YORK INDUSTRIES

ENGINEERING STANDARDS

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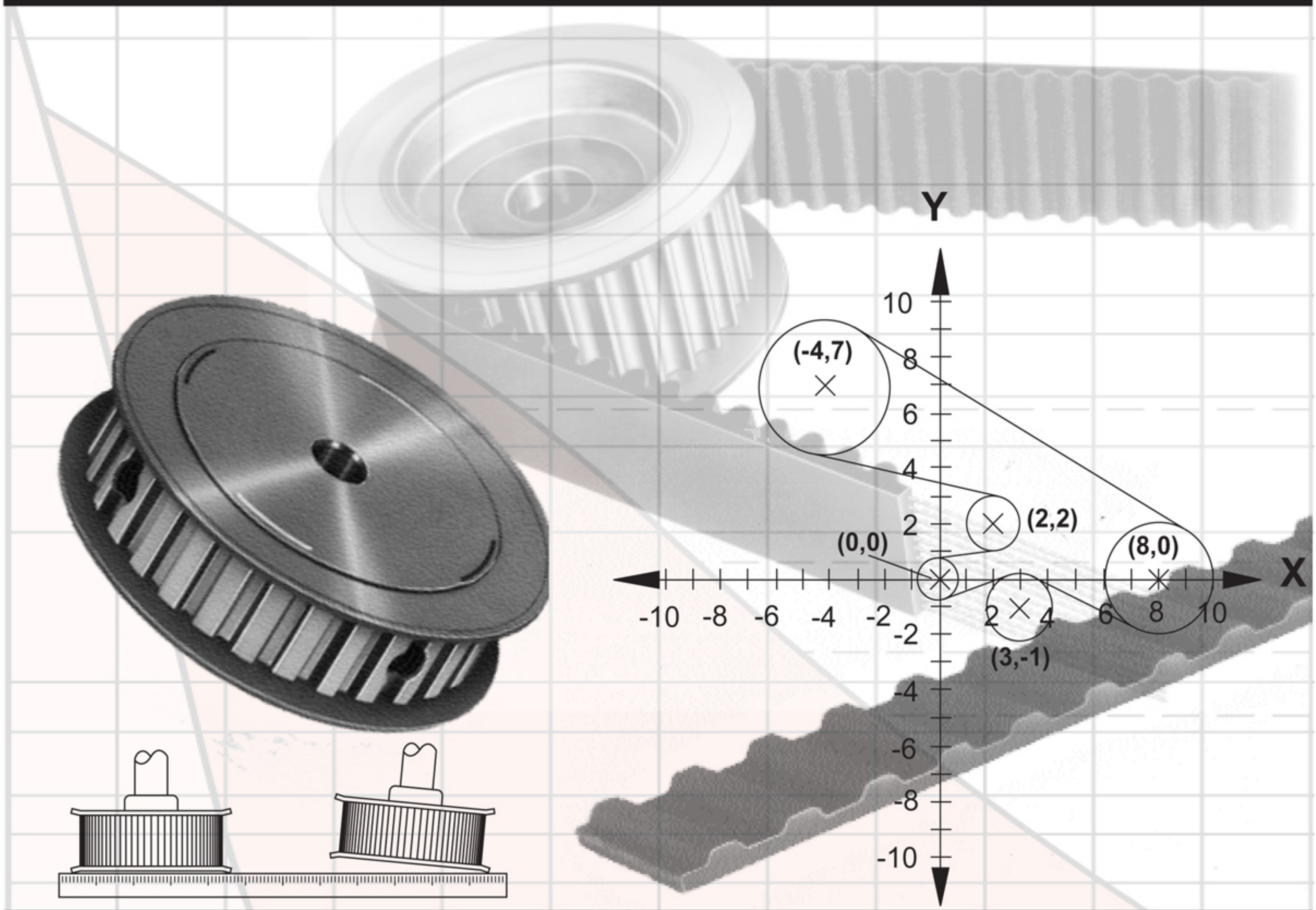
Facts, Formulas and Detailed Design Data



Synchronous Belt Drives

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Synchronous Belt Drives - Engineering Standards

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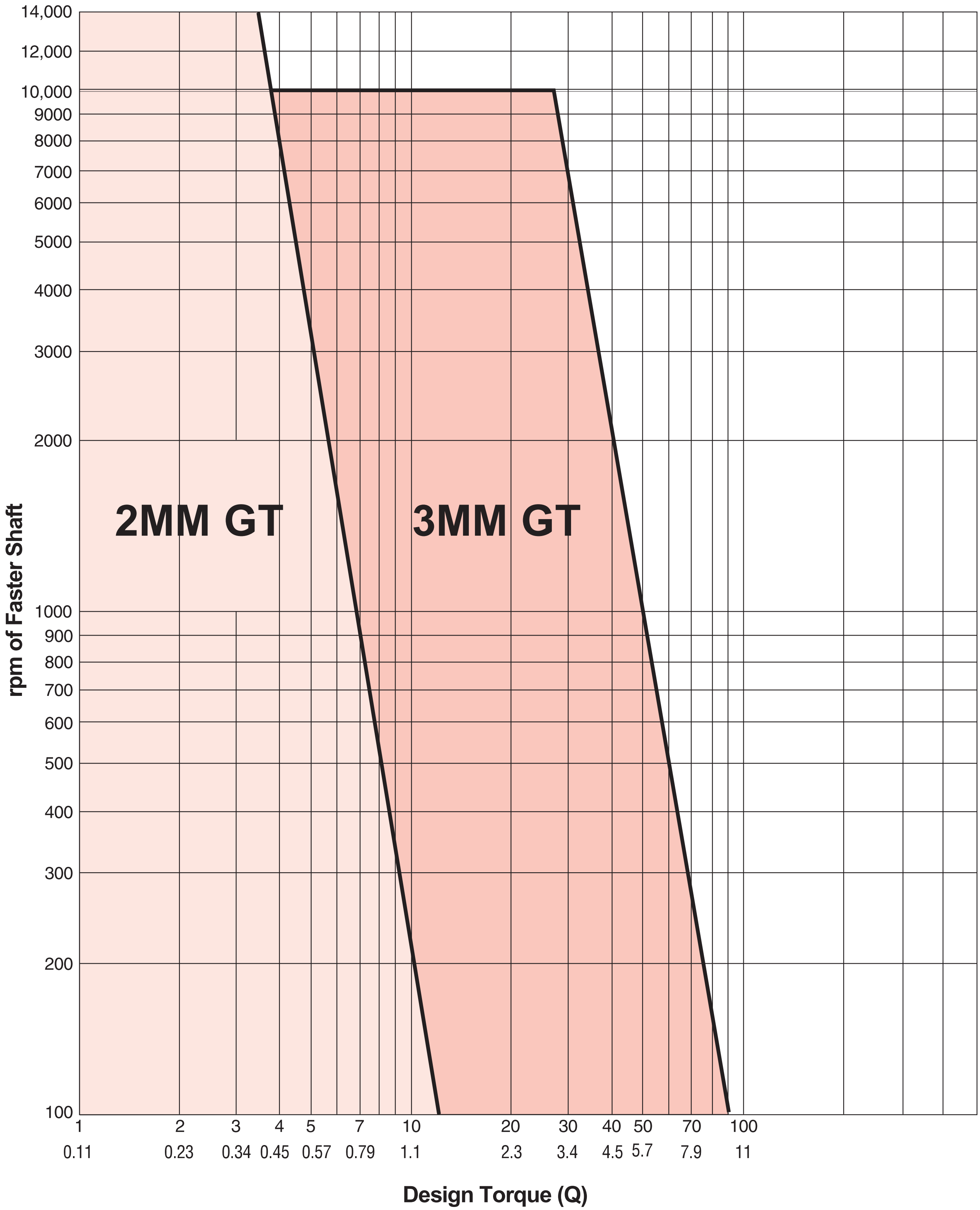
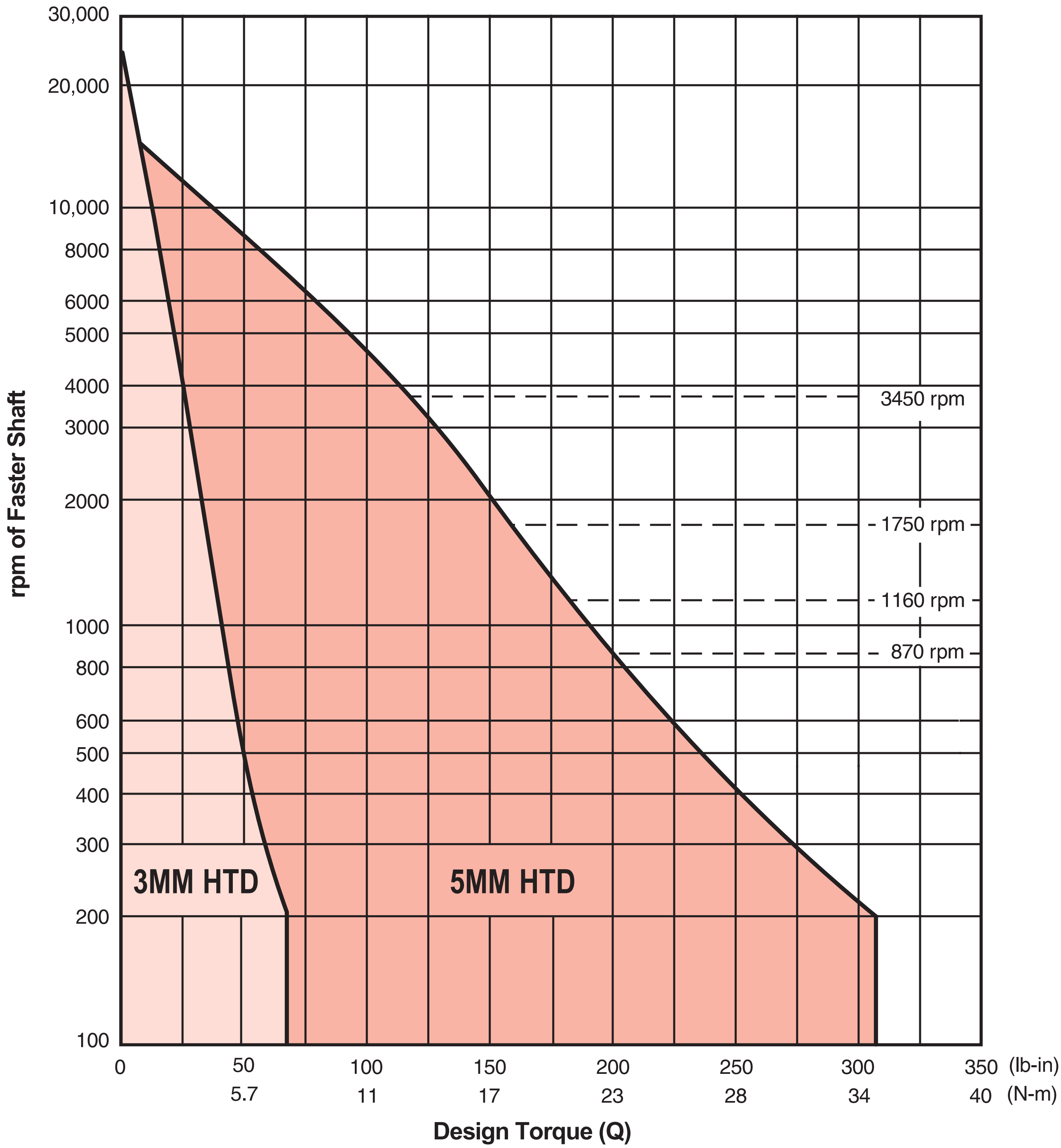
PowerGrip® GT® 2 Belt Drives

I. Belt Pitch Selection Guide



PowerGrip® HTD® Belt Drives

I. Belt Pitch Selection Guide



PowerGrip® HTD® Belt Drives

II. Belt Width Selection Tables - 5mm PowerGrip HTD Belts

The following table represents the torque ratings for each belt in its base width at the predetermined number of grooves, pitch diameters and rpm. These ratings must be multiplied by the appropriate width factor and applicable belt length factor to obtain the corrected torque rating.

Belt Width (mm)	9	15	25
Width Multiplier	1.0	1.89	3.38

Rated Torque (lb-in) For Small Sprocket - 9mm Belt Width

Number of Grooves	14	16	18	20	22	24	26	28	32	36	40	44	48	56	64	72
Pitch Diameter mm	22.28	25.46	28.65	31.83	35.01	38.20	41.38	44.56	50.93	57.30	63.66	70.03	76.39	89.13	101.86	114.59
Pitch Diameter (in)	.877	1.003	1.128	1.253	1.379	1.504	1.629	1.754	2.005	2.256	2.506	2.757	3.008	3.509	4.010	4.511
rpm of Faster Shaft																
10	19.0	22.3	25.7	29.3	33.0	36.9	40.9	45.1	53.8	63.1	73.0	83.5	94.5	113.3	129.5	145.7
20	19.0	22.3	25.7	29.3	33.0	36.9	40.9	45.1	53.8	63.1	73.0	83.5	94.5	113.3	129.5	145.7
40	19.0	22.3	25.7	29.3	33.0	36.9	40.9	45.1	53.8	63.1	73.0	83.5	94.5	113.3	129.5	145.7
60	19.0	22.3	25.7	29.3	33.0	36.9	40.9	45.1	53.8	63.1	73.0	83.5	94.5	113.3	129.5	145.7
100	19.0	22.3	25.7	29.3	33.0	36.9	40.9	45.1	53.8	63.1	73.0	83.5	94.5	113.3	129.5	145.7
200	19.0	22.3	25.7	29.3	33.0	36.9	40.9	45.1	53.8	63.1	73.0	83.5	94.5	113.3	129.5	145.7
300	17.3	20.2	23.3	26.5	29.9	33.3	36.9	40.6	48.3	56.5	65.2	74.4	84.0	100.4	114.8	129.1
400	16.2	18.9	21.8	24.7	27.8	31.0	34.3	37.7	44.8	52.3	60.2	68.5	77.2	92.2	105.3	118.5
500	15.3	17.9	20.6	23.4	26.3	29.3	32.4	35.6	42.2	49.2	56.5	64.3	72.3	86.2	98.5	110.8
600	14.7	17.2	19.7	22.4	25.1	28.0	30.9	33.9	40.2	46.8	53.7	61.0	68.5	81.7	93.3	104.9
700	14.2	16.5	19.0	21.6	24.2	26.9	29.7	32.6	38.6	44.9	51.5	58.3	65.5	78.0	89.1	100.1
800	13.7	16.0	18.4	20.9	23.4	26.0	28.7	31.5	37.2	43.3	49.6	56.1	63.0	74.9	85.5	96.2
870	13.5	15.7	18.0	20.4	22.9	25.5	28.1	30.8	36.4	42.3	48.4	54.8	61.4	73.0	83.4	93.7
1000	13.0	15.2	17.4	19.8	22.1	24.6	27.1	29.7	35.1	40.7	46.5	52.6	58.9	70.0	79.9	89.8
1160	12.6	14.7	16.8	19.1	21.3	23.7	26.1	28.6	33.7	39.1	44.6	50.4	56.4	66.9	76.3	85.7
1400	12.0	14.0	16.1	18.2	20.4	22.6	24.9	27.2	32.0	37.1	42.3	47.7	53.2	63.1	71.9	80.7
1450	11.9	13.9	15.9	18.0	20.2	22.4	24.6	27.0	31.7	36.7	41.9	47.2	52.7	62.4	71.1	79.8
1600	11.7	13.6	15.6	17.6	19.7	21.8	24.0	26.3	30.9	35.7	40.7	45.8	51.1	60.4	68.9	77.2
1750	11.4	13.3	15.2	17.2	19.2	21.3	23.5	25.6	30.1	34.8	39.6	44.6	49.7	58.7	66.8	74.9
1800	11.3	13.2	15.1	17.1	19.1	21.2	23.3	25.5	29.9	34.5	39.3	44.2	49.2	58.2	66.2	74.1
2000	11.1	12.9	14.7	16.6	18.6	20.6	22.7	24.7	29.0	33.5	38.1	42.8	47.6	56.2	63.9	71.4
2500	10.5	12.2	13.9	15.7	17.6	19.4	21.3	23.3	27.3	31.4	35.6	39.9	44.2	51.9	58.8	65.5
3000	10.0	11.7	13.3	15.0	16.7	18.5	20.3	22.1	25.8	29.7	33.5	37.5	41.5	48.5	54.6	60.5
3600	9.6	11.1	12.7	14.3	15.9	17.6	19.3	21.0	24.4	27.9	31.5	35.1	38.6	44.8	50.1	55.0
5000	8.8	10.2	11.6	13.1	14.5	15.9	17.4	18.9	21.8	24.7	27.6	30.4	33.1	37.4	40.6	43.0
8000	7.8	8.9	10.1	11.2	12.3	13.4	14.4	15.4	17.3	19.0	20.4	21.5	22.3			
10000	7.2	8.2	9.2	10.1	11.0	11.9	12.7	13.4	14.5	15.3						

Rated Torque (N-m)

rpm of Faster Shaft	14	16	18	20	22	24	26	28	32	36	40	44	48	56	64	72
10	2.1	2.5	2.9	3.3	3.7	4.2	4.6	5.1	6.1	7.1	8.3	9.4	10.7	12.8	14.6	16.5
20	2.1	2.5	2.9	3.3	3.7	4.2	4.6	5.1	6.1	7.1	8.3	9.4	10.7	12.8	14.6	16.5
40	2.1	2.5	2.9	3.3	3.7	4.2	4.6	5.1	6.1	7.1	8.3	9.4	10.7	12.8	14.6	16.5
60	2.1	2.5	2.9	3.3	3.7	4.2	4.6	5.1	6.1	7.1	8.3	9.4	10.7	12.8	14.6	16.5
100	2.1	2.5	2.9	3.3	3.7	4.2	4.6	5.1	6.1	7.1	8.3	9.4	10.7	12.8	14.6	16.5
200	2.1	2.5	2.9	3.3	3.7	4.2	4.6	5.1	6.1	7.1	8.3	9.4	10.7	12.8	14.6	16.5
300	2.0	2.3	2.6	3.0	3.4	3.8	4.2	4.6	5.5	6.4	7.4	8.4	9.5	11.3	13.0	14.6
400	1.8	2.1	2.5	2.8	3.1	3.5	3.9	4.3	5.1	5.9	6.8	7.7	8.7	10.4	11.9	13.4
500	1.7	2.0	2.3	2.6	3.0	3.3	3.7	4.0	4.8	5.6	6.4	7.3	8.2	9.7	11.1	12.5
600	1.7	1.9	2.2	2.5	2.8	3.2	3.5	3.8	4.5	5.3	6.1	6.9	7.7	9.2	10.5	11.9
700	1.6	1.9	2.1	2.4	2.7	3.0	3.4	3.7	4.4	5.1	5.8	6.6	7.4	8.8	10.1	11.3
800	1.6	1.8	2.1	2.4	2.6	2.9	3.2	3.6	4.2	4.9	5.6	6.3	7.1	8.5	9.7	10.9
870	1.5	1.8	2.0	2.3	2.6	2.9	3.2	3.5	4.1	4.8	5.5	6.2	6.9	8.2	9.4	10.6
1000	1.5	1.7	2.0	2.2	2.5	2.8	3.1	3.4	4.0	4.6	5.3	5.9	6.7	7.9	9.0	10.1
1160	1.4	1.7	1.9	2.2	2.4	2.7	3.0	3.2	3.8	4.4	5.0	5.7	6.4	7.6	8.6	9.7
1400	1.4	1.6	1.8	2.1	2.3	2.6	2.8	3.1	3.6	4.2	4.8	5.4	6.0	7.1	8.1	9.1
1450	1.3	1.6	1.8	2.0	2.3	2.5	2.8	3.0	3.6	4.1	4.7	5.3	6.0	7.0	8.0	9.0
1600	1.3	1.5	1.8	2.0	2.2	2.5	2.7	3.0	3.5	4.0	4.6	5.2	5.8	6.8	7.8	8.7
1750	1.3	1.5	1.7	1.9	2.2	2.4	2.7	2.9	3.4	3.9	4.5	5.0	5.6	6.6	7.6	8.5
1800	1.3	1.5	1.7	1.9	2.2	2.4	2.6	2.9	3.4	3.9	4.4	5.0	5.6	6.6	7.5	8.4
2000	1.3	1.5	1.7	1.9	2.1	2.3	2.6	2.8	3.3	3.8	4.3	4.8	5.4	6.3	7.2	8.1
2500	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	3.1	3.5	4.0	4.5	5.0	5.9	6.6	7.4
3000	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.9	3.4	3.8	4.2	4.7	5.5	6.2	6.8
3600	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.8	3.2	3.6	4.0	4.4	5.1	5.7	6.2
5000	1.0	1.2	1.3	1.5	1.6	1.8	2.0	2.1	2.5	2.8	3.1	3.4	3.7	4.2	4.6	4.9
8000	.9	1.0	1.1	1.3	1.4	1.5	1.6	1.7	2.0	2.1	2.3	2.4	2.5			
10000	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7						

Length Correction Factor			0.80	0.90	1.00	1.10	1.20
For Belt	From	Length (mm)	350	440	555	845	1095
		# of teeth	70	88	111	169	219
	To	Length (mm)	435	550	840	1090	1100 & up
		# of teeth	87	110	168	218	220 & up

Shaded area indicates sprocket and rpm that will result in reduced service life. Contact York Application Engineering for specific recommendations.

III. Operating Characteristics

NOTE: This engineering section provides general engineering information for synchronous belts and sprockets (or pulleys) which are useful in general drive design work. Where we refer to "sprockets" (for PowerGrip® GT® 2 and HTD belts), you can substitute "pulleys" for PowerGrip Timing Belts. If you need additional information, contact York Application Engineering.

A. Low Speed Operation

Synchronous drives are especially well suited for low speed-high torque applications. Their positive driving nature prevents potential slippage associated with V-belt drives, and even allows significantly greater torque carrying capability. Small pitch synchronous drives operating at speeds of 50 ft./min.(.25 m/s or less are considered to be low speed. Care should be taken in the drive selection process as stall and peak torques can sometimes be very high. While intermittent peak torques can often be carried by synchronous drives without special considerations, high cyclic peak torque loading should be carefully reviewed.

Proper belt installation tension and rigid drive bracketry and framework is essential in preventing belt tooth jumping under peak torque loads. It is also helpful to design with more than the normal minimum of 6 belt teeth in mesh to ensure adequate belt tooth shear strength.

Newer generation curvilinear systems like PowerGrip® GT®2 and PowerGrip HTD should be used in low speed-high torque applications, as PowerGrip Timing Belts are more prone to tooth jumping, and have significantly less load carrying capacity.

B. High Speed Operation

Synchronous belt drives are often used in high speed applications even though V-belt drives are typically better suited. They are often used because of their positive driving characteristic (no creep or slip), and because they require minimal maintenance (minimal stretch). A significant drawback of high speed synchronous drives is drive noise. High speed synchronous drives will nearly always produce more noise than V-belt drives. Small pitch synchronous drives operating at speeds in excess of 1300 ft/min (6.6 m/s) are considered to be high speed.

Special considerations should be given to high speed drive designs, as a number of factors can significantly influence belt performance. Cord fatigue and belt tooth wear are the two most significant factors that must be controlled to ensure success. Moderate sprocket diameters should be used to reduce the rate of cord flex fatigue. Designing with a smaller pitch belt will often provide better cord flex fatigue characteristics than a larger pitch belt. PowerGrip® GT® 2 is especially well suited for high speed drives because of its excellent belt tooth entry/exit characteristics. Smooth interaction between the belt tooth and sprocket groove minimizes wear and noise. Belt installation tension is especially critical with high speed drives. Low belt tension allows the belt to ride out of the driveN sprocket resulting in rapid belt tooth and sprocket groove wear

C. Smooth Running

Some ultra-sensitive applications require the belt drive to operate with as little vibration as possible, as vibration sometimes has an effect on the system operation or finished manufactured product. In these cases, the characteristics and properties of all appropriate belt drive products should be reviewed. The final drive system selection should be based upon the most critical design requirements, and may require some compromise.

Vibration is not generally considered to be a problem with synchronous belt drives. Low levels of vibration typically result from the process of tooth meshing and/or as a result of their high tensile modulus properties. Vibration resulting from tooth meshing is a normal characteristic of synchronous belt drives, and cannot be completely eliminated. It can be minimized by avoiding small sprocket diameters, and instead choosing moderate sizes. The dimensional accuracy of the sprockets also influences tooth meshing quality. Additionally the installation tension has an impact on meshing quality PowerGrip® GT® 2 drives mesh very cleanly resulting in the smoothest possible operation. Vibration resulting from high tensile modulus can be a function of sprocket quality. Radial run out causes belt tension variation with each sprocket revolution. V-belt sheaves are also manufactured with some radial run out, but V-belts have a lower tensile modulus resulting in less belt tension variation. The high tensile modulus found in synchronous belts is necessary to maintain proper pitch under load.

D. Drive Noise

Drive noise evaluation in any belt drive system should be approached with care. There are many potential sources of noise in a system including vibration from related components, bearings, and resonance and amplification through framework and panels.

Synchronous belt drives typically produce more noise than V -belt drives. Noise results from the process of belt tooth meshing and physical contact with the sprockets. The sound pressure level generally increases as operating speed and belt width increases, and as sprocket diameter decreases. Drives designed on moderate sprocket sizes without excessive capacity (over-designed) are generally the quietest. PowerGrip® GT® 2 drives have been found to be significantly quieter than other systems due to their improved meshing characteristics. Polyurethane belts generally produce more noise than neoprene belts. Proper belt installation tension is also very important in minimizing drive noise. The belt should be tensioned at a level that allows it to run with as little meshing interference as possible. See Belt Tensioning on page 8 for additional tensioning guidelines.

Drive alignment also has a significant effect on drive noise. Special attention should be given to minimizing angular misalignment (shaft parallelism). This assures that belt teeth are loaded uniformly and minimizes side tracking forces against the flanges. Parallel misalignment (sprocket offset) is not as critical of a concern so long as the belt is not trapped or pinched between opposite flanges. Refer to Drive Alignment on page 8 for more discussion on misalignment. Sprocket materials and dimensional accuracy also influence drive noise. Some users have found that steel sprockets are the quietest followed closely by aluminum. Polycarbonates have been found to be noisier than metallic materials. Machined sprockets are generally quieter than molded sprockets. The reasons for this revolve around material density and resonance characteristics as well as dimensional accuracy.

E. Static Conductivity

Small synchronous rubber or urethane belts can generate an electrical charge while operating on a drive. Factors such as humidity and operating speed influence the potential of the charge. If determined to be a problem, rubber belts can be produced in a conductive construction to dissipate the charge into the sprockets, and to ground. This prevents the accumulation of electrical charges that might be detrimental to material handling processes or sensitive electronics. It also greatly reduces the potential for arcing or sparking in flammable environments. Urethane belts cannot be produced in a conductive construction.

III. Operating Characteristics - continued

RMA has outlined standards for static conductive belts in their bulletin IP-3-3. Unless otherwise specified, York does not offer the synchronous rubber belt products included in this catalog to any specific conductivity standard. A static conductive construction for rubber belts is available on a made-to-order basis. Unless otherwise specified, conductive belts will be built to yield a resistance of 300,000 ohms or less when new. A static conductive belt has sufficient conductivity to prevent measurable static voltage buildup, thus preventing a static discharge.

When a belt is used in a hazardous environment, additional protection must be employed to assure that there are no accidental static spark discharges. The portion of the belt that contacts the sprocket must be conductive to ensure that static charge is conducted into the drive hardware. Synchronous belts must have a static conductive tooth surface in contact with conductive sprocket grooves.

Unusual or excessive debris or contaminant on the belt contact surface or sprocket grooves should be cleaned and removed.

Any belt drive system that operates in a potentially hazardous environment must be properly grounded. A continuous conductive path to ground is necessary to bleed off the static charge. This path includes a static conductive belt, a conductive sprocket, a conductive bushing, a conductive shaft, conductive bearings, and the ground. As an additional measure of protection, a static-conductive brush or similar device should be employed to bleed off any residual static buildup that might remain around the belt.
Non-conductive belt constructions are also available for rubber belts. These belts are generally built specifically to the customer's conductivity requirements. They are generally used in applications where one shaft must be electrically isolated from the other.

It is important to note that a static conductive belt cannot dissipate an electrical charge through plastic sprockets. At least one metallic sprocket in a drive is required for the charge to be dissipated to ground. A grounding brush or similar device can also be used to dissipate electrical charges. Urethane timing belts are not static conductive and cannot be built in a special conductive construction. Special conductive rubber belts should be used when the presence of an electrical charge is a concern.

F. Operating Environments

Synchronous drives are suitable for use in a wide variety of environments. Special considerations may be necessary, however, depending on the application.

Temperature: Either excessively high or low environmental temperatures can present problems to synchronous belts. The maximum recommended environmental temperature for stock belts is 185 deg. F (85 deg. C). Environmental temperatures beyond this result in gradual compound hardening as the vulcanization process continues. The belt will eventually begin cracking as it stiffens. A high temperature construction capable of a continuous environmental temperature of 230 deg. F (110 deg. C) and intermittent peaks up to 250 deg. F (121 deg. C) is available on a made-to-order basis.

Dust: Dusty environments do not generally present serious problems to synchronous drives as long as the particulates are fine and dry. Particulate matter will, however, act as an abrasive resulting in a higher rate of belt and sprocket wear. Damp or sticky particulate matter deposited and packed into sprocket grooves can cause belt tension to increase significantly. This increased tension can impact shafting, bearings, and framework. Electrical charges within a drive system can sometimes attract particulate matter.

Debris: Debris should be prevented from falling into any synchronous belt drive. Debris caught in the drive is generally either forced through the belt or results in a stalling of the system. In either case, serious damage occurs to the belt and related drive hardware.

Water: Light and occasional contact with water (occasional wash downs) should not seriously affect synchronous belts. Prolonged contact (constant spray or submersion) results in significantly reduced tensile strength in fiberglass belts, and potential length variation in aramid belts. Prolonged contact with water also causes rubber compounds to swell, although less than with oil contact. Internal belt adhesion systems are also gradually broken down with the presence of water. Additives to water such as lubricants, chlorine, anti corrosives, etc. can have a more detrimental effect on the belts than pure water. Urethane timing belts also suffer from water contamination. Polyester tensile cord shrinks significantly and experiences loss of tensile strength in the presence of water. Aramid tensile cord maintains its strength fairly well, but experiences length variation. Urethane swells more than neoprene in the presence of water. This swelling can increase belt tension significantly causing belt and related hardware problems.

Oil: Light contact with oils on an occasional basis will not generally damage synchronous belts. Prolonged contact with oil or lubricant, either directly or airborne, results in significantly reduced belt service. Lubricants cause the rubber compound to swell, break down internal adhesion systems, and reduce belt tensile strength. While alternate rubber compounds may provide some marginal improvement in durability, it is best to prevent oil from contacting synchronous belts.

Ozone: The presence of ozone can be detrimental to the compounds used in rubber synchronous belts. Ozone degrades belt materials in much the same way as excessive environmental temperatures. Although the rubber materials used in synchronous belts are compounded to resist the effects of ozone, eventually chemical break down occurs and they become hard and brittle and begin cracking. The amount of degradation depends upon the ozone concentration and time of exposure. For good performance of rubber belts, the following concentration levels should not be exceeded:(parts per hundred million)

Standard Construction: 100 pphm
Non Marking Construction: 20 pphm
Conductive Construction: 75 pphm
Low Temperature Construction: 20 pphm

Radiation: Exposure to gamma radiation can be detrimental to the compounds used in rubber and urethane synchronous belts. Radiation degrades belt materials much the same way excessive environmental temperatures do. The amount of degradation depends upon the intensity of radiation and the exposure time. For good belt performance, the following exposure levels should not be exceeded:

Standard Construction: 10^8 rads
Non Marking Construction: 10^4 rads
Conductive Construction: 10^6 rads
Low Temperature Construction: 10^4 rads

Dust Generation: Rubber synchronous belts are known to generate small quantities of fine dust as a natural result of their operation. The quantity of dust is typically higher for new belts, as they run in. The period of time for run in to occur depends upon the belt and sprocket size, loading, and speed. Factors

III. Operating Characteristics - continued

such as sprocket surface finish, operating speeds, installation tension, and alignment influence the quantity of dust generated.

Clean Room: Rubber synchronous belts may not be suitable for use in clean room environments where all potential contamination must be minimized or eliminated. Urethane timing belts typically generate significantly less debris than rubber timing belts. However, they are recommended only for light operating loads. Also, they cannot be produced in a static conductive construction to allow electrical charges to dissipate.

Static Sensitive: Applications are sometimes sensitive to the accumulation of static electrical charges. Electrical charges can affect material handling processes (like paper and plastic film transport), and sensitive electronic equipment. Applications like these require a static conductive belt so that the static charges generated by the belt can be dissipated into the sprockets, and to ground. Standard rubber synchronous belts do not meet this requirement, but can be manufactured in a static conductive construction on a made-to-order basis. Normal belt wear resulting from long term operation or environmental contamination can influence belt conductivity properties.

In sensitive applications, rubber synchronous belts are preferred over urethane belts since they cannot be produced in a conductive construction.

G. Belt Tracking

Lateral tracking characteristics of synchronous belts is a common area of inquiry. While it is normal for a belt to favor one side of the sprockets while running, it is abnormal for a belt to exert significant force against a flange resulting in belt edge wear and potential flange failure. Belt tracking is influenced by several factors. In order of significance, discussion about these factors is as follows:

Tensile Cord Twist: Tensile cords are formed into a single twist configuration during their manufacture. Synchronous belts made with only single twist tensile cords track laterally with a significant force. To neutralize this tracking force, tensile cords are produced in right and left hand twist (or S and Z twist) configurations. Belts made with S twist tensile cords track in the opposite direction of those built with Z twist cord. Belts made with alternating S and Z twist tensile cords track with minimal lateral force because the tracking characteristics of the two cords offset each other. The content of S and Z twist tensile cord varies slightly with every belt that is produced. As a result, every belt has an unpredictable tendency to track in either one direction or the other. When an application requires a belt to track in one specific direction only, a single-twist construction is used. Contact York Application Engineering for assistance in selecting the proper belt construction for special or unusual applications.

Angular Misalignment: Angular Misalignment, or shaft non parallelism, causes synchronous belts to track laterally. See Drive Alignment on page 8 for more on misalignment. The angle of misalignment influences the magnitude and direction of the tracking force. Synchronous belts tend to track downhill to a state of lower tension or shorter center distance.

Belt Width: The potential magnitude of belt tracking force is directly related to belt width. Wide belts tend to track with more force than narrow belts.

Sprocket Diameter: Belts operating on small sprocket diameters can tend to generate higher tracking forces than on large diameters. This is particularly true as the belt width approaches the sprocket diameter. Drives with sprocket diameters less than the belt width are not generally recommended because belt tracking forces can become excessive.

Belt Length: Because of the way tensile cords are applied on to belt molds, short belts can tend to exhibit higher tracking forces than long belts. The helix angle of the tensile cord decreases with increasing belt length.

Gravity: In drive applications with vertical shafts, gravity pulls the belt downward. The magnitude of this force is minimal with small pitch synchronous belts. Sag in long belt spans should be avoided by applying adequate belt installation tension.

Torque Loads: Sometimes while in operation, a synchronous belt will move laterally from side to side on the sprockets rather than operating in a consistent position. While not generally considered to be a significant concern, one explanation for this is varying torque loads within the drive. Synchronous belts sometimes track differently with changing loads. There are many potential reasons for this, the primary cause is related to tensile cord distortion while under pressure against the sprockets. Variation in belt tensile loads can also cause changes in framework deflection, and angular shaft alignment,resulting in belt movement.

Belt Installation Tension: Belt tracking is sometimes influenced by the level of belt installation tension. The reasons for this are similar to the effect that varying torque loads have on belt tracking.

When problems with belt tracking are experienced, each of these potential contributing factors should be investigated in the order that they are listed. In most cases, the primary problem will probably be identified before moving completely through the list.

H. Sprocket Flanging

Sprocket guide flanges are necessary to keep synchronous belts operating on their sprockets. As discussed previously in section G on belt tracking, it is normal for synchronous belts to favor one side of the sprockets when running.

Proper flange design is important in preventing belt edge wear, minimizing noise and preventing the belt from climbing out of the sprocket. Dimensional recommendations for custom-made or molded flanges are included in Table 16 on Page 22. Proper flange placement is important so that the belt is adequately restrained within its operating system. Because design and layout of small synchronous drives is so diverse, the wide variety of flanging situations potentially encountered cannot easily be covered in a simple set of rules without finding exceptions. Despite this, the following broad flanging guidelines should help the designer in most cases:

Two Sprocket Drives: On simple two sprocket drives, either one sprocket should be flanged on both sides, or each sprocket should be flanged on opposite sides.

Multi Sprocket Drives: On multiple sprocket (or serpentine) drives, either every other sprocket should be flanged on both sides, or every sprocket should be flanged on alternating sides around the system.

Vertical Shaft Drives: On vertical shaft drives, at least one sprocket should be flanged on both sides, and the remaining sprockets should be flanged on at least the bottom side.

III. Operating Characteristics - continued

Long Span Lengths: Flanging recommendations for small synchronous drives with long belt span lengths cannot easily be defined due to the many factors that can affect belt tracking characteristics. Belts on drives with long spans (generally 12 times the diameter of the smaller sprocket or more) often require more lateral restraint than with short spans. Because of this, it is generally a good idea to flange the sprockets on both sides.

Large Sprockets: Flanging large sprockets can be costly. Designers often wish to leave large sprockets unflanged to reduce cost and space. Belts generally tend to require less lateral restraint on large sprockets than small and can often perform reliably without flanges. When deciding whether or not to flange, the previous guidelines should be considered. The groove face width of unflanged sprockets should also be greater than with flanged sprockets. See Table 17 on Page 22 for specific recommendations.

Idlers: Flanging of idlers is generally not necessary. Idlers designed to carry lateral side loads from belt tracking forces can be flanged if needed to provide lateral belt restraint. Idlers used for this purpose can be used on the inside or backside of the belts. The previous guidelines should also be considered.

I. Servo & Stepper Motors

Within automated machinery, motors are commonly used to provide rotational energy for specific positioning and placement operations. Motor output requirements in these applications differ from conventional motors in that shaft rotation must be incremental in accurate steps, capable of starting / stopping / reversing, variable speed, and may not ever run at a fixed speed for an extended period of time. In these position control systems, the motor shaft rotational position and speed, as well as output torque, must be accurately controlled.

A special class of motors are required to provide accurate motion and position control for automated systems. This class is primarily comprised of servo motors and stepper motors. These motors are used in a broad range of products in a variety of applications. They are used in low cost computer printers to accurately position the print heads, in ATM machines and ticket dispensers to accurately increment rollers used in feeding and retrieving operations, in machine tools to accurately rotate precision lead screws and tool holders, etc.

Belt drives are sometimes used between precision motors and the final driven shafts for more compact motor placement, to multiply motor output torque, or to reduce motor output speed.

Belt Drive Design For Servo & Stepper Motors: Establishing a design torque load from DC servo or step motor drives when designing a new belt drive system is not always a straight forward process. Every application is unique in the way that it utilizes the available motor output torque. Few applications run continuously, as most motion control systems are used for incremental positioning and placement. Many systems reciprocate back and forth, alternate speed and/or direction, operate intermittently, etc. By the nature of their operational diversity, DC servo and step motor drive systems may utilize maximum, stall, or holding motor torque at some periodic frequency. While system duty cycle data is useful, the designer must still determine how to size a belt drive for the estimated system loads.While this determination is dependent upon many factors (design life, drive rigidity, equipment operation / usage, belt installation tension, etc.) and its basis may differ in every case, some rough guidelines from which to start may be useful.

In many DC servo or step motor drives, maximum, stall, or holding torque loads are considerably greater than continuous or intermittent loads. In addition, maximum, stall, and holding torque loads are seen on an intermittent basis. In these cases it is reasonable to size a belt drive for either the maximum, stall, or holding motor torque load rating (depending upon the system's operation) with a design service factor of 1.0. The capacity of the proposed belt drive should then be compared with normal system running loads (carried the majority of the time) to make sure that the selected belt drive will provide a design service factor within a typical range of 1.5 to 2.0.

Contact York for assistance in designing belt drive systems with servo and stepper motors.

J. Registration

The three primary factors contributing to belt drive registration (or positioning) errors are belt elongation, backlash, and tooth deflection. When evaluating the potential registration capabilities of a synchronous belt drive, the system must first be determined to be either static or dynamic in terms of its registration function and requirements.

Static Registration: A static registration system moves from its initial static position to a secondary static position. During the process the designer is concerned only with how accurately and consistently the drive arrives at its secondary position. Potential registration errors that occur during transport are not considered. Therefore, the primar y factor contributing to registration error in a static registration system is backlash. The effects of belt elongation and tooth deflection do not have any influence on the registration accuracy of this type of system.

Dynamic Registration: A dynamic registration system is required to perform a registering function while in motion with torque loads varying as the system operates. In this case, the designer is concerned with the rotational position of the drive sprockets with respect to each other at every point in time. Therefore, belt elongation, backlash, and tooth deflection will all contribute to registrational inaccuracies.

Further discussion about each of the factors contributing to registration error is as follows:

Belt Elongation: Belt elongation, or stretch, occurs naturally when a belt is placed under tension. The total tension exerted within a belt results from installation as well as working loads. The amount of belt elongation is a function of the belt tensile modulus, which is influenced by the type of tensile cord and the belt construction. The standard tensile cord used in rubber synchronous belts is fiberglass. Fiberglass has a high tensile modulus, is dimensionally stable, and has excellent flex-fatigue characteristics. If a higher tensile modulus is needed, aramid tensile cords can be considered, although they are generally used to provide resistance to harsh shock and impulse loads. Aramid tensile cords used in small synchronous belts generally have only a marginally higher tensile modulus in comparison to fiberglass. When needed, belt tensile modulus data is available from York Engineering.

Backlash:
Backlash in a synchronous belt drive results from clearance between the belt teeth and the sprocket grooves. This clearance is needed to allow the belt teeth to enter and exit the grooves smoothly with a minimum of interference. The amount of clearance necessary depends upon the belt tooth profile. PowerGrip® Timing Belt Drives are known for having relatively little backlash. PowerGrip® GT® 2 Drives have improved torque carrying capability and resist ratcheting, but have a significant amount of backlash. PowerGrip® GT® 2 Drives have even further improved torque carrying capability, and have as little or less

backlash than PowerGrip Timing Belt Drives. In special cases, alterations can be made to drive systems to further decrease backlash. These alterations typically result in increased belt wear, increased drive noise and shorter drive life. Contact York Engineering for additional information.

Tooth Deflection: Tooth deformation in a synchronous belt drive occurs as a torque load is applied to the system, and individual belt teeth are loaded. The amount of belt tooth deformation depends upon the amount of torque loading, sprocket size, installation tension and belt type. Of the three primary contributors to registration error, tooth deflection is the most difficult to quantify. Experimentation with a prototype drive system is the best means of obtaining realistic estimations of belt tooth deflection.

Additional guidelines that may be useful in designing registration critical drive systems are as follows:

- PowerGrip® GT® 2 or PowerGrip Timing Drives.
- Design with large sprockets with more teeth in mesh.
- Keep belts tight, and control tension closely.
- Design frame/shafting to be rigid under load.
- Use high quality machined sprockets to minimize radial run out and lateral wobble.

IV. Drive Alignment

A. Angular And Parallel

Drive misalignment is one of the most common sources of drive performance problems. Misaligned drives can exhibit symptoms such as high belt tracking forces, uneven belt tooth wear, high noise levels, and tensile cord failure. The two primary types of drive misalignment are angular and parallel. Discussion about each of these types are as follows:

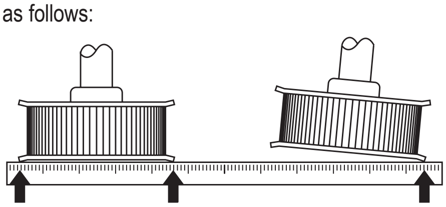


Figure 1 - Angular Misalignment

Angular: Angular misalignment results when the drive shafts are not parallel (see Fig. 1). As a result, the belt tensile cords are not loaded evenly, resulting in uneven tooth / land pressure and wear. The edge cords on the high tension side are often overloaded. Overloading often results in an edge cord failure that propagates across the entire belt width. Angular misalignment often results in high belt tracking forces as well. High tracking forces cause accelerated belt edge wear, sometimes leading to flange failure or belts tracking off of the sprockets.

Parallel: Parallel misalignment results from sprockets being mounted out of line from each other (see Fig.2). Parallel misalignment is generally more of a concern with V-type belts than with synchronous belts because V-type belts run in grooves and are unable to free float on the sheaves.

Synchronous belts will generally free float on the sprockets and essentially self align themselves as they run. This self aligning can occur so long as the sprockets have sufficient groove face width beyond the width of the belts. If not, the belts can become trapped between opposite sprocket flanges causing serious performance problems. Parallel misalignment is not generally a significant concern with synchronous drives so long as the belts do not become trapped or pinched between opposite flanges. For recommendations on sprocket groove face width, see Table 17 on Page 22.

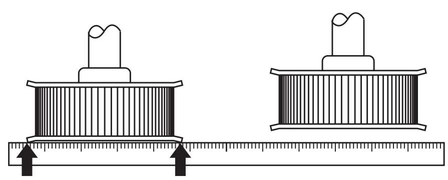


Figure 2 - Parallel Misalignment

Allowable Misalignment: In order to maximize performance and reliability, synchronous drives should be aligned closely. This is not, however, always a simple task in a production environment. The maximum allowable misalignment, angular and parallel combined, is 1/4".

B. Practical Tips

Angular misalignment is not always easy to measure or quantify. It is sometimes helpful to use the observed tracking characteristics of a belt, to make a judgment as to the systems relative alignment. Neutral tracking S and Z synchronous belts generally tend to track "down hill" or to a state of lower tension or shorter center distance when angularly misaligned. This may not always hold true since neutral tracking belts naturally tend to ride lightly against either one flange or the other due to numerous factors discussed in section G., Belt Tracking on Page 6. This tendency will generally hold true with belts that track hard against a flange. In those cases, the shafts will require adjustment to correct the problem.

Parallel misalignment is not often found to be a problem in synchronous belt drives. If clearance is always observable between the belt and all flanges on one side, then parallel misalignment should not be a concern.

V. Belt Tensioning

A. What Is Proper Installation Tension

One of the benefits of small synchronous belt drives is lower belt pre-tensioning in comparison to comparable V-belt drives, proper installation tension is still important in achieving the best possible drive performance. In general terms, belt pre-tensioning is needed for proper belt/sprocket meshing to prevent belt ratcheting under peak loading, to compensate for initial belt tension decay, and to pre-stress the drive framework. The amount of installation tension that is actually needed is influenced by the type of application as well as the system design. Some general examples of this are as follows:

Motion Transfer Drives: Motion transfer drives, by definition, are required to carry extremely light torque loads. In these applications,belt installation tension is needed only to cause the belt to conform to and mesh properly with the sprockets. The amount of tension necessary for this is referred to as the minimum tension (Tst). Minimum tensions on a per span basis are included in Table 1 on page 9. Some motion transfer drives carry very little torque, but have tight registration requirements. These systems may require additional static (or installation) tension in order to minimize registration error.

Normal Power Transmission Drives: Normal power transmission drives should be designed in accordance with published torque ratings and a reasonable service factor (between 1.5 and 2.0). In these applications, belt installation tension is needed to allow the belt to maintain proper fit with the sprockets while under load, and to prevent belt ratcheting under peak loads. For these drives, proper installation tension can be determined using two different approaches. If torque loads are known and well defined, and an accurate tension value is desired, Formula 1, page 9 should be used. If the torque loads are not as well defined, and a quick value is desired for use as a starting point, values from Table 2 can be used. All static tension values are on a per span basis.

V. Belt Tensioning - continued

Formula 1

$$T_{st} = \frac{1.21\,Q}{d} + mS^2 \text{, lb.}$$

Where: T_{st} = Static Tension per span, pounds

Q = driveR torque load, pound inches

d = driveR pitch diameter, inches

S = Belt Speed/1000, feet per minute

Belt Speed = (driveR pitch diameter x driveR rpm)/3.82

m = Mass factor from Table 1

Table 1

Belt Section	Belt Width	m	Y	Minimum T_{st} (lb) Per Span
2MM GT2	4mm	0.026	1.37	1.3
	6mm	0.039	2.05	2.0
	9mm	0.058	3.08	3.0
	12mm	0.077	4.10	4.0
3MM GT2	6mm	0.077	3.22	2.2
	9mm	0.120	4.83	3.3
	12mm	0.150	6.45	4.4
	15mm	0.190	8.06	5.5
5MM GT2	9mm	0.170	14.90	8.4
	12mm	0.280	24.90	14.1
	15mm	0.380	33.20	18.7
	25mm	0.470	41.50	23.4
3MM HTD	6mm	0.068	3.81	2.5
	9mm	0.102	5.71	4.3
	15mm	0.170	9.52	7.8
5MM HTD	9mm	0.163	14.90	6.3
	15mm	0.272	24.90	12.0
	25mm	0.453	41.50	21.3
MXL	1/8"	0.003	1.40	1.0
	3/16"	0.004	2.11	1.7
	1/4"	0.005	2.81	2.3
XL	1/4"	0.070	3.30	3.2
	3/8"	0.105	4.94	5.1

Note: If the value of T_{st} calculated with Formula 1 is less than the minimum T_{st} value in Table 1, use the Minimum T_{st} value from the table for T_{st} in all further belt tension calculations. The minimum value must be used on lightly loaded drives to ensure that belts wrap and mesh properly with the sprockets.

Registration Drives: Registration drives are required to register, or position, accurately (see section J. Registration on Page 7). Higher belt installation tensions help in increasing belt tensile modulus as well as in increasing meshing interference, both reducing backlash. Tension values for these applications should be determined experimentally to confirm that desired performance characteristics have been achieved. As a beginning point, use values from Table 2 multiplied by 1.5 to 2.0.

Table 2 - Static BeltTension - General Values Tst (lb) Per Span

PowerGrip® GT® 2 Belt Widths

Section	4 mm	6 mm	9 mm	12 mm	15 mm	20 mm	25 mm
2MM GT2	3	4	6	8	-	-	-
3MM GT2	-	15	23	30	38	50	-
5MM GT2	-	-	30	40	50	67	84

PowerGrip HTD Belt Widths

Section	4 mm	6 mm	9 mm	12 mm	15 mm	20 mm	25 mm
3MM	-	9	15	21	27	40	-
5MM	-	-	16	-	30	42	54

PowerGrip Timing Belt Widths

Section	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"
MXL	2	3	4	4	5	-	-
XL	-	-	5	6	7	8	10

Most synchronous belt applications often exhibit their own individual operating characteristics. The static installation tensions recommended in this catalog should serve as a general guideline in determining the level of tension required. The drive system should be thoroughly tested to confirm that it performs as intended. Consult York Engineering for further guidance.

B. Making Measurements

Belt installation tension is generally measured in the following ways:

Force/Deflection: Belt span tension can be measured by deflecting a belt span 1/64" per inch of span length at mid-span, with a known force (see Fig. 3). This method is generally convenient, but not always very accurate due to difficulty in measuring small deflections and forces common in small synchronous drives. The force/deflection method is most effective on larger drives with long span lengths. The static or installation tension (T_{st}) can either be calculated from Formula 1 or selected from Table 1 or Table 2. The deflection forces can be calculated from Formula 3 and Formula 4. The span length can either be calculated from Formula 2 If the calculated static tension is less than the minimumT_{st} values in Table 1,use the minimum values.

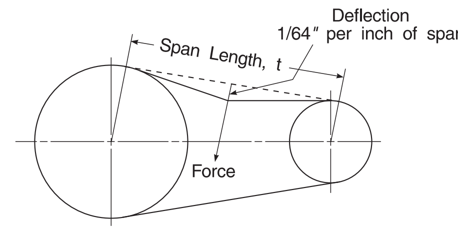


Figure 3 - Belt Deflection Distance

Formula 2

$$t = \sqrt{CD^2 - \left(\frac{PD - pd}{2}\right)^2}$$

Where: t = span length, inches

CG = Drive center distance

PD = Large pitch diameter, inches

pd = Small pitch diameter, inches

Formula 3

$$\text{Deflection force, Min.} = \frac{T_{st} + \left(\frac{t}{L}\right)Y}{16} \text{, lb.}$$

Formula 4

$$\text{Deflection force, Max.} = \frac{1.1\,T_{st} + \left(\frac{t}{L}\right)Y}{16} \text{, lb.}$$

Where: T_{st} = Static tension, pounds

t = span length, inches

L = belt pitch length, inches

Y = constant from Table 1

Synchronous Belt Drives - Engineering

V. Belt Tensioning - continued

Shaft Separation: Belt installation tension can be applied directly by exerting a force against either the driveR or drivenN shaft in a simple 2 point drive system (see Fig.4). The resulting belt tension will be accurate as the force applied to the driveR or driveN shaft. This method is considerably easier to perform than the force/deflection method, and in some cases more accurate.

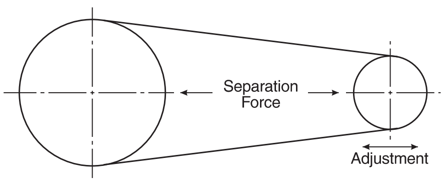


Figure 4 - Shaft Separation

In order to calculate the required shaft separation force, the proper static tension (on a per span basis) should first be determined as previously discussed. This tension value will be present in both belt spans as tension is applied. The angle of the spans with respect to the movable shaft should then be determined. The belt spans should be considered to be vectors (force with direction), and be summed into a single tension vector force (see Fig. 5). Refer to Belt Pull on pages 13 and 14 for further instructions on summing vectors.Contact York Engineering for assistance if needed.

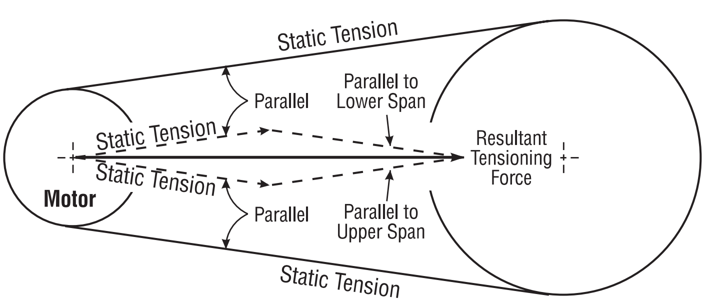


Figure 5 - Vector Addition

Idler Force: Belt installation tension can also be applied by exerting a force against an idler sprocket within the system that is used to take up belt slack (see Fig.6). This force can be applied manually, or with a spring. Either way, lthe idler should be locked down after the appropriate tension has been applied.

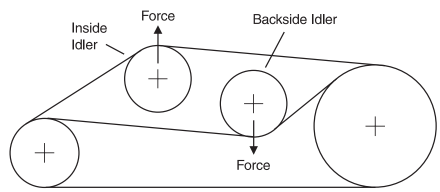


Figure 6 - Idler Force

Calculating the required force will involve a vector analysis as described above in the shaft separation section. Contact York Engineering for assistance if needed.

Sonic Tension Meter: The Sonic Tension Meter is an electronic device that measures the natural frequency of a free stationary belt span and instantly computes the static belt tension based upon the belt span length, belt width, and belt type. This provides accurate and repeatable tension measurements while using a non-intrusive procedure (the measurement process itself doesn't change the belt span tension). A measurement is made simply by plucking the belt while holding the sensor close to the vibrating belt span.

The unit is a bit larger than a cell phone (6" long x 2" wide x 1" thick) so it can be easily handled. The sensor is about 1/2" in diameter for use in cramped spaces, and the unit is battery operated. The unit measures virtually all types of Light Power & Precision belts.

Contact York Engineering for further technical details. Contact York for price and availability.

VI. Installation and Take Up

A. Installation Allowance

When designing a drive system for a production product, allowance for belt installation must be built into the system. While specific installation allowances could be published, as they are for larger industrial belt drives, small synchronous drive applications are generally quite diverse making it nearly impossible to arrive at values that apply in all cases. When space is at a premium, the necessary installation allowances should be determined experimentally using actual production parts for the best possible results.

B. Belt Installation

During the belt installation process, it is very important that the belt be fully seated in the sprocket grooves before applying final tension. Serpentine drives with multiple sprockets and drives with large sprockets are particularly vulnerable to belt tensioning problems resulting from the belt teeth being only partially engaged in the sprockets during installation. In order to prevent these problems, the belt installation tension should be evenly distributed to all belt spans by rotating the system by hand. After confirming that belt teeth are properly engaged in the sprocket grooves, belt tension should be re-checked and verified. Failure to do this may result in an under-tensioned condition with the potential for belt ratcheting.

C. Belt Take-Up

Synchronous belt drives generally require little if any tensioning when used in accordance with proper design procedures. A small amount of belt tension decay can be expected within the first several hours of operation. After this time, the belt tension should remain relatively stable.

D. Fixed Center Drives

Designers sometimes attempt to design synchronous belt drive systems without any means of belt adjustment or take up. This type of system is called a Fixed Center Drive. While this approach is often viewed as being economical,and is simple for assemblers, it often results in troublesome reliability and performance problems in the long run.
The primary pitfall in a fixed center design approach is failure to consider the affects of system tolerance accumulation. Belts and sprockets are manufactured with industry accepted production tolerances. There are limits to the accuracy that the center distance can be maintained on a production basis as well. The potential effects of this tolerance accumulation is as follows:

Low Tension:
Long Belt with Small Sprockets on a Short Center Distance

High Tension:
Short Belt with Large Sprockets on a Long Center Distance.
Belt tension in these two cases can vary by a factor of 3 or more with a standard fiberglass tensile cord, and even more with an aramid tensile cord. This potential variation is great enough to overload bearings and shafting, as well as the belts themselves. The probability of these extremes occurring is a matter of statistics, but however remote the chances may seem, they will occur in a production setting. In power transmission drives, the appearance of either extreme is very likely to impact drive system performance in a negative manner.

The most detrimental aspect of fixed center drives is generally the potentially high tension condition. This condition can be avoided by adjusting the design center distance. A common approach in these designs is to reduce the center distance from the exact calculated value by some small fraction. This results in a drive system that is inherently loose, but one that has much less probability of yielding excessively high shaft loads.
NOTE: This approach should not be used for power transmission drives since the potentially loose operating conditions could result in accelerated wear and belt ratcheting, even under nominal loading.
There are times when fixed center drive designs can't be avoided. In these cases, the following recommendations will maximize the probability of success.

1. Do not use a fixed center design for power transmission drives. Consider using a fixed center design only for lightly loaded or motion transfer applications.

2. Do not use a fixed center design for drives requiring high motion quality or registration precision.

3. When considering a fixed center design, the center distance must be held as accurately as possible, typically within 0.002" - 0.003" (0.05mm - 0.08mm).This accuracy often requires the use of stamped steel framework. Molding processes do not generally have the capability of maintaining the necessary accuracy.

4. Sprockets for fixed center systems should be produced with a machining process for accuracy. Molding and sintering processes are generally not capable of holding the finished O.D. with sufficient accuracy for these systems.

5. The performance capabilities of the drive system should be verified by testing belts produced over their full length tolerance range on drive systems representing the full potential center-distance variation. Contact York Engineering for further details.

6. Contact York Engineering for design center distance recommendations, and to review the application.

VII. Idler Usage

Idlers in synchronous belt drives are commonly used to take up belt slack, apply installation tension or to clear obstructions within a system. While idlers cause additional belt bending, resulting in fatigue, this effect is generally not significant as long as proper design procedures are followed. Synchronous belts elongate very little over time making them relatively maintenance free. All idlers should be capable of being locked down after being adjusted and should require little additional attention. Specific guidelines and recommendations follow in the upcoming paragraphs.

A. Inside/Outside

Inside idlers are generally preferred over backside idlers from a belt fatigue standpoint. Both are commonly used with good success. Inside idlers should be sprockets, but can be flat if the O.D. is equivalent to the pitch diameter of a 40 groove sprocket. Backside idlers should be flat and uncrowned.

B. Tight Side/Slack Side

Idlers should be placed on the slack (or non-load carrying) side if possible. Their affect on belt fatigue is less on the slack side than on the tight (or load carrying) side. If spring loaded idlers are used, they should never be placed on the tight side (see D. Spring Loaded Idlers). Also note that drive direction reversal causes the tight and slack spans to reverse, potentially placing the idler on the tight side.

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VII. Idler Usage - continued

C. Idler Placement

In synchronous belt drives, idlers can be placed nearly anywhere they are needed. Synchronous and belt wrap angles than V-belt drives. The designer should be sure that at least 6 belt teeth are in mesh on load carrying sprockets. For every tooth in mesh less than this (with a minimum of 2), 20% of the belt torque rating must be subtracted. In order to minimize the potential for belt ratcheting, each loaded sprocket in the system should also have a wrap angle of at least 60°. If a loaded sprocket has less than 6 teeth in mesh and 60° of wrap, idlers can often be used to improve this condition. Non-loaded idler sprockets do not have tooth meshing or wrap angle restrictions.

D. Spring Loaded Idlers

Using a spring to apply a predetermined force installation tension is a common practice. The idler is typically locked down after belt installation. This provides a simple and repeatable process that Dworks well in a production setting.
ynamic spring loaded idlers are generally not recommended for synchronous belt drives. If used, spring-loaded idlers should never be used on the tight (or load carrying) side Tight side tensions vary with the magnitude and type of load carried by the system. High tight side tensions can overcome the idler spring force allowing the belt to ratchet. In order to prevent this from occurring, an excessively high spring force is required. This high spring force can result in high shaft/bearing loads and accelerated belt wear.

Note that the tight and slack spans shift as the direction of drive rotation reverses. This could place the spring loaded idler on the tight side. For this reason, dynamic spring loaded idlers are that reverse rotational direction. Also note that in some cases, drive vibration and harmonic problems may also be encountered with the use of spring loaded idlers.

Dynamic spring loaded idlers can be beneficial in some belt drive systems in that they maintain constant slack side span tension regardless of the magnitude of drive loads, and can actually reduce the potential of belt ratcheting. They can also be beneficial in applications with flexing or changing centers. If dynamic spring loaded idlers are to be used, they should always be used on the slack (or non-load carrying) side of the drive.

E. Size Recommendations

Inside idler sprockets can be used in the minimum recommended size for each particular belt pitch. Inside flat idlers can be used on the tooth side of synchronous belts as long as they are of a diameter equivalent to the pitch diameter of a 40-groove sprocket in the same pitch. Drives with inside flat idlers should be tested, as noise and belt wear may occur.

Flat backside idlers should be used with diameters at least 30% larger than the minimum recommended inside sprocket size.
Table 3 summarizes our idler size recommendations.

Table 3 - Idler Size Recommendations

Belt	Minimum Inside Idler	Minimum Backside Idler	Minimum Inside Flat Idler
MXL	12 grooves	0.50" O.D.	1.00" O.D.
XL	12 grooves	1.00" O.D.	2.50" O.D.
3MMHTD	12 grooves	0.75" O.D.	1.50" O.D.
5MMHTD	14 grooves	1.25" O.D.	2.50" O.D.
2MM GT 2	12 grooves	0.50" O.D.	1.00" O.D.
3MM GT 2	12 grooves	0.75" O.D.	1.50" O.D.
5MM GT 2	14 grooves	1.25" O.D.	2.50" O.D.

Contact York Engineering for additional information.

F. Specifying Shaft Locations in Multipoint Drive Layouts

When collecting geometrical layout data for multiple sprocket drive layouts, it is important to use a standard approach that is readily understood and usable for drive design calculations. This is of particular importance when the data will be provided to York Engineering for analysis.

2 - Point Drive

When working with a simple 2-point drive (driveR/driveN only) it is sufficient to specify the desired distance between shaft centers for belt length calculations.

3 - Point Drive

When working with a 3-point drive (driveR/driveN/idler), X-Y coordinates are desirable. It is sufficient, however, to specify desired center distances between each of the three shaft centers to form a triangle. In either case, sprocket/idler movement details for belt tensioning and take-up are also necessary.

Multipoint Drive

When working with a drive system having more than 3 shafts, the geometrical layout data must be collected in terms of X-Y coordinates for analysis. For thos unfamiliar with X-Y coordinates, the X-Y cartesian coordinate system is commonly used in mathematical and engineering calculations and utilizes a horizontal and vertical axis as illustrated in Figure 7.

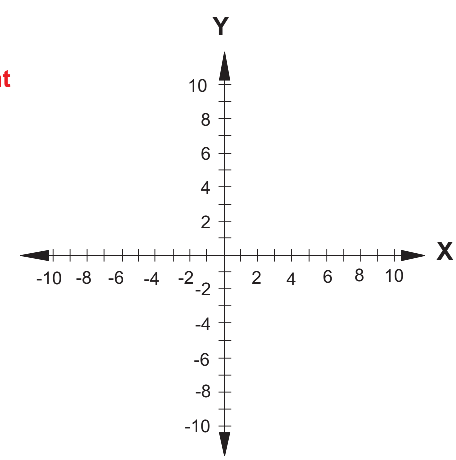


Figure 7 - X-Y Coordinate Axis

VII. Idler Usage
- continued

The axes cross at the zero point, or origin. Along the horizontal, or "X" axis, all values to the right of the zero point are positive, and all values to the left of the zero point are negative. Along the vertical, or "Y" axis, all values above the zero point are positive, and all values below the zero point are negative. This is also illustrated in Figure 7 on page 12. When identifying a shaft center location, each X-Y coordinate is specified with a measurement in the "X" as well as the "Y" direction. This requires a horizontal and vertical measurement for each shaft center in order to establish a complete coordinate. Either English or Metric units of measurement may be used.

A complete coordinate is specified as follows:

(X,Y) where X = measurement along X-axis (horizontal)
Y = measurement along Y-axis (vertical)

In specifying X-Y coordinates for each shaft center the origin (zero point) must first be chosen as a reference. The driveR shaft most often serves this purpose, but any shaft center can be used. Measurements for all remaining shaft centers must be taken from this origin or reference point. The origin is specified as (0,0).

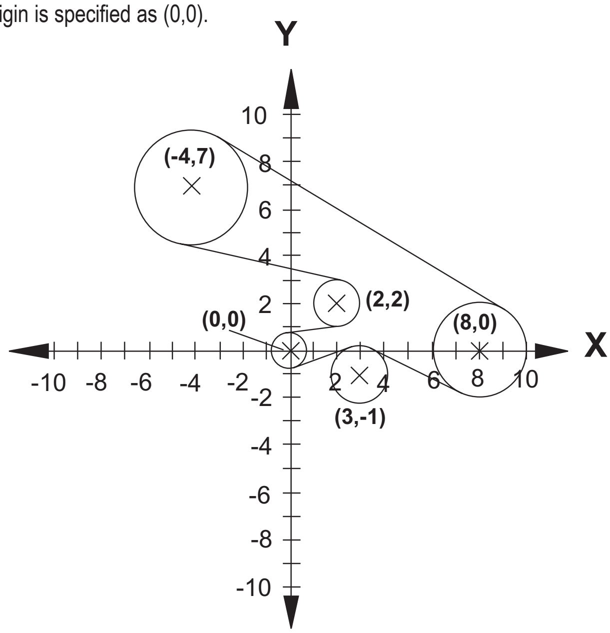


Figure 8 - Drive Layout Using X-Y Coordinates

An example layout of a 5-point drive system is illustrated in Figure 10. Here each of the five shaft centers are located and identified on the X-Y coordinate grid.

When specifying parameters for the moveable or adjustable shaft (for belt installation and tensioning), the following approaches are generally used:

Fixed Location: Specify the nominal shaft location coordinate with a movement direction.

Slotted Location: Specify a location coordinate for the beginning of the slot, and a location coordinate for the end of the slot along its path of linear movement.

Pivoted Location: Specify the initial shaft location coordinate along with a pivot point location coordinate and the pivot radius.

Performing belt length and idler movement/positioning calculations by hand can be quite difficult and time consuming. With a complete geometrical drive description, we can make the drive design and layout process quite simple for you. Contact York Engineering for computer-aided assistance.

VIII. Belt Pull

Synchronous belt drives are capable of exerting lower shaft loads than V-belt drives in some circumstances. If pre-tensioned according to York recommendations for a fully loaded steady state condition, synchronous and V-belt drives will generate comparable shaft loads. If the actual torque loads are reduced and the level of pre-tension remains the same, they will continue to exert comparable shaft loads. In some cases, synchronous belts can be pre-tensioned for less than full loads, under non-steady state conditions, with reasonable results. Reduced pre-tensioning in synchronous belts can be warranted in a system that operated with uniform loads most of the time, but generates peak loads on an intermittent basis. While V-belt drives require pre-tensioning based upon peak loads to prevent slippage, synchronous drive pre-tensioning can be based upon lower average loads rather than intermittent peak loads, so long as the belt does not ratchet under the peak loads. When the higher peak loads are carried by the synchronous drive, the belt will self-generate tension as needed to carry the load. The process of self-tensioning results in the belt teeth riding out of the sprocket grooves as the belt enters the driveN sprocket on the slack side, resulting in increased belt tooth and sprocket wear. So long as peak loads occur intermittently and belts do not ratchet, reduced installation tension will result in reduced average belt pull without serious detrimental effects. Synchronous belts generally require less pre-tension than V-belts for the same load. They do not require additional installation tension for belt wrap less than 180 degrees on loaded sprockets and V-belt drives do. In most cases, these factors contribute to lower static and dynamic shaft loads in synchronous belt drives.

Designers often wish to calculate how much force a belt drive will exert on a shafting/bearings/framework in order to properly design their system. It is difficult to make accurate belt pull calculations because factors such as torque load variation, installation tension and sprocket run-out all have a significant influence. Estimations, however, can be made as follows:

VIII. Belt Pull - continued

A. Motion Transfer Drives

Motion transfer drives, by definition do not carry a significant torque load. As a result, the belt pull is dependent only on the installation tension. Because installation tensions are provided on a per-strand basis, the total belt pull can be calculated by vector addition.

B. Power Transmission Drives

Torque load and installation tension both influence the belt pull in power transmission drives. The level of installation tension influences the dynamic tension ratio of the belt spans. The tension ratio is defined as the tight side (or load carrying) tension T_T divided by the slack side (or non-load carrying) tension T_S. Synchronous belt drives are generally pre-tensioned to operate dynamically at a 8:1 tension ratio in order to provide the best possible performance. After running for a short time, this ratio is known to increase somewhat as the belt runs in and seats with the sprockets reducing tension. Formula 5 and Formula 6 can be used to calculate the estimated T_T and T_S tensions assuming a 8:1 tension ratio. T_T and T_S tensions can then be summed into a single vector force and direction.

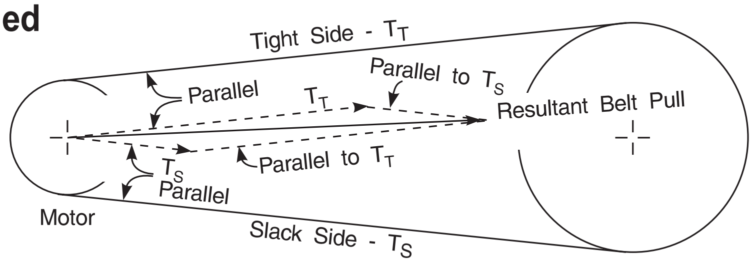


Figure 9 - Vector Addition

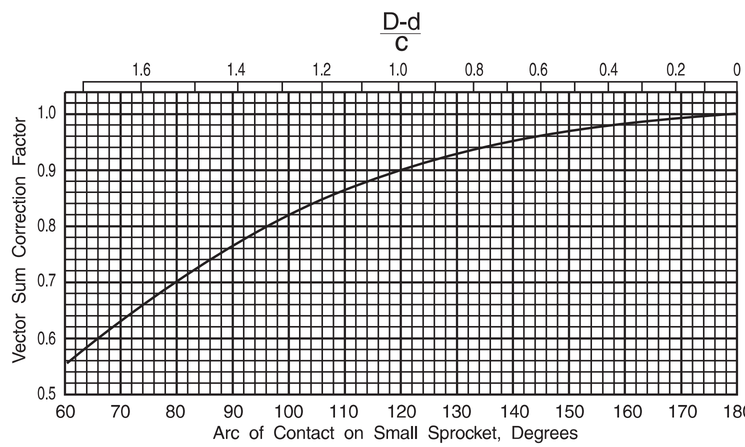


Figure 10 - Vector Sum Correction Factor

Formula 5

$$T_T = \frac{2.286(Q)}{Pd}\text{, lb.}$$

Formula 6

$$T_S = \frac{0.285(Q)}{Pd}\text{, lb.}$$

Where: T_T = Tight side tension, pounds
T_S = Slack side tension, pounds
Q = Torque Load, pound inches
Pd = Pitch diameter, inches

If both direction and magnitude of belt pull are required, the vector sum of T_T and T_S can be found by graphical vector addition as shown in Fig. 9. T_T and T_S vectors are drawn parallel to the tight and slack sides at a convenient scale. The magnitude and direction of the resultant vector, or belt pull, can then be measured graphically. The same procedures can be used for finding belt pull on the driveN shaft. This method can also be used for drives using three or more sprockets or idlers.

For two sprocket drives, belt pull on the driveR and driveN shafts is equal but opposite in direction. For drives using idlers, both magnitude and direction may be different. If only the magnitude of the belt pull is needed in a two sprocket drive, use the following procedure.

1. Add T_T and T_S
2. Using the value of (D-d)/C for the drive, find the vector sum correction factor using Fig. 10. Or, use the known arc of contact on the small sprocket where:

D = large diameter
d = small diameter
C = center distance

3. Multiply the sum of T_T and T_S by the vector sum correction factor to find the vector sum, or belt pull.

For drives using idlers, either use the graphical method or contact York Engineering for assistance.

C. Registration Drives

Synchronous belt drives used for purposes of accurate registration or synchronization generally require the use of higher than normal installation tensions (see section III. Belt Tensioning, pages 8-10). These drives will operate with higher belt pulls than normal power transmission drives. Belt pull values for these types of applications should be verified experimentally, but can be estimated by adding the installation tension in each belt span vectorially.

Synchronous Belt Drives - Engineering

IX. Handling And Storage

The following has been condensed from RMA Bulletin No. IP-3-4; "Storage Of Power Transmission Belts".

Recommendations for proper belt storage is of interest to designers as well as to users. Under favorable storage conditions, high quality belts maintain their performance capabilities and manufactured dimensions. Good storage conditions and practices will result in the best value from belt products.

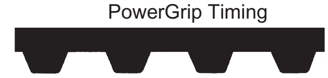
Power transmission belts should ideally be stored in a cool and dry environment. Excess weight against belts resulting in distortion should be avoided. Avoid storing belts in environments that may allow exposure to sunlight, moisture, excessive heat, ozone, or where evaporating solvents or other chemicals are present. Belts have been found to be capable of withstanding storage, without changing significantly, for as long as 8 years at temperatures less than 85°F (30°C) and relative humidity below 70 percent without direct contact with sunlight.

Proper handling of synchronous belts is also important in preventing damage that could reduce their performance capabilities. Synchronous belts should never be crimped or tightly bent. Belts should not be bent tighter than the minimum recommended sprocket size specified for each belt section, or pitch. Belt backside bending should be limited to the values specified in Table 3 on Page 12.

X. Special Constructions

In addition to the standard belt products offered by York, there are many special belts available on a made-to-order basis. These non-standard belts can be helpful when used in unusual applications, or when the designer has special performance requirements. See Table 4 for general made-to-order manufacturing capabilities. Contact York Engineering for additional information.

Table 4 - Made-To-Order Belt Constructions

Type of MTO Belt	Application	Tooth Profiles Available
Nonstock widths and/or lengths with tooling available	When exact length is required	PowerGrip GT
High temperature	Dry operation from -40°F to 225°F (-40°C to 107°C)	
Low temperature	Dry operation from -65°F to 175°F (-54°C to 79°C)	
Oil resistant	For excessively oily atmospheres, including immersion in commercial motor oil. Temperature range: dry -40°F to 210°F (-40°C to 99°C)	PowerGrip HTD 
Static conductive (Static dissipating)	Resistance of 300,000 ohms or less to dissipate static charge	
Nonconductive	When electrical isolation within a system is required. Conductivity properties per customer requirements	
Nonmarking backing	For conveyers or material handling processes	PowerGrip Timing 
Extra-thick rubber backing	For special applications where the belt backing serves a functional purpose	
Ground backing	For sensitive applications requiring minimal vibration from outside idlers	
Alternate tensile cord	For special tensile modulus, bending flexibility or durability requirements	
Special tracking	When belt must track in a particular direction	
Urethane PowerGrip belts	Light loads, appliances, office machinery	
Micro-V backing	Special serpentine drives	

XI. General Belt Tolerances

York belt length and width tolerances for synchronous belts are based upon industry standard RMA (Rubber Manufacturers Association) tolerances.

Table 5 - Center Distance Tolerances - Single Sided Belts

Belt Length (in)		Belt Length (mm)	Center Distance Tolerance (in)	Center Distance Tolerance (mm)
Up to	10	254	±.008	±.20
Over To	10 15	254 381	±.009	±.23
Over To	15 20	381 508	±.010	±.25
Over To	20 30	508 762	±.012	±.30
Over To	30 40	762 1016	±.013	±.33
Over To	40 50	1016 1270	±.015	±.38
Over To	50 60	1270 1524	±.016	±.41
Over To	60 70	1524 1778	±.017	±.43
Over To	70 80	1778 2032	±.018	±.46
Over To	80 90	2032 2286	±.019	±.48
Over To	90 100	2286 2540	±.020	±.51
Over To	100 110	2540 2794	±.021	±.53
Over To	110 120	2794 3048	±.022	±.56

Table 6 - Center Distance Tolerances - Twin Power Belts

Belt Length (in)	Tolerance Center Distance (in)
15 to 20	±.020
20.01 to 30	±.024
30.01 to 40	±.026
40.01 to 50	±.030
50.01 to 60	±.032
60.01 to 70	±.034
over 70	To be specified

Table 7 - Belt Width Tolerances Single Sided & Twin Power Belts

Belt Width			Belt Length 0 to 33 in. (0 to 838mm)		33.01 to 66 in. (839 to 1676mm)		Over 66 in. (1676mm)	
	(in)	(mm)	(in)	(mm)	(in)	(mm)	(in)	(mm)
From To	0.125 0.438	3 11	+0.016 -0.031	+0.4 -0.8	+0.016 -0.031	+0.4 -0.8	-	-
Over To	0.438 1.500	11 38.1	+0.031 -0.031	+0.8 -0.8	+0.031 -0.047	+0.8 -1.2	+0.031 -0.047	+0.8 -1.2
Over To	1.500 2.000	38.1 50.8	+0.031 -0.047	+0.8 -1.2	+0.047 -0.047	+1.2 -1.2	+0.047 -0.063	+1.2 -1.6

Table 8 - Belt Width Tolerances -Long-Length Belting

	Belt Width Tolerence	
All Spiral Cut Belting	+ 0.031" +0.8mm	- 0.047" -1.2mm

Table 9 - Overall Belt Thickness Dimensions

Pitch Code	Belt Pitch	Overall Thickness (ref) (in)	Overall Thickness (ref) (mm)
2MM GT2	2mm	.060	1.52
3MM GT2	3mm	.095	2.41
5MM GT2	5mm	.150	3.81
3M HTD	3mm	.095	2.41
5M HTD	5mm	.150	3.81
MXL	.080in.	.045	1.14
XL	.200in.	.090	2.29

Table 10 - Overall Belt Thickness Tolerance Single Sided Belts

Standard	Class 2	Class 1
±0.015 in.	±0.010 in.	±0.005 in.
±0.38mm	±0.25mm	±0.13mm

NOTE: Belts with pitch lengths greater than 5.5 in. (140mm) are furnished with a Class II grind unless otherwise specified. Belts with pitch lengths less than 5.5 in. (140mm) are unground and produced to standard tolerances.

NOTE: A class 1 grind is available at additional cost for finished belts only.

Table 11 - Overall Belt Thickness Dimensions - Twin Power Belts

Pitch	T (in)	W (in) (Reference)
3MM GT2	.120 ±.006	.030
5MM GT2	.197 ±.007	.045
3MM HTD	.126 ±.006	.030
5MM HTD	.209 ±.007	.045
XL (.200 in)	.120 ±.007	.020

Synchronous Belt Drives – Sprocket Specifications

XII. Sprocket Specifications - A. Sprocket Diameters

2mm Pitch Sprocket Diameters

No. of Grooves	Diameters mm (in) P.D.	Diameters mm (in) O.D.	No. of Grooves	Diameters mm (in) P.D.	Diameters mm (in) O.D.	No. of Grooves	Diameters mm (in) P.D.	Diameters mm (in) O.D.	No. of Grooves	Diameters mm (in) P.D.	Diameters mm (in) O.D.	No. of Grooves	Diameters mm (in) P.D.	Diameters mm (in) O.D.
12	7.64 0.301	7.13 0.281	42	26.74 1.053	26.23 1.033	72	45.84 1.805	45.33 1.785	102	64.94 2.557	64.43 2.537	132	84.03 3.308	83.53 3.288
13	8.28 0.326	7.77 0.306	43	27.37 1.078	26.87 1.058	73	46.47 1.830	45.97 1.810	103	65.57 2.582	65.06 2.562	133	84.67 3.333	84.16 3.313
14	8.91 0.351	8.40 0.331	44	28.01 1.103	27.50 1.083	74	47.11 1.855	46.60 1.835	104	66.21 2.607	65.70 2.587	134	85.31 3.359	84.80 3.339
15	9.55 0.376	9.04 0.356	45	28.65 1.128	28.14 1.108	75	47.75 1.880	47.24 1.860	105	66.85 2.632	66.34 2.612	135	85.94 3.384	85.44 3.364
16	10.19 0.401	9.68 0.381	46	29.28 1.153	28.78 1.133	76	48.38 1.905	47.88 1.885	106	67.48 2.657	66.97 2.637	136	86.58 3.409	86.07 3.389
17	10.82 0.426	10.31 0.406	47	29.92 1.178	29.41 1.158	77	49.02 1.930	48.51 1.910	107	68.12 2.682	67.61 2.662	137	87.22 3.434	86.71 3.414
18	11.46 0.451	10.95 0.431	48	30.56 1.203	30.05 1.183	78	49.66 1.955	49.15 1.935	108	68.75 2.707	68.25 2.687	138	87.85 3.459	87.35 3.439
19	12.10 0.476	11.59 0.456	49	31.19 1.228	30.69 1.208	79	50.29 1.980	49.79 1.960	109	69.39 2.732	68.88 2.712	139	88.49 3.484	87.98 3.464
20	12.73 0.501	12.22 0.481	50	31.83 1.253	31.32 1.233	80	50.93 2.005	50.42 1.985	110	70.03 2.757	69.52 2.737	140	89.13 3.509	88.62 3.489
21	13.37 0.526	12.86 0.506	51	32.47 1.278	31.96 1.258	81	51.57 2.030	51.06 2.010	111	70.66 2.782	70.16 2.762	141	89.76 3.534	89.26 3.514
22	14.01 0.551	13.50 0.531	52	33.10 1.303	32.60 1.283	82	52.20 2.055	51.69 2.035	112	71.30 2.807	70.79 2.787	142	90.40 3.559	89.89 3.539
23	14.64 0.576	14.13 0.556	53	33.74 1.328	33.23 1.308	83	52.84 2.080	52.33 2.060	113	71.94 2.832	71.43 2.812	143	91.04 3.584	90.53 3.564
24	15.28 0.602	14.77 0.582	54	34.38 1.353	33.87 1.333	84	53.48 2.105	52.97 2.085	114	72.57 2.857	72.07 2.837	144	91.67 3.609	91.17 3.589
25	15.92 0.627	15.41 0.607	55	35.01 1.379	34.51 1.359	85	54.11 2.130	53.60 2.110	115	73.21 2.882	72.70 2.862	145	92.31 3.634	91.80 3.614
26	16.55 0.652	16.04 0.632	56	35.65 1.404	35.14 1.384	86	54.75 2.155	54.24 2.135	116	73.85 2.907	73.34 2.887	146	92.95 3.659	92.44 3.639
27	17.19 0.677	16.68 0.657	57	36.29 1.429	35.78 1.409	87	55.39 2.181	54.88 2.161	117	74.48 2.932	73.98 2.912	147	93.58 3.684	93.08 3.664
28	17.83 0.702	17.32 0.682	58	36.92 1.454	36.42 1.434	88	56.02 2.206	55.51 2.186	118	75.12 2.958	74.61 2.938	148	94.22 3.709	93.71 3.689
29	18.46 0.727	17.95 0.707	59	37.56 1.479	37.05 1.459	89	56.66 2.231	56.15 2.211	119	75.76 2.983	75.25 2.963	149	94.86 3.735	94.35 3.715
30	19.10 0.752	18.59 0.732	60	38.20 1.504	37.69 1.484	90	57.30 2.256	56.79 2.236	120	76.39 3.008	75.89 2.988	150	95.49 3.760	94.99 3.740
31	19.74 0.777	19.23 0.757	61	38.83 1.529	38.33 1.509	91	57.93 2.281	57.42 2.261	121	77.03 3.033	76.52 3.013	151	96.13 3.785	95.62 3.765
32	20.37 0.802	19.86 0.782	62	39.47 1.554	38.96 1.534	92	58.57 2.306	58.06 2.286	122	77.67 3.058	77.16 3.038	152	96.77 3.810	96.26 3.790
33	21.01 0.827	20.50 0.807	63	40.11 1.579	39.60 1.559	93	59.21 2.331	58.70 2.311	123	78.30 3.083	77.80 3.063	153	97.40 3.835	96.89 3.815
34	21.65 0.852	21.14 0.832	64	40.74 1.604	40.24 1.584	94	59.84 2.356	59.33 2.336	124	78.94 3.108	78.43 3.088	154	98.04 3.860	97.53 3.840
35	22.28 0.877	21.77 0.857	65	41.38 1.629	40.87 1.609	95	60.48 2.381	59.97 2.361	125	79.58 3.133	79.07 3.113	155	98.68 3.885	98.17 3.865
36	22.92 0.902	22.41 0.882	66	42.02 1.654	41.51 1.634	96	61.12 2.406	60.61 2.386	126	80.21 3.158	79.71 3.138	156	99.31 3.910	98.80 3.890
37	23.55 0.927	23.05 0.907	67	42.65 1.679	42.15 1.659	97	61.75 2.431	61.24 2.411	127	80.85 3.183	80.34 3.163	157	99.95 3.935	99.44 3.915
38	24.19 0.952	23.68 0.932	68	43.29 1.704	42.78 1.684	98	62.39 2.456	61.88 2.436	128	81.49 3.208	80.98 3.188	158	100.59 3.960	100.08 3.940
39	24.83 0.977	24.32 0.957	69	43.93 1.729	43.42 1.709	99	63.03 2.481	62.52 2.461	129	82.12 3.233	81.62 3.213	159	101.22 3.985	100.71 3.965
40	25.46 1.003	24.96 0.983	70	44.56 1.754	44.06 1.734	100	63.66 2.506	63.15 2.486	130	82.76 3.258	82.25 3.238	160	101.86 4.010	101.35 3.990
41	26.10 1.028	25.59 1.008	71	45.20 1.780	44.69 1.760	101	64.30 2.531	63.79 2.511	131	83.40 3.283	82.89 3.263			

NOTE: See Page 21 for sprocket O.D. tolerances.

Synchronous Belt Drives – Sprocket Specifications

XII. Sprocket Specifications - continued

3mm Pitch Sprocket Diameters

No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.
*12	11.46 .451	10.70 .421	42	40.11 1.579	39.35 1.549	72	68.75 2.707	67.99 2.677	102	97.40 3.835	96.64 3.805	132	126.05 4.963	125.29 4.933
*13	12.41 .489	11.65 .459	43	41.06 1.617	40.30 1.587	73	69.71 2.744	68.95 2.714	103	98.36 3.872	97.60 3.842	133	127.01 5.000	126.25 4.970
*14	13.37 .526	12.61 .496	44	42.02 1.654	41.26 1.624	74	70.66 2.782	69.90 2.752	104	99.31 3.910	98.55 3.880	134	127.96 5.038	127.20 5.008
*15	14.32 .564	13.56 .534	45	42.97 1.692	42.21 1.662	75	71.62 2.820	70.86 2.790	105	100.27 3.948	99.51 3.918	135	128.92 5.075	128.16 5.045
16	15.28 .602	14.52 .572	46	43.93 1.729	43.17 1.699	76	72.57 2.857	71.81 2.827	106	101.22 3.985	100.46 3.955	136	129.87 5.113	129.11 5.083
17	16.23 .639	15.47 .609	47	44.88 1.767	44.12 1.737	77	73.53 2.895	72.77 2.865	107	102.18 4.023	101.42 3.993	137	130.83 5.151	130.07 5.121
18	17.19 .677	16.43 .647	48	45.84 1.805	45.08 1.775	78	74.48 2.932	73.72 2.902	108	103.13 4.060	102.37 4.030	138	131.78 5.188	131.02 5.158
19	18.14 .714	17.38 .684	49	46.79 1.842	46.03 1.812	79	75.44 2.970	74.68 2.940	109	104.09 4.098	103.33 4.068	139	132.74 5.226	131.98 5.196
20	19.10 .752	18.34 .722	50	47.75 1.880	46.99 1.850	80	76.39 3.008	75.63 2.978	110	105.04 4.136	104.28 4.106	140	133.69 5.263	132.93 5.233
21	20.05 .790	19.29 .760	51	48.70 1.917	47.94 1.887	81	77.35 3.045	76.59 3.015	111	106.00 4.173	105.24 4.143	141	134.65 5.301	133.89 5.271
22	21.01 .827	20.25 .797	52	49.66 1.955	48.90 1.925	82	78.30 3.083	77.54 3.053	112	106.95 4.211	106.19 4.181	142	135.60 5.339	134.84 5.309
23	21.96 .865	21.20 .835	53	50.61 1.993	49.85 1.963	83	79.26 3.120	78.50 3.090	113	107.91 4.248	107.15 4.218	143	136.55 5.376	135.79 5.346
24	22.92 .902	22.16 .872	54	51.57 2.030	50.81 2.000	84	80.21 3.158	79.45 3.128	114	108.86 4.286	108.10 4.256	144	137.51 5.414	136.75 5.384
25	23.87 .940	23.11 .910	55	52.52 2.068	51.76 2.038	85	81.17 3.196	80.41 3.166	115	109.82 4.324	109.06 4.294	145	138.46 5.451	137.70 5.421
26	24.83 .977	24.07 .947	56	53.48 2.105	52.72 2.075	86	82.12 3.233	81.36 3.203	116	110.77 4.361	110.01 4.331	146	139.42 5.489	138.66 5.459
27	25.78 1.015	25.02 .985	57	54.43 2.143	53.67 2.113	87	83.08 3.271	82.32 3.241	117	111.73 4.399	110.97 4.369	147	140.37 5.527	139.61 5.497
28	26.74 1.053	25.98 1.023	58	55.39 2.181	54.63 2.151	88	84.03 3.308	83.27 3.278	118	112.68 4.436	111.92 4.406	148	141.33 5.564	140.57 5.534
29	27.69 1.090	26.93 1.060	59	56.34 2.218	55.58 2.188	89	84.99 3.346	84.23 3.316	119	113.64 4.474	112.88 4.444	149	142.28 5.602	141.52 5.572
30	28.65 1.128	27.89 1.098	60	57.30 2.256	56.54 2.226	90	85.94 3.384	85.18 3.354	120	114.59 4.511	113.83 4.481	150	143.24 5.639	142.48 5.609
31	29.60 1.165	28.84 1.135	61	58.25 2.293	57.49 2.263	91	86.90 3.421	86.14 3.391	121	115.55 4.549	114.79 4.519	151	144.19 5.677	143.43 5.647
32	30.56 1.203	29.80 1.173	62	59.21 2.331	58.45 2.301	92	87.85 3.459	87.09 3.429	122	116.50 4.587	115.74 4.557	152	145.15 5.715	144.39 5.685
33	31.51 1.241	30.75 1.211	63	60.16 2.369	59.40 2.339	93	88.81 3.496	88.05 3.462	123	117.46 4.624	116.70 4.594	153	146.10 5.752	145.34 5.722
34	32.47 1.278	31.71 1.248	64	61.12 2.406	60.36 2.376	94	89.76 3.534	89.00 3.504	124	118.41 4.662	117.65 4.632	154	147.06 5.790	146.30 5.760
35	33.42 1.316	32.66 1.286	65	62.07 2.444	61.31 2.414	95	90.72 3.572	89.96 3.542	125	119.37 4.699	118.61 4.669	155	148.01 5.827	147.25 5.797
36	34.38 1.353	33.62 1.323	66	63.03 2.481	62.27 2.451	96	91.67 3.609	90.91 3.579	126	120.32 4.737	119.56 4.707	156	148.97 5.865	148.21 5.835
37	35.33 1.391	34.57 1.361	67	63.98 2.519	63.22 2.489	97	92.63 3.647	91.87 3.617	127	121.28 4.775	120.52 4.745	157	149.92 5.903	149.16 5.873
38	36.29 1.429	35.53 1.399	68	64.94 2.557	64.18 2.527	98	93.58 3.684	92.82 3.654	128	122.23 4.812	121.47 4.782	158	150.88 5.940	150.12 5.910
39	37.24 1.466	36.48 1.436	69	65.89 2.594	65.13 2.564	99	94.54 3.722	93.78 3.692	129	123.19 4.850	122.43 4.820	159	151.83 5.978	151.07 5.948
40	38.20 1.504	37.44 1.474	70	66.85 2.632	66.09 2.602	100	95.49 3.760	94.73 3.730	130	124.14 4.887	123.38 4.857	160	152.79 6.015	152.03 5.985
41	39.15 1.541	38.39 1.511	71	67.80 2.669	67.04 2.639	101	96.45 3.797	95.69 3.767	131	125.10 4.925	124.34 4.895			

NOTE: See Page 21 for sprocket O.D. tolerances.

XII. Sprocket Specifications - continued

5mm Pitch Sprocket Diameters

No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.	No. of Grooves	Diameters P.D.	mm (in) O.D.
*14	22.28 .877	21.14 .832	44	70.03 2.757	68.89 2.712	74	117.77 4.637	116.63 4.592	104	165.52 6.517	164.38 6.472	134	213.27 8.396	212.13 8.351
*15	23.87 .940	22.73 .895	45	71.62 2.820	70.48 2.775	75	119.37 4.699	118.23 4.654	105	167.11 6.579	165.97 6.534	135	214.86 8.459	213.72 8.414
*16	25.46 1.003	24.32 .958	46	73.21 2.882	72.07 2.837	76	120.96 4.762	119.82 4.717	106	168.70 6.642	167.56 6.597	136	216.45 8.522	215.31 8.477
*17	27.06 1.065	25.92 1.020	47	74.80 2.945	73.66 2.900	77	122.55 4.825	121.41 4.780	107	170.30 6.705	169.16 6.660	137	218.04 8.584	216.90 8.539
18	28.65 1.128	27.51 1.083	48	76.39 3.008	75.25 2.963	78	124.14 4.887	123.00 4.842	108	171.89 6.767	170.75 6.722	138	219.63 8.647	218.49 8.602
19	30.24 1.191	29.10 1.146	49	77.99 3.070	76.85 3.025	79	125.73 4.950	124.59 4.905	109	173.48 6.830	172.34 6.785	139	221.23 8.710	220.09 8.665
20	31.83 1.253	30.69 1.208	50	79.58 3.133	78.44 3.088	80	127.32 5.013	126.18 4.968	110	175.07 6.893	173.93 6.848	140	222.82 8.772	221.68 8.727
21	33.42 1.316	32.28 1.271	51	81.17 3.196	80.03 3.151	81	128.92 5.075	127.78 5.030	111	176.66 6.955	175.52 6.910	141	224.41 8.835	223.27 8.790
22	35.01 1.379	33.87 1.334	52	82.76 3.258	81.62 3.213	82	130.51 5.138	129.37 5.093	112	178.25 7.018	177.11 6.973	142	226.00 8.898	224.86 8.853
23	36.61 1.441	35.47 1.396	53	84.35 3.321	83.21 3.276	83	132.10 5.201	130.96 5.156	113	179.85 7.081	178.71 7.036	143	227.59 8.960	226.45 8.915
24	38.20 1.504	37.06 1.459	54	85.94 3.384	84.80 3.339	84	133.69 5.263	132.55 5.218	114	181.44 7.143	180.30 7.098	144	229.18 9.023	228.04 8.978
25	39.79 1.566	38.65 1.521	55	87.54 3.446	86.40 3.401	85	135.28 5.326	134.14 5.281	115	183.03 7.206	181.89 7.161	145	230.77 9.086	229.63 9.041
26	41.38 1.629	40.24 1.584	56	89.13 3.509	87.99 3.464	86	136.87 5.389	135.73 5.344	116	184.62 7.268	183.48 7.223	146	232.37 9.148	231.23 9.103
27	42.97 1.692	41.83 1.647	57	90.72 3.572	89.58 3.527	87	138.46 5.451	137.32 5.406	117	186.21 7.331	185.07 7.286	147	233.96 9.211	232.82 9.166
28	44.56 1.754	43.42 1.709	58	92.31 3.634	91.17 3.589	88	140.06 5.514	138.92 5.469	118	187.80 7.394	186.66 7.349	148	235.55 9.274	234.41 9.229
29	46.15 1.817	45.01 1.772	59	93.90 3.697	92.76 3.652	89	141.65 5.577	140.51 5.532	119	189.39 7.456	188.25 7.411	149	237.14 9.336	236.00 9.291
30	47.75 1.880	46.61 1.835	60	95.49 3.760	94.35 3.715	90	143.24 5.639	142.10 5.594	120	190.99 7.519	189.85 7.474	150	238.73 9.399	237.59 9.354
31	49.34 1.942	48.20 1.897	61	97.08 3.822	95.94 3.777	91	144.83 5.702	143.69 5.657	121	192.58 7.582	191.44 7.537	151	240.32 9.462	239.18 9.417
32	50.93 2.005	49.79 1.960	62	98.68 3.885	97.54 3.840	92	146.42 5.765	145.28 5.720	122	194.17 7.644	193.03 7.599	152	241.92 9.524	240.78 9.479
33	52.52 2.068	51.38 2.023	63	100.27 3.948	99.13 3.903	93	148.01 5.827	146.87 5.782	123	195.76 7.707	194.62 7.662	153	243.51 9.587	242.37 9.542
34	54.11 2.130	52.97 2.085	64	101.86 4.010	100.72 3.965	94	149.61 5.890	148.47 5.845	124	197.35 7.770	196.21 7.725	154	245.10 9.650	243.96 9.605
35	55.70 2.193	54.56 2.148	65	103.45 4.073	102.31 4.028	95	151.20 5.953	150.06 5.908	125	198.94 7.832	197.80 7.787	155	246.69 9.712	245.55 9.667
36	57.30 2.256	56.16 2.211	66	105.04 4.136	103.90 4.091	96	152.79 6.015	151.65 5.970	126	200.54 7.895	199.40 7.850	156	248.28 9.775	247.14 9.730
37	58.89 2.318	57.75 2.273	67	106.63 4.198	105.49 4.153	97	154.38 6.078	153.24 6.033	127	202.13 7.958	200.99 7.913	157	249.87 9.838	248.73 9.793
38	60.48 2.381	59.34 2.336	68	108.23 4.261	107.09 4.216	98	155.97 6.141	154.83 6.096	128	203.72 8.020	202.58 7.975	158	251.46 9.900	250.32 9.855
39	62.07 2.444	60.93 2.399	69	109.82 4.324	108.68 4.279	99	157.56 6.203	156.42 6.158	129	205.31 8.083	204.17 8.038	159	253.06 9.963	251.92 9.918
40	63.66 2.506	62.52 2.461	70	111.41 4.386	110.27 4.341	100	159.15 6.266	158.01 6.221	130	206.90 8.146	205.76 8.101	160	254.65 10.026	253.51 9.981
41	65.25 2.569	64.11 2.524	71	113.00 4.449	111.86 4.404	101	160.75 6.329	159.61 6.284	131	208.49 8.208	207.35 8.163			
42	66.85 2.632	65.71 2.587	72	114.59 4.511	113.45 4.466	102	162.34 6.391	161.20 6.346	132	210.08 8.271	208.94 8.226			
43	68.44 2.694	67.30 2.649	73	116.18 4.574	115.04 4.529	103	163.93 6.454	162.79 6.409	133	211.68 8.334	210.54 8.289			

NOTE: See Page 21 for sprocket O.D. tolerances.

Synchronous Belt Drives – Sprocket Specifications

XII. Sprocket Specifications - continued

MXL (.080 in Pitch Pulley Diameters

No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)	
	P.D.	O.D.		P.D.	O.D.		P.D.	O.D.		P.D.	O.D.		P.D.	O.D.
10	.255	.235	39	.993	.973	68	1.731	1.711	97	2.470	2.450	126	3.209	3.189
11	.280	.260	40	1.019	.999	69	1.757	1.737	98	2.496	2.476	127	3.234	3.214
12	.306	.286	41	1.044	1.024	70	1.783	1.763	99	2.521	2.501	128	3.259	3.239
13	.331	.311	42	1.070	1.050	71	1.808	1.788	100	2.546	2.526	129	3.285	3.265
14	.357	.337	43	1.095	1.075	72	1.833	1.813	101	2.572	2.552	130	3.310	3.290
15	.382	.362	44	1.120	1.100	73	1.859	1.839	102	2.597	2.577	131	3.336	3.316
16	.407	.387	45	1.146	1.126	74	1.884	1.864	103	2.623	2.603	132	3.361	3.341
17	.433	.413	46	1.171	1.151	75	1.910	1.890	104	2.648	2.628	133	3.387	3.367
18	.458	.438	47	1.197	1.177	76	1.935	1.915	105	2.674	2.654	134	3.412	3.392
19	.484	.464	48	1.222	1.202	77	1.961	1.941	106	2.699	2.679	135	3.438	3.418
20	.509	.489	49	1.248	1.228	78	1.986	1.966	107	2.725	2.705	136	3.463	3.443
21	.535	.515	50	1.273	1.253	79	2.012	1.992	108	2.750	2.730	137	3.489	3.469
22	.560	.540	51	1.299	1.279	80	2.037	2.017	109	2.776	2.756	138	3.514	3.494
23	.586	.566	52	1.324	1.304	81	2.063	2.043	110	2.801	2.781	139	3.540	3.520
24	.611	.591	53	1.350	1.330	82	2.088	2.068	111	2.827	2.807	140	3.565	3.545
25	.637	.617	54	1.375	1.355	83	2.114	2.094	112	2.852	2.832	141	3.591	3.571
26	.662	.642	55	1.401	1.381	84	2.139	2.119	113	2.878	2.858	142	3.616	3.596
27	.687	.667	56	1.426	1.406	85	2.165	2.145	114	2.903	2.887	143	3.641	3.621
28	.713	.693	57	1.451	1.431	86	2.190	2.170	115	2.928	2.908	144	3.667	3.647
29	.738	.718	58	1.477	1.457	87	2.215	2.195	116	2.954	2.934	145	3.692	3.672
30	.764	.744	59	1.502	1.482	88	2.241	2.221	117	2.979	2.959	146	3.718	3.698
31	.789	.769	60	1.528	1.508	89	2.266	2.246	118	3.005	2.985	147	3.743	3.723
32	.815	.795	61	1.553	1.533	90	2.292	2.272	119	3.030	3.010	148	3.769	3.749
33	.840	.820	62	1.579	1.559	91	2.317	2.297	120	3.056	3.036	149	3.794	3.774
34	.866	.846	63	1.604	1.584	92	2.343	2.323	121	3.081	3.061	150	3.820	3.800
35	.891	.871	64	1.630	1.610	93	2.368	2.348	122	3.107	3.087			
36	.917	.897	65	1.655	1.635	94	2.394	2.374	123	3.132	3.112			
37	.942	.922	66	1.681	1.661	95	2.419	2.399	124	3.158	3.138			
38	.968	.948	67	1.706	1.686	96	2.445	2.425	125	3.183	3.163			

NOTE: See Page 21 for sprocket O.D. tolerances.

1/5 (.200 in) Pitch Pulley Diameters

No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)		No. of Grooves	Dimensions (in)	
	P.D.	O.D.		P.D.	O.D.		P.D.	O.D.		P.D.	O.D.		P.D.	O.D.
10	.637	.617	33	2.101	2.081	56	3.565	3.545	79	5.029	5.009	102	6.494	6.474
11	.700	.680	34	2.165	2.145	57	3.629	3.609	80	5.093	5.073	103	6.557	6.537
12	.764	.744	35	2.228	2.208	58	3.692	3.672	81	5.157	5.137	104	6.621	6.601
13	.828	.808	36	2.292	2.272	59	3.756	3.736	82	5.220	5.200	105	6.685	6.665
14	.891	.871	37	2.355	2.335	60	3.820	3.800	83	5.284	5.264	106	6.748	6.728
15	.955	.935	38	2.419	2.399	61	3.883	3.863	84	5.348	5.328	107	6.812	6.792
16	1.019	.999	39	2.483	2.463	62	3.947	3.927	85	5.411	5.391	108	6.875	6.855
17	1.082	1.062	40	2.546	2.526	63	4.011	3.991	86	5.475	5.455	109	6.939	6.919
18	1.146	1.126	41	2.610	2.590	64	4.074	4.054	87	5.539	5.519	110	7.003	6.983
19	1.210	1.190	42	2.674	2.654	65	4.138	4.118	88	5.602	5.582	111	7.066	7.046
20	1.273	1.253	43	2.737	2.717	66	4.202	4.182	89	5.666	5.646	112	7.130	7.110
21	1.337	1.317	44	2.801	2.781	67	4.265	4.245	90	5.730	5.710	113	7.194	7.174
22	1.401	1.331	45	2.865	2.845	68	4.329	4.309	91	5.793	5.773	114	7.257	7.237
23	1.464	1.444	46	2.928	2.908	69	4.393	4.373	92	5.857	5.837	115	7.321	7.301
24	1.528	1.508	47	2.992	2.972	70	4.456	4.436	93	5.921	5.901	116	7.385	7.365
25	1.592	1.572	48	3.056	3.086	71	4.520	4.500	94	5.984	5.964	117	7.448	7.428
26	1.655	1.635	49	3.119	3.099	72	4.584	4.564	95	6.048	6.028	118	7.512	7.492
27	1.719	1.699	50	3.183	3.163	73	4.647	4.627	96	6.112	6.092	119	7.576	7.556
28	1.783	1.763	51	3.247	3.227	74	4.711	4.691	97	6.175	6.155	120	7.639	7.619
29	1.846	1.826	52	3.310	3.290	75	4.775	4.755	98	6.239	6.219			
30	1.910	1.890	53	3.474	3.354	76	4.838	4.818	99	6.303	6.283			
31	1.974	1.954	54	3.438	3.418	77	4.902	4.882	100	6.366	6.346			
32	2.037	2.017	55	3.501	3.481	78	4.966	4.946	101	6.430	6.410			

NOTE: See Page 21 for sprocket O.D. tolerances.

XII. Sprocket Specifications - continued

B. General Tolerances

York sprockets are precision made to close tolerances for the best possible performance. Sprockets and bar stock included in this catalog areintended to be used primarily for prototype work. York can supply made to order sprockets in a widerange of materials. York Engineering is able to assist in sprocket design. General tolerances are included in the following tables to assist the designer.

Table 12 - Sprocket O.D. Tolerances

Sprocket O.D.			Sprocket O.D. Tolerances	
	(in)	(mm)	(in)	(mm)
Up to	1.000	25.4	+.002-.000	+.05 -.00
Over To	1.000 2.000	25.4 50.8	+.003-.000	+.08 -.00
Over To	2.000 4.000	50.8 101.6	+.004-.000	+.10 -.00
Over To	4.000 7.000	101.6 177.8	+.005-.000	+.13 -.00
Over To	7.000 12.000	177.8 304.8	+.006-.000	+.15 -.00
Over To	12.000 20.000	304.8 508.0	+.007-.000	+.18 -.00
Over	20.000	508.0	+.008-.000	+.20-.00

Eccentricity: The allowable amount of radial runout from the sprocket bore to the O.D. is shown in Table13.

Table 13 - Sprocket Run Out

Outside Diameter		Total Run Out Total Indicator Reading	
(in)	(mm)	(in)	(mm)
Up to 2	50	0.0025	0.06
Over 2 To 4	50 100	0.003	0.08
Over 4 To 8	100 200	0.004	0.10
Over 8	200	.005 per inch O.D. over 8 "	.013 per mm O.D. over 200 mm
		(may not exceed face diameter tolerance)	

Table 14 - Bore Tolerance for MPB Sprockets

Bore		Bore Tolerance	
(in)	(mm)	(in)	(mm)
Up to 1.000	25.4	+.0010 - .000	+.025 - .000
Over 1.000 To 2.000	25.4 50.8	+.0015 - .000	+.038 - .000

Pitch Accuracy: Adequate pitch to pitch accuracy (center of one groove to center of adjacent groove) is generally more difficult to achieve with molded sprockets than with machined sprockets. Recommended tolerances are listed in Table 15.

Table 15 - Sprocket Pitch Accuracy

Pulley O.D.			Pitch to Pitch Variation		Accumulative over 90°	
	(mm)	(in)	(in)	(mm)	(in)	(mm)
Up to	25.40	1.000	±.001	±0.025	±.0025	±0.064
Over To	25.40 50.80	1.000 2.000	±.001	±0.025	±.0035	±0.081
Over To	50.80 101.60	2.000 4.000	±.001	±0.025	±.0045	±0.114
Over To	101.60 177.80	4.000 7.000	±.001	±0.025	±.0050	±0.127
Over To	177.80 304.80	7.000 12.000	±.001	±0.025	±.0060	±0.152
Over To	304.80 508.00	12.000 20.000	±.001	±0.025	±.0065	±0.165
Over	508.00	20.000	±.001	±0.025	±.0075	±0.191

Helix Angle: Grooves should be parallel to the axis of the bore within 0.001 (0.025mm) per inch (25.4mm) of sprocket groove face width.

Draft: The maximum permissible draft on the groove form is 0.001 (0.025mm) per inch (25.4mm) of face width and must not exceed the O.D. tolerance.

Parallelism: The bore of the sprocket is to be perpendicular to the vertical faces of the sprocket within 0.001 (0.025mm) per inch (25.4mm) of diameter with a maximum of 0.020 (0.51mm) total indicator reading.

Balancing: Balancing is often not required on machined metal sprockets. All sprockets should be statically balanced to 1/8 oz. (3.5 grams) in all sizes. Drives exceeding 6500 ft./min. (33 m/s) may require special materials, and should be dynamically balanced to 1/4 oz-in. (1.78 newton millimeters) Production sprockets should be produced as closely to these tolerances as possible to maximize drive performance.

XII. Sprocket Specifications - continued

C. Groove Specifications

Accurate reproduction of the correct sprocket groove profile in production sprockets is essential in obtaining the full performance capabilities of the drive system. The correct groove profile for a sprocket changes as the number of grooves changes. York can assist the designer with sprocket groove profile data. Data can be furnished in the following forms:

Master Profile: A scaled line drawing of the ideal groove profile with tolerance bands plotted on dimensionally stable translucent material. Suitable for groove inspection purposes on an optical comparitor.

Dimensioned Profile Drawing: A line drawing of the ideal groove profile with all arcs and radii defined. Suitable for mold design.

Digitized Points: A series of X and Y coordinates defining the ideal groove profile. Available in printed form or in a data file. Suitable for mold design.

Some sprocket groove profile data is proprietary and can be furnished only on special circumstances Check with York Engineering for availability.

Tolerancing/Inspection Procedure: A typical sprocket groove tolerance band is illustrated in Fig. 13. Groove inspections must by made on an optical comparitor at a specified magnification. The actual sprocket groove profile must fit within the specified tolerance bands without any sharp transitions or under cuts.

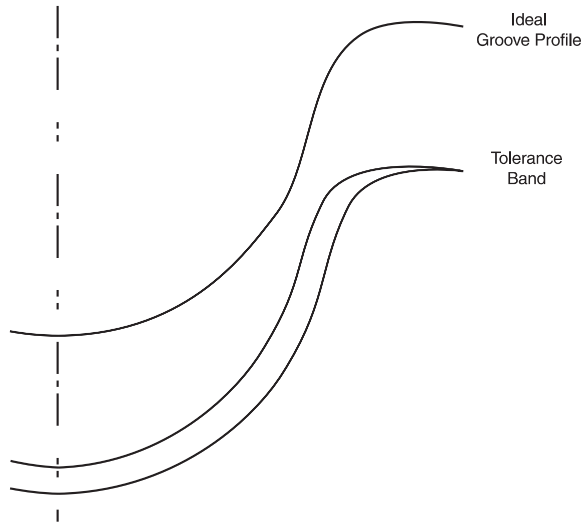
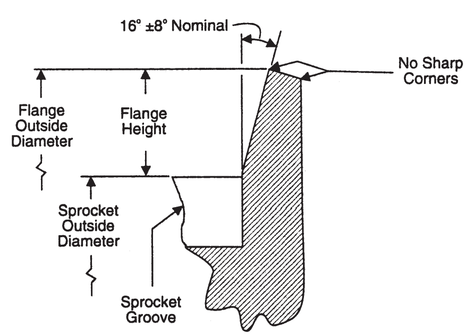


Figure 10

D. Flange Design and Face Width Guidelines

Flanging Guidelines



Face Width Guidelines

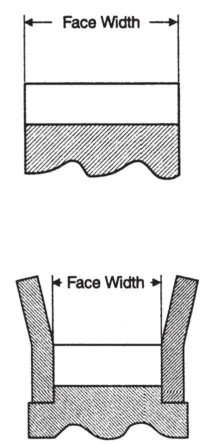


Table 16

Nominal Flange Dimensions for Molding, Sintering, Casting, etc.

Belt Section	Minimum Flange Height (in)	Minimum Flange Height (mm)	Nominal Flange Height (in)	Nominal Flange Height (mm)
MXL	0.040	-	0.050	-
XL	0.060	-	0.080	-
2GT	0.043	1.10	0.059	1.50
3M&3GT	0.067	1.70	0.098	2.50
5M&5GT	0.091	2.30	0.150	3.80

Table 17

Additional amount of Face Width recommended over Nominal Belt Width (Add Table Values to Nominal Belt Width for Nominal Face Width)

Belt Section	Nominal Face Width Unflanged (in)	Nominal Face Width Unflanged (mm)	Nominal Face Width Flanged (in)	Nominal Face Width Flanged (mm)
MXL	+0.125	-	+0.040	-
XL	+0.190	-	+0.060	-
2GT	+0.118	+3.00	+0.039	+1.00
3M&3GT	+0.157	+4.00	+0.049	+1.25
5M&5GT	+0.197	+5.00	+0.059	+1.50