Gates
PRODUCT APPLICATION NOTES

Voelzow & Company, Inc.
4804 Lawyers Rd E • Wingate, NC 28174
704-233-9222 • Fax 704-233-9211
E-mail: nvoelzow@perigee.net
Web: www.LaserAlignment.net

Volume 56, No. 2
March, 2009

Sonic Tension Meter Accuracy

The Gates Sonic Tension Meter's accuracy surpasses conventional force-deflection or belt elongation measurements but just how accurate are the readings? This PA Note reviews the factors affecting Sonic Tension Meter accuracy, estimates accuracy, and provides recommendations to maximize accuracy.

Factors Affecting Sonic Tension Meter Accuracy

Meter Calibration

Sonic Tension Meter output accuracy is partly a function of the internal meter electronics. Even though Sonic Tension Meter accuracy is tested and verified during production, users sometimes wish to confirm that the accuracy has remained within specifications. Also, Sonic Tension Meter calibration testing may be needed to satisfy user quality process requirements. The Gates Service Center below can test Sonic Tension Meter calibration and provide certification for a nominal fee:

Gates Service Center
7822 S. Wheeling court; Suite A
Englewood, CO 80112
Attn: Sonic Tension Meter Service
Phone: (303) 936-1350
info@reataeng.com

It is highly unusual for Sonic Tension Meters to fail calibration testing. Note that Sonic Tension Meters cannot be adjusted if they are found to be outside of specification, and can only be replaced.

Sonic Tension Meter calibration testing does not include sensor effects, which can influence output accuracy due to individual frequency response characteristics. While sensor effects on Sonic Tension Meter accuracy are minor, the combined meter and sensor accuracy can be evaluated by using standard tuning forks, available from many music stores.

Meter Functionality

When a belt span is initially plucked during the belt tension measuring process, it emits the fundamental belt span frequency, along with a broad spectrum of harmonics and other unrelated frequencies. The unrelated frequencies quickly dissipate leaving the fundamental belt span frequency. In computing belt span tension, the Sonic Tension Meter electronically determines the fundamental belt span frequency. While meter electronics perform this task accurately, the process may still result in small meter output variations. When measuring belt span tension with the Sonic Tension Meter, at least three consecutive readings should be taken to ensure that the fundamental belt span frequency is being detected properly. The three readings should be close together, and can be averaged together for an accurate average belt tension reading.

Belt Cross Sectional Rigidity

Sonic Tension Meter calculations are based upon "string theory" which assumes infinite flexibility of the vibrating member. The natural frequencies of belt spans are influenced by belt cross sectional rigidity, or belt bending resistance. Thinner belt cross sections, and longer belt spans will produce the most accurate fundamental belt span frequencies. Consider the following guidelines for minimum recommended belt span lengths in order for belt tension measurements to remain reasonably accurate:

- Synchronous belt span lengths should have at least 20 belt teeth
- V-belts span lengths should be at least 30 times the belt top width

Note that the fundamental belt span frequency will be affected as these minimum recommended belt span length values are approached.

Belt Mass Constants

Belt mass constants for individual belt sections within the Gates industrial belt product line are available from the Sonic Tension Meter Users Manual and Data Card. Belt mass constants are also included in Design Flex® Pro® and Design IQ™ drive design software. The values were derived by weighing a series of production belts, computing normalized unit weight values and averaging the results. Note that mass constants for V-belts have been adjusted in order to compensate for belt cross sectional rigidity (see previous section).

The actual mass of individual belts can be influenced by overall belt cross sectional dimensions, material component densities, manufactured belt length, and other factors. While these variations are generally small, the actual mass values of individual belts can vary from the average published values.

Belt Span Length

Belt span length is a critical component of the belt tension calculations within the Sonic Tension Meter. The basic belt tension equation used is as follows:

$$T = 4(M)(W)(S^2)(f^2) \times 10^{-9}$$

Where: T = Belt Span Tension (newtons)
M = Belt Mass Constant (grams/meter)
W = Belt Width (mm) or Number of Belt Strands
S = Belt Span Length (mm)
f = Belt Span Frequency (hz)

In this equation, the belt span length and belt span frequency are both squared terms. This means that any error in their values will be multiplied by their square, making their accuracy especially critical. Belt span length should be calculated rather than measured due to the difficulty of accurately determining beginning and end points of the belt span. Belt span length values are automatically calculated in Design Flex Pro and Design IQ drive design software. Note, though, that manufactured belt lengths can vary within allowable manufacturing tolerances for each belt section. These small belt length variations can influence actual belt span lengths in every belt drive application.

Sprocket & Sheave Eccentricity

All sprockets and sheaves rotate with some eccentricity or radial run out resulting from manufacturing variations and shaft mounting. As eccentric sprockets and sheaves rotate, the belt length changes resulting in belt tension variations. As belt drives rotate, the belt tension naturally rises and falls cyclically. A belt tension measurement cannot be reproduced unless the sprockets or sheaves are in the identical positions as when the original measurement was taken. Because belt tension measurements will naturally vary with sprocket or sheave rotational positions, users especially concerned with belt tension measurement accuracy must decide whether to target minimum or maximum belt tension readings. While neither minimum nor maximum tension levels are preferred over one another, several acceptable approaches to belt tension measurement are available

- Rotate the drive and locate the lowest belt span tension reading
- Rotate the drive and locate the highest belt span tension reading
- Rotate the drive and locate both low and high belt span tension readings and average them

Estimating Sonic Tension Meter Accuracy

Numerous factors affect Sonic Tension Meter accuracy. The combined effects of the factors are too complex to consider analytically in a practical manner.

As a point of reference, the accuracy of the Sonic Tension Meter is far superior to conventional methods of belt tension measurement such as force-deflection and V-belt elongation. While variations in Sonic Tension Meter readings are normal, overall accuracy, repeatability, and consistency between different users are all quite good.

For overall Sonic Tension Meter accuracy, the following estimates can be used:

- Estimated accuracy for Synchronous belt drives: ± 10%
- Estimated accuracy for V-Belt drives: ± 20%

Both of these estimates neglect the effect of sprocket and sheave eccentricity, which can have a considerably greater effect by itself.

Maximizing Sonic Tension Meter Accuracy

To maximize the accuracy of belt tension measurements using the Sonic Tension Meter, the following suggestions should be considered:

- Obtain several belt tension readings close together and average the values
- Take belt tension readings while incrementally rotating drives and identify minimum and maximum values (minimum and maximum values can be used directly or averaged together)
- Compare Sonic Tension Meter readings against known belt tension values (possibly from a test fixture) and develop correction multipliers if necessary