSTANTS M AND Y

Factors	Narrow			Narrow Cog		Classical					Classical COG			
	3V	5V	8V	3VX	5VX	AP	BP	CP	DP	EP	AX	BX	CX	DX
M Single Belts	.46	1.23	3.28	.39	1.08	.66	1.08	1.98	3.74	5.85	.61	1.00	1.78	3.97
M V-Band	.51	1.32	3.80	.43	1.17	-	1.40	2.33	4.29	6.26	-	1.28	2.10	4.56
Y	4.0	12.00	22.00	7.0	20.0	6.0	9.0	16.0	30.00	45.00	7.0	10.00	28.00	82.00

Belt Elongation Method

This method is recommended for V-band drives where larger deflecting forces make the use of previously described methods impractical.

Elongation is related to the tension causing it; thus, tape measured V-band lengths, both slack and tight, can be used to obtain proper V-band tension.

Step 1: Decrease the center distance until the V-band(s) can be easily slipped into the sheave grooves. Forcing the belts on can damage the load-carrying cords and cause premature belt failure.

Step 2: With the V-band(s) still on the drive at NO tension, measure the outside circumference (slack O.C.) of the bands. Note: If retensioning a used drive, decrease the center distance until there is no tension on the band(s), then measure the outside circumference (slack O.C.) of the band(s).

Step 3: Determine the required Static Tension (Ts) per individual rib strand using the following formula.

$$Ts = \frac{K \times DHP}{N \times S} + \frac{MS^2}{2}$$

Step 4: Find a range of recommended tensions.
Lower Tension = Ts
Upper Tension = 1.5 times Ts

Step 5: Calculate minimum and maximum elongated band lengths for use in tensioning the drive.

a. From table 4, find length multipliers corresponding to the lower and upper Ts values in Step 4 above.

b. Multiply the slack O.C. found in Step 2 by the length multipliers to find the minimum and maximum elongated band lengths.

Step 6: Increase the drive center distance until a tape measurement of the band(s) O.C. is between the two values calculated for elongated band length Step 5b.

Step 7: Retension as required. New V-bands may lose tension rapidly during the run-in period and will probably require retensioning. V-bands that have been on a drive for some time may also require retensioning due to tension decay from normal use and wear.

Table 4. BELT LENGTH MULTIPLIERS FOR TENSIONING BANDED BELTS

Ts Per Strand (lbs.)	NARROW BANDED					CLASSICAL BANDED					CLASSICAL COG BANDED		
	CROSS SECTION												
	3V	5V		8V		BP		CP		DP	BX All Sizes	CX All Sizes	DX All Sizes
		5V1700 & under	5V1800 & over	8V1700 & under	8V1800 & over	BP144 & under	Over BP144	CP144 & under	Over CP144				
10	1.00186	1.00056	1.00001	1.00013	1.00010	1.00113	1.00141	1.00029	1.00052	1.00013	1.00082	1.00027	1.00013
12	1.00220	1.00068	1.00097	1.00016	1.00012	1.00135	1.00168	1.00035	1.00062	1.00016	1.00098	1.00032	1.00016
14	1.00254	1.00079	1.00113	1.00019	1.00014	1.00157	1.00194	1.00041	1.00072	1.00019	1.00114	1.00038	1.00019
16	1.00288	1.00090	1.00129	1.00021	1.00016	1.00178	1.00220	1.00046	1.00082	1.00021	1.00129	1.00043	1.00021
18	1.00320	1.00101	1.00144	1.00024	1.00018	1.00199	1.00246	1.00052	1.00092	1.00024	1.00145	1.00048	1.00024
20	1.00352	1.00112	1.00159	1.00027	1.00020	1.00220	1.00271	1.00058	1.00102	1.00027	1.00160	1.00054	1.00027
24	1.00414	1.00133	1.00190	1.00032	1.00024	1.00261	1.00320	1.00069	1.00122	1.00033	1.00191	1.00065	1.00032
28	1.00472	1.00155	1.00219	1.00037	1.00029	1.00301	1.00368	1.00081	1.00141	1.00038	1.00220	1.00075	1.00038
32	1.00520	1.00176	1.00249	1.00043	1.00033	1.00339	1.00414	1.00092	1.00161	1.00044	1.00250	1.00086	1.00043
36	1.00556	1.00197	1.00277	1.00048	1.00037	1.00377	1.00458	1.00104	1.00180	1.00050	1.00278	1.00097	1.00049
40	1.00588	1.00217	1.00305	1.00054	1.00042	1.00413	1.00500	1.00115	1.00199	1.00056	1.00306	1.00107	1.00054
45	1.00625	1.00243	1.00340	1.00060	1.00047	1.00458	1.00529	1.00129	1.00222	1.00063	1.00341	1.00121	1.00061
50	1.00659	1.00268	1.00374	1.00067	1.00053	1.00500	1.00553	1.00144	1.00246	1.00071	1.00374	1.00134	1.00068
55	1.00691	1.00293	1.00406	1.00074	1.00058	1.00528	1.00574	1.00158	1.00268	1.00078	1.00407	1.00147	1.00075
60	1.00722	1.00317	1.00438	1.00081	1.00064	1.00553	1.00591	1.00172	1.00291	1.00086	1.00439	1.00161	1.00081
65	1.00754	1.00341	1.00470	1.00088	1.00070	1.00576	1.00606	1.00186	1.00313	1.00094	1.00470	1.00174	1.00088
70	1.00787	1.00365	1.00500	1.00095	1.00076	1.00596	1.00620	1.00200	1.00335	1.00102	1.00500	1.00187	1.00095
75	1.00822	1.00389	1.00523	1.00101	1.00082	1.00614	1.00632	1.00214	1.00357	1.00110	1.00522	1.00200	1.00102
80	1.00861	1.00412	1.00545	1.00108	1.00088	1.00631	1.00644	1.00228	1.00378	1.00118	1.00543	1.00213	1.00109
85	1.00903	1.00434	1.00566	1.00115	1.00094	1.00646	1.00656	1.00242	1.00399	1.00127	1.00563	1.00227	1.00116
90	1.00949	1.00456	1.00586	1.00122	1.00100	1.00659	1.00668	1.00256	1.00420	1.00135	1.00581	1.00240	1.00123
95	1.01000	1.00478	1.00606	1.00129	1.00106	1.00672	1.00682	1.00270	1.00441	1.00144	1.00599	1.00253	1.00130
100	1.01056	1.00500	1.00625	1.00136	1.00113	1.00684	1.00697	1.00284	1.00461	1.00152	1.00616	1.00266	1.00137
120	1.01333	1.00561	1.00696	1.00164	1.00139	1.00727	1.00780	1.00339	1.00528	1.00188	1.00679	1.00319	1.00166
140	1.01692	1.00617	1.00765	1.00192	1.00166	1.00771	1.00912	1.00393	1.00579	1.00226	1.00736	1.00371	1.00195
160	1.02081	1.00672	1.00836	1.00220	1.00194	1.00827	1.01104	1.00447	1.00627	1.00265	1.00793	1.00423	1.00224
180	1.02385	1.00728	1.00913	1.00249	1.00223	1.00902	1.01357	1.00500	1.00675	1.00306	1.00854	1.00474	1.00253
200	1.02655	1.00787	1.01000	1.00277	1.00254	1.01000	1.01718	1.00534	1.00724	1.00349	1.00922	1.00525	1.00283
240	1.03118	1.00921	1.01213	1.00335	1.00319	1.01279	1.02268	1.00607	1.00832	1.00440	1.01090	1.00625	1.00343
280	1.03579	1.01088	1.01524	1.00395	1.00389	1.01663	1.02737	1.00692	1.00963	1.00542	1.01313	1.00724	1.00405
320	1.04070	1.01292	1.01834	1.00454	1.00461	1.02088	1.03275	1.00797	1.01124	1.00656	1.01590	1.00824	1.00468
360	1.04671	1.01562	1.02162	1.00515	1.00543	1.02423	1.03853	1.00926	1.01317	1.00771	1.01925	1.00924	1.00532
400	1.05308	1.01826	1.02526	1.00575	1.00631	1.02708	1.04393	1.01081	1.01580	1.00886	1.02229	1.01026	1.00598
450	-	1.02179	1.03056	1.00652	1.00744	1.03072	1.05000	1.01311	1.01877	1.01028	1.02625	1.01156	1.00683
500	-	1.02558	1.03643	1.00732	1.00859	1.03425	-	1.01610	1.02186	1.01164	1.03000	1.01292	1.00768
550	-	1.02927	1.04200	1.00813	1.00976	1.03781	-	1.01888	1.02500	1.01293	1.03354	1.01435	1.00856
600	-	1.03286	1.04642	1.00896	1.01094	1.04158	-	1.02169	1.02813	1.01413	1.03685	1.01557	1.00946
650	-	1.03632	1.05000	1.00982	1.01213	1.04567	-	1.02449	1.03123	1.01524	1.04000	1.01729	1.01037
700	-	1.03967	-	1.01071	1.01331	1.05000	-	1.02718	1.03426	1.01625	1.04333	1.01919	1.01130
750	-	1.04310	-	1.01163	1.01449	-	-	1.03000	1.03719	1.01718	1.04667	1.02126	1.01224
800	-	1.04655	-	1.01257	1.01571	-	-	1.03282	1.04000	1.01802	1.05000	1.02372	1.01320
850	-	1.05000	-	1.01354	1.01689	-	-	1.03563	1.04268	1.01833	-	1.02607	1.01418
900	-	-	-	1.01454	1.01887	-	-	1.03838	1.04524	1.01936	-	1.02840	1.01518
950	-	-	-	1.01561	1.01927	-	-	1.04101	1.04768	1.02044	-	1.03068	1.01619
1000	-	-	-	1.01667	1.02049	-	-	1.04345	1.05000	1.02156	-	1.03209	1.01717

Use Of Idlers - V-Belt Drives

Idlers are occasionally used in the design of classical and narrow V-belt drives for various reasons:

1. To provide take-up for fixed center drives.
2. To clear obstructions,
3. To subdue belt whip on long center drives.
4. To maintain tension when the idler is spring loaded or weighted.

Idlers should be avoided where possible because they either reduce the horsepower rating or shorten belt life. Idlers should be located, if at all possible, on the slack side of the drive. This is especially true when spring loaded or weighted idlers are being used. This keeps the spring force or the weight to a minimum. Caution should be exercised in applying spring loaded or weighted idlers to a reversing drive. In such a case the slack side can become the tight side, and vice versa. A common serious fault in designing drives is the use of idlers, which are too small. The use of such idlers introduces severe reverse ending stresses in the belt or belts, resulting in drastically reduced belt life.

Idlers may be placed either inside or outside the drive.

A flat idler pulley, either inside or outside, should be located as close as possible to the preceding sheave.

This is because V-belts move back and forth slightly on a flat pulley and locating it as far away from the next sheave minimizes the possibility of the belt entering that sheave in a misaligned condition.

OUTSIDE IDLERS

An outside idler increases the arc of contact, but the amount of take-up, in the case of take-up idlers, will be limited by the belt on the opposite side of the drive. Outside idlers are always flat because they contact the top of the V-belts. Outside flat idlers should be one third larger than the smallest loaded sheave. It should be remembered that the smallest loaded sheave should not be smaller than the minimum recommended diameter for the cross section.

INSIDE IDLERS

An inside idler decreases the arc of contact on the adjacent sheaves. Inside idlers may be either flat or grooved for classical V-belts, but in the case of narrow V-belt they should be a grooved sheave. An inside idler sheave may be located at any point along the span, preferably so that it gives nearly equal arcs of contact on the two adjacent sheaves. Inside idlers should be at least as large in diameter as the smallest loaded sheave.

IDLER MOUNTING

Mounting brackets for idlers should be sturdily constructed and meticulously aligned. It is frequently found that drive problems described as “belt stretch,” “belt instability,” “short belt life,” “belt roughness,” “belt vibration,” and many others are traceable to flimsy idler brackets, bearings, etc. the idler mounting must be designed to be capable of withstanding forces imposed by the operating belt tensions.

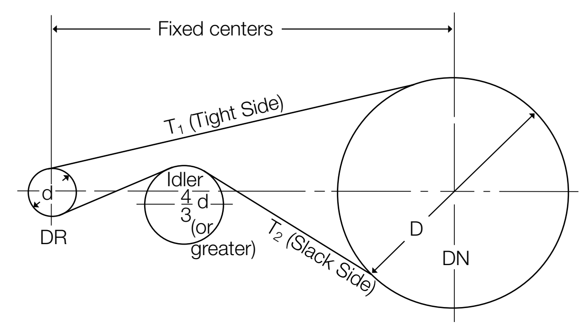
SERVICE FACTORS

If the above recommendations are followed it is possible to design satisfactory V-belt drives using idlers. However, idlers always impose an additional bending stress on the belt. This reduces the belt horsepower rating. This is reflected by an addition to the service factor when designing.

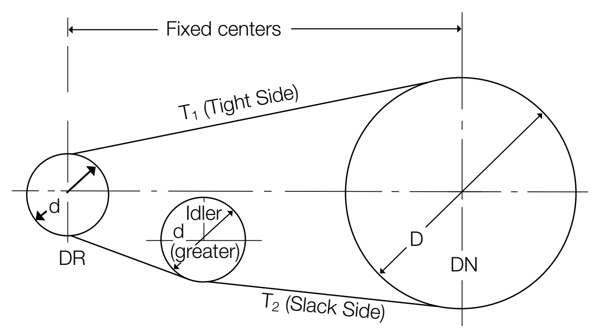
For each idler on the slack side (inside) add 0.0
For each idler on the slack side (outside) add 0.1
For each idler on the tight side (inside) add 0.1
For each idler on the tight side (outside) add 0.2

If the horsepower ratings are not reduced to account for the use of an idler, belt life will be reduced. The horsepower rating of a drive or its life expectancy is drastically reduced when idlers below the minimum recommended diameter are used. The bending stress induced in the belt becomes greater as the idler diameter becomes smaller.

CENTER DISTANCES MUST BE FIXED AND RIGID



Typical Outside Flat Idler Arrangement



Typical Inside Idler Arrangement

V-Flat Drive Selection

As the name indicates, a V-Flat drive is one which uses a grooved sheave and a flat pulley. Usually the sheave is the small wheel and the pulley is the large wheel. Such drives came into prominence during the period when a large number of flat-belt drives were being converted to use V-Belts. The reason for the use of V-Flat drives was that a more economical conversion could be made if the large pulley or flywheel already on hand did not have to be discarded.

The feasibility of the V-Flat drive is based on the arc of contact on the flat pulley. The arc of contact depends on the relative sheave and pulley diameters and the center distance. The best results are achieved when the drive combination results in a value as close as possible to:

$$\frac{D - d}{C} = .85 \text{ (arc of contact)}$$

Where:
D = large pulley diameter
d = small sheave diameter
C = center distance

A V-Flat drive will also operate at values other than "ideal"; however, it requires more tension to keep the belts from slipping on the flat pulley. The arc of contact determines whether a V-Flat drive is practical, and the value from the above formula must be over **.5** but not greater than **1.1**.

Before selecting a V-Flat drive, the following information pertaining to the application is required:

1. Horsepower, RPM, and Type of Prime Mover
2. Desired RPM and Type of DriveN Machine
3. Shaft Diameter of Prime Mover
4. Center Distance between shafts
5. Hours DriveN Machine will operate per day

In addition to above information, you will need to know several facts pertaining to the pulley:

1. Outside Diameter
2. Face Width
3. Straight or Crown

Preferably the pulley should be straight face for best operation. However, if the pulley is crowned (crown is the difference between the diameter at the center and edge of the pulley face) and does not exceed .125 inches per foot of face width, it can be used. Should the crown exceed .125 in./ft., it must be removed.

Note: Individual Narrow V-Belts (3VX, 5VX, 5V, 8VX, 8V) are NOT recommended for use on a V-Flat drive. Their relatively narrow "bottom" width makes them susceptible to turn over on the flat pulley. Classical, Classical Banded, Classical Cog Banded, and Narrow V-Belt Banded are ideally suited for V-Flat drives.

Step 1. Find the Design Horsepower
DHP = Prime Mover Horsepower or Brake Horsepower x Service Factor

Step 2. Choose the Belt Cross Section
Determine the optimum Belt Cross Section from either the Narrow or Classical Belt Cross Section Selection Chart.

Step 3. Find the Speed Ratio

$$\text{Speed Ratio} = \frac{\text{Faster RPM}}{\text{Slower RPM}}$$

(Continued)

Step 4.

A. Determine the Pitch Diameter of the large flat pulley by ADDING the proper value from the list below to the outside diameter of the pulley.

NARROW V-BELT (banded only)		
R3VX	R5V	R8V
.45”	.83”	1.41”

CLASSICAL SINGLE & BANDED			
AP	BP	CP	DP
.69”	.88”	1.13”	1.50”

B. Determine the Small Sheave Diameter

$$\text{Small Sheave P.D.} = \frac{\text{Flat Pulley P.D.}}{\text{Speed Ratio}}$$

Note: If the Prime Mover is an electric motor, check to see that the small sheave conforms to NEMA’s recommended minimum diameter. The use of a smaller motor sheave than recommended increases the bearing loads and should be approved by the motor manufacturer.

C. Refer to the stock sheave dimensional tables and look for a sheave with a P.D. close to the calculated diameter. If one doesn’t exist it may be necessary to order a special MTO to get the speed.

D. Check the rim speed using the formula listed. If the speed exceeds 6500 FPM the sheave and pulley will need to be special, contact TB Woods Engineering.

FPM = Small sheave outside diameter (in.) x .262 x Faster rpm

Step 5. Determine the Center Distance and Belt Length

A. If the center distance is unknown, use the following formula:

$$C = \frac{D - d}{.85}$$

D&d = Datum diameters

B. Once the center distance has been established, calculate a tentative belt length using the following:

$$L = 2C + 1.57\,(D + d) + \frac{(D - d)^2}{4C}$$

Refer to the stock belt tables and select a standard belt length closest to that calculated above.

Step 6. Determine the number of belts

A. Refer to the Horsepower Rating Tables for the belt cross section selected and find the Basic HP rating for the small sheave at the Faster RPM. Read across to the right and obtain the “Add-on” HP for the speed ratio at the faster RPM. Obtain the Lc factor for the belt chosen from the Belt Length Correction Tables. Refer to the table below to find the Ac correction factor.

$\frac{D-d}{C}$	Arc of Contact on Small Sheave	AC Factor V-Flat
.00	180	.75
.10	174	.76
.20	169	.78
.30	163	.79
.40	157	.81
.50	151	.82
.60	145	.83
.70	139	.84

$\frac{D-d}{C}$	Arc of Contact on Small Sheave	AC Factor V-Flat
.80	133	.86
.90	127	.85
1.00	120	.82
1.10	113	.80
1.20	106	.77
1.30	99	.73
1.40	91	.70
1.50	83	.65

Corrected HP per Belt = (Basic HP + Add-on) x Lc x Ac
Number of Grooves = Design HP/Corrected HP per Belt

V-Flat Drive Selection

(Continued)

Step 7. Determine Minimum Flat Pulley Face Width

Refer to the table below to make sure the Flat Pulley or Flywheel meets the required minimum face width.

No. Belts Per Drive	Conventional Cross Section			
	A *	B **	C	D
1	1-3/4”	2-1/4”	2-3/4”	3-3/4”
2	2-3/8”	3.0”	3-3/4”	5-3/16”
3	3.0”	3-3/4”	4-3/4”	6-5/8”
4	3-5/8”	4-1/2”	5-3/4”	8-1/16”
5	4-1/4”	5-1/4”	6-3/4”	9-1/2”
6	4-7/8”	6.0”	7-3/4”	10-15/16”
7	5-1/2”	6-3/4”	8-3/4”	12-3/8”
8	6-1/8”	7-1/2”	9-3/4”	13-13/16”
9	6-3/4”	8-1/4”	10-3/4”	15-1/4”
10	7-3/8”	9.0”	11-3/4”	16-11/16”
Add’l Belts (Add)	5/8”	3/4”	1.0”	1-7/16”

*For “A” groove sheave only
**For “B” or combination “A-B” sheave

No. Ribs Per Drive	Ultra-V Band Cross Section		
	R3V	R5V	R8V
2	2.4	3.3	4.6
3	2.8	4.0	5.8
4	3.2	4.7	6.9
5	3.6	5.4	8.0
6	4.0	6.0	9.1
7	4.4	6.7	10.3
8	4.8	7.4	11.4
9	5.2	8.1	12.5
10	5.6	8.8	13.6
Add’l Rib (Add)	.4	.7	1.1

Step 8. Flat Pulley Construction

V-Flat drives are usually capable of transmitting higher loads than the flat belt drives which they replace. If you are replacing a flat belt drive and using the existing flywheel or flat pulley already on the driveN machine, you know that the construction is adequate to carry the required load.

If you are designing a V-Flat drive for a new application the construction of the flat pulley must be checked for strength. Consult T.B. Wood’s Incorporated Engineering Department.

Step 9. Review the Drive Selected

At this point the sheave selected should be checked for stock groove availability and Sure-Grip bushing bore range. Refer to the Balance Chart and check the sheave selected to determine if Dynamic Balance is required.

Example

The following example is typical where the flat pulley diameter and belt section to use are spelled out by the user.

A V-flat drive is desired to connect a 50 HP 875 RPM motor to a single roll crusher at 250 RPM. The crusher already has a 35.5” OD x 8” wide flat flywheel which is to be used as the driven wheel. Operation will be 16 to 20 hours per day.
The center distance is approximately 37”. Use conventional “C” section belting.

PROCEDURE		SOLUTION
Step 1.	Find the Design Horsepower a. Choose service factor from page B2–23. b. Apply service factor to motor rating.	Service Factor = 1.5 DHP = 50 x 1.5 = 75
Step 2.	Find the Desired Speed Ratio a. Speed Ratio $= \frac{\text{Faster RPM}}{\text{Slower RPM}}$	$\frac{875}{250}$ = 3.5:1 ratio
Step 3.	Determine the Drive Pitch Diameters a. Determine the PITCH DIAMETER of the large flat pulley by adding the proper value from table to the outside diameter of the flat pulley. b. The small sheave PITCH DIAMETER is obtained by dividing the large pulley PD by the ratio. (This is above the recommended minimum sheave diameter of 9” from table on page B2–24.) c. Refer to stock sheave dimensions, page B2–8, and select closest stock pitch diameter. d. Check small sheave maximum safe operating surface speed using: OD x .262 x RPM.	35.5 + 1.13 = 36.63 $\frac{36.63}{3.5}$ = 10.47” PD stock sheave = 10.4 PD 2384 FPM – below the 6500 FPM max. limit
Step 4.	Determine the Belt Length a. Calculate a tentative belt length $(2)\ 37 + 1.57\ (36.63 + 10.4) + \frac{(36.63 - 10.4)^2}{4 \times 37} = 152.5”$ Closest stock belt is CP150 @ 152.9”	Actual CD = 37.2”
Step 5.	Determine the Number of Belts Required a. From the Horsepower Rating Tables obtain the “Basic” horsepower rating plus the “add-on” rating for the speed ratio. b. From the Belt Length Correction table obtain the length factor for the CP150 belt chosen. c. Using $\frac{D - d}{C} = \frac{36.63 - 10.4}{37.2} =$ .71 find the Ac correction factor from the table. d. Corrected HP per belt = Rated HP x Ac x Lc = 15.95 x 1.01 x .84 e. $\frac{\text{Design Horsepower}}{\text{HP per belt}} = \frac{75}{13.53} = 5.54$ • use 6 belts	Basic HP = 14.88 Add-on = 1.07 Rated HP = 15.95 Lc = 1.01 Ac = .84 HP per belt = 13.53 Number of Belts = 6
Step 6.	Minimum Flat Pulley Face Width a. Using the table check the existing pulley or flywheel face width versus the recommended minimum allowable.	Pulley Face = 8” Minimum = 7-3/4”
Step 7.	Flat Pulley Construction a. Construction okay as existing flywheel was designed to carry the required load.	Construction okay
Step 8.	Check Sheave Balance and Availability a. Using balance chart determine type of balance. b. The 10.4 P.D. x 6C is a stock sheave and takes an F bushing. Specify sheave part number by the datum diameter.	Static Balance 10.0 x 6C – F

Quarter Turn Drives

Quarter Turn Drives are used to transmit power from a vertical shaft to a horizontal shaft or vice versa. Such drives are commonly used from engines to vertical turbine pumps, and are found on many other types of applications.

To design a quarter turn drive, proceed as you would to select any other Classical or Narrow V-Belt drive, taking the following special points into consideration:

- Maximum speed ratio is 2.5 to 1. For greater speed ratios use a quarter turn drive from the driveR shaft to a jackshaft, and a straight V-drive or Synchronous drive between the jackshaft and the driven machine shaft. Provisions must be made for aligning and tensioning both drives.
- The Arc of Contact correction factor for quarter turn drives is 1.0.
- The direction of rotation must be such that the tight side of the drive is on the bottom.
- Deep groove sheaves should always be used on quarter turn drives.*
- Quarter turn drives require long centers to ensure the angle of entry and exit of the belts in the sheaves grooves is not more than 5 degrees. Therefore, a standard V-belt length should be chosen that will give a minimum center distance of:

C minimum = 5.5 (D + W)

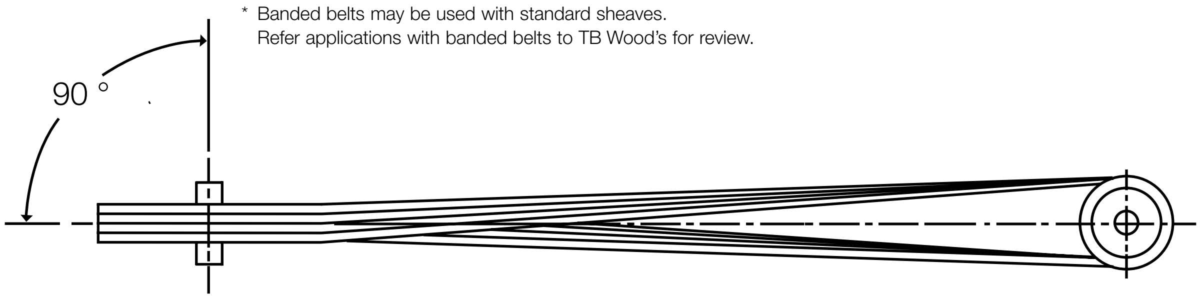
Where D = Large sheave diameter
W = The width of the belts as determined from table below
C = Center distance

WIDTH OF BELTS ON DEEP GROOVE SHEAVES (INCHES)

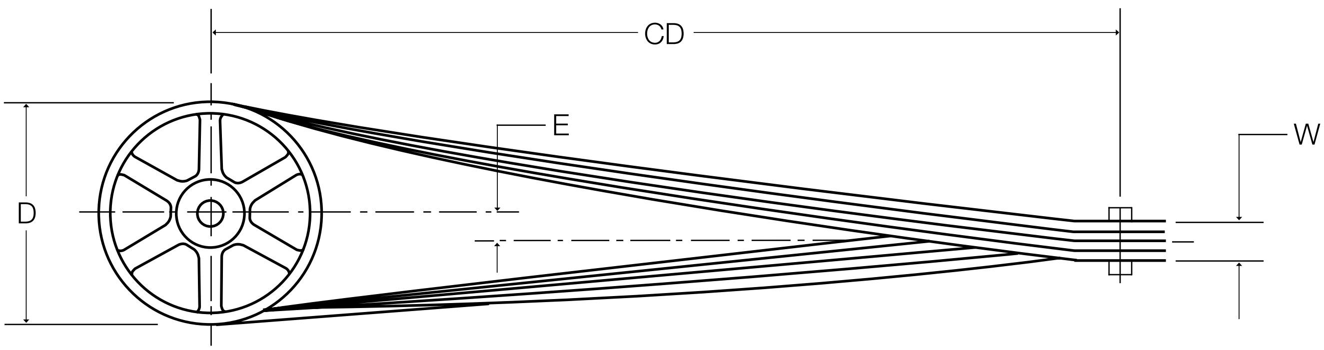
V-belt Section	Groove Type	Number of Belts									
		1	2	3	4	5	6	7	8	9	10
3VX	deep groove	.4	.9	1.4	1.9	2.4	2.9	3.4	3.9	4.4	4.9
5V/5VX	deep groove	.6	1.4	2.3	3.1	3.9	4.7	5.5	6.3	7.1	7.9
8V/8VX	deep groove	1.0	2.3	3.6	4.9	6.3	7.6	8.9	10.2	11.5	12.8
A	deep groove	.5	1.3	2.0	2.8	3.5	4.3	5.0	5.8	6.5	7.3
B	deep groove	.7	1.5	2.4	3.3	4.2	5.0	5.9	6.8	7.7	8.5
C	deep groove	.9	2.1	3.4	4.6	5.9	7.1	8.4	9.6	10.9	12.1
D	deep groove	1.3	3.0	4.8	6.5	8.3	10.0	11.8	13.5	15.3	17.0

Drive Alignment: When looking down on the drive (Top View), the sheaves should be installed so that a line from the center of the Vertical Shaft will pass through the center of the face of the sheave on the Horizontal Shaft. Both shafts should be at right angles to this line.

* Banded belts may be used with standard sheaves.
Refer applications with banded belts to TB Wood's for review.



When looking at the drive from the side (Side View), the center of the Horizontal Shaft should be above the center of the sheave on the Vertical Shaft by the amount given in the table below.



"E" DIMENSIONS FOR VARIOUS CENTER DISTANCES

Drive Center Distance	Narrow V-Belts	Classical Belts
20"	-	.2
30"	-	.2
40"	-	.4
50"	-	.4
60"	.2	.5
80"	.3	.5
100"	.4	1.0
120"	.6	1.5
140"	.9	2.0
160"	1.2	2.5
180"	1.5	3.5
200"	1.8	4.0
220"	2.2	5.0
240"	2.6	6.0

Belt tension: The proper belt tension procedure for a quarter turn drive is the same as any other V-belt drive and can be determined by referring to the belt tensioning section of this manual.

Quarter Turn Drives

Example

A quarter turn drive is required to connect a 40 HP 1800 RPM engine to a vertical turbine pump at 1020 RPM. Engine shaft is 1-3/4” and the pump shaft is 2”. The pump will operate continuously and the center distance is 90”.

PROCEDURE		SOLUTION
Step 1.	Find the Speed Ratio a. Speed Ratio $= \frac{\text{Faster RPM}}{\text{Slower RPM}}$ b. The ratio is less than the maximum allowable of 2.5. A drive design is possible.	$\frac{1800}{1020}$ = 1.76:1 ratio
Step 2.	Find the Design Horsepower a. Choose service factor from page B1-14 or B2-23. b. Apply Service Factor to Engine Rating.	Service Factor 1.2 DHP = 40 x 1.2 = 48
Step 3.	Choose the Belt Cross Section a. Refer to table on page B1-15 or B2-24	Belt Section: 5V/5VX
Step 4.	Determine Small Sheave Maximum Diameter a. O.D. $= \frac{\text{6500 FPM}}{\text{Faster RPM x .262}}$	$\frac{\text{6500 FPM}}{\text{1800 x .262}}$ = 13.7 O.D.
Step 5.	Select the Drive a. Refer to the Stock Drive Selection table page B1—42 and find the desired ratio or closest one to it. b. DriveR and DriveN sheave diameters. Note: If the prime mover is an electric motor, check to see that the motor sheave conforms to the NEMA minimum recommended diameter. c. Read across on this same line and find a preliminary C.D. of 87.5” with 5V2120 belt.	Find 1.77.1 DR: 8.5 DN: 15.0 Tentative C.D. = 87.5
Step 6.	Find Estimated Belt Horsepower and Number of Grooves. a. Refer to the 5V HP rating table on page B1-66. Find the basic HP rating plus the add-on HP for the small sheave at the faster RPM. b. Estimated HP per belt is 21.9 + 1.88 = 23.78. The Ac correction factor is always 1.0 on quarter turn drives. Belt length correction factor (Lc) is taken as 1.0 until the actual length is determined. c. Estimated number of belts $= \frac{\text{DHP}}{\text{HP per belt}}$ d. Width of band of belts from table = 1.4 e. Check C.D. required. CD = 5.5 (15 + 1.4) = 90.2 Refer to 5V drive tables, speed ratio 1.77, for the sheaves selected and select a belt that gives a C.D. greater than the minimum.	Basic = 21.9 Add-on = 1.88 HP per belt = 23.78 $\frac{48}{23.78}$ = 2.02 call 2 Minimum C.D. = 90.2” Actual C.D. = 93.5” Belts = 5V2240
Step 7.	Determine Actual Number of Grooves Required. a. From table on page B1-16 find the correction factor of 1.09 for the 5V2240 belt. b.Corrected HP per belt = 23.78 x 1.09 = 25.92 c. Number of belts $= \frac{\text{DHP}}{\text{HP per belt}} = \frac{48}{25.92} = 1.85$	Number of belts = 2
Step 8.	Specify Drive a. Check balance requirements and specify drive components. Remember deep groove sheaves are required for quarter turn drives.	5V 8.0 x 2 – SK x 1-3/4 5V15.0 x 2 – SF x 2 5V2240 – belts Above require deep grooves.

Belt Pull And Bearing Loads

The drive designer is often asked by the machine designer for the necessary data to calculate bearing loads. That portion of the total bearing load induced by the belt drive is a combination of load due to the sheave or pulley weight and belt pull. Sheave and pulley weights can be found in the appropriate tables included in this catalog. Belt pull can be calculated if the following drive data is known:

1. **Horsepower transmitted:** for a given set of sheaves, more horsepower requires more belt pull.

2. **Belt speed:** higher belt speed (larger sheave or pulley diameter) means less pull for the same horsepower load.

3. **Arc of contact:** reduced arc of contact (wrap) requires more tension to prevent slip, resulting in increased belt pull for the same horsepower load.

> NOTE: For a given diameter and load the required belt pull is independent of the number of V-belts used on a drive. The number of belts affects only the amount of overhung load from the center of belt pull to the bearings.

The approximate resultant belt pull of a V-belt drive installed with proper installation tension may be calculated from the following formula. This formula establishes the arithmetic sum of the tight and slack side tensions. The result does not include weight of the sheave.

FPM = Pitch diameter x RPM x .262 — for “Ac” Factor see chart on page BEV-3

Design Horsepower = driver horsepower x service factor.

Effective Pull = (33,000 x design horsepower) / FPM

Minimum Belt Pull = $\dfrac{[\,2.5-Ac]}{Ac}$ **x Effective Pull**

Maximum Belt Pull = 1.5 x Minimum Belt Pull

The result obtained from the above formula is a conservative estimate of the magnitude of the force. However, it does not establish the direction of the force on the bearings. Total belt pull will vary depending upon the tension applied to the belts.

BELT PULL AND BEARING LOADS (continued)

To determine the direction of the belt pull, it is first necessary to establish the magnitude of T_1 and T_2, the tight and slack side tensions respectively. Once these are established, it is then necessary to add them vectorially. To this vectorial sum can then be added the weight of the sheave. This must be added vectorially to the resultant belt pull.

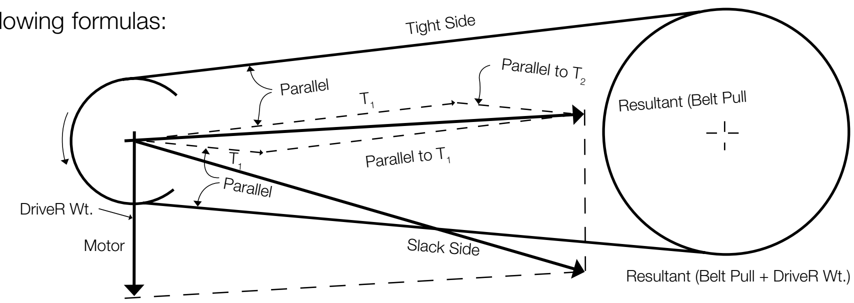
To determine T_1 and T_2 individually, use the following formulas:

$$T_1 \text{ Min.} = \frac{1.25 \times \text{Effective Pull}}{\text{Ac}}$$

$$T_1 \text{ Max.} = \frac{1.625 \times \text{Effective Pull}}{\text{Ac}}$$

$$T_2 \text{ Min.} = T_1 \text{ Min.} - \text{Effective Pull}$$

$$T_2 \text{ Max.} = T_1 \text{ Max.} - \text{Effective Pull}$$



GRAPHICAL ADDITION OF T_1, T_2 AND SHEAVE WEIGHT

BEARING LOAD CALCULATIONS

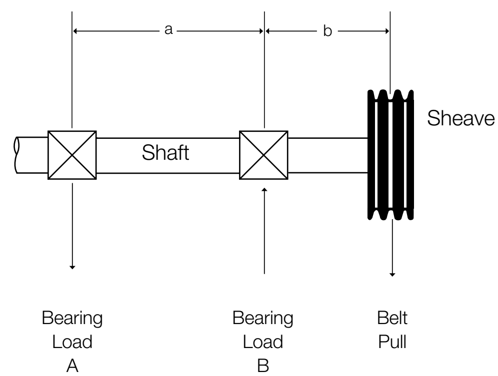
In order to find actual bearing loads, it is necessary to know weights of machine components and the value of all other forces contributing to the load. However, it is sometimes desired to know the bearing load contributed by the belt drive alone. You can find bearing load due to the drive if you know your bearing spacing with respect to the sheave center, and the belt pull as calculated above. To do this use the following formulas:

A. OVERHUNG SHEAVE

$$\text{Load at B, pounds} = \frac{\text{Belt Pull} \times (a + b)}{a}$$

$$\text{Load at A, pounds} = \text{Belt Pull} \times \frac{b}{a}$$

where: a and b = spacing, inches, per drawing at right



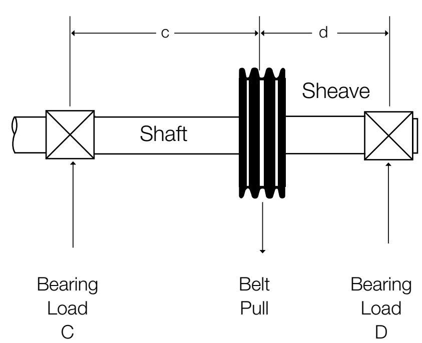
OVERHUNG SPROCKET

B. SHEAVE BETWEEN BEARINGS

$$\text{Load at D, pounds} = \frac{\text{Belt Pull} \times c}{(c + d)}$$

$$\text{Load at C, pounds} = \frac{\text{Belt Pull} \times d}{(c + d)}$$

where: c and d = spacing, inches, per drawing at right



SPROCKET BETWEEN BEARINGS