



LUDECA

Keep it running.

PULLEY ALIGNMENT GUIDE

including
5-Step Sheave/Pulley Alignment Procedure



Pulley Alignment Guide

Precision alignment is an essential part of a proactive reliability program. This guide provides information for the implementation of good pulley alignment of belt-driven equipment including terminology, alignment methods as well as belt maintenance, storage and tensioning.

The content of this guide and our 5-Step Sheave/Pulley Alignment Procedure are basic guides to re-align machines. In practice, more details must be taken into account. LUDECA is not responsible for any damage or injury arising out of the use of these documents.

About LUDECA

LUDECA is a leading provider of Preventive, Predictive and Corrective Maintenance Solutions including laser alignment, vibration analysis, balancing, induction heating and ultrasound equipment as well as software, rentals, services and training. For more information, visit www.ludeca.com

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Pulley Alignment Guide

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Introduction

Getting the most out of your belt drive systems involves several things, key among them good pulley alignment and good sheave and belt maintenance. Good design, good quality components and correct installation are the starting points. Thereafter, keeping it running well requires attention to the details.

Good sheave alignment will increase efficiency by reducing premature wear or failure of belts, pulleys and bearings. This can be accomplished by several different alignment methods, such as the labor intensive string and straightedge method (most common), or by laser. Laser pulley alignment systems are now well established in the sheave alignment field, and have proven themselves in greatly reducing downtime and the manpower needed to do the alignment, while simultaneously achieving far greater accuracy. This results in significant labor savings and increased production uptime. Later on this guide we will acquaint you with one such system and its features and benefits.

A V-Belt drive is a very efficient method of power transmission (from 90 to 98%) and has traditionally been thought of as very forgiving; however, proper alignment and belt tension are extremely important and can make a huge difference in MTBF (Mean Time Between Failure.) Do not assume that only a drive which is squeaking is slipping: Belt slippage of as much as 20% can occur noiselessly, resulting in loss of efficiency, premature wear and damage to the belts and their sheaves.

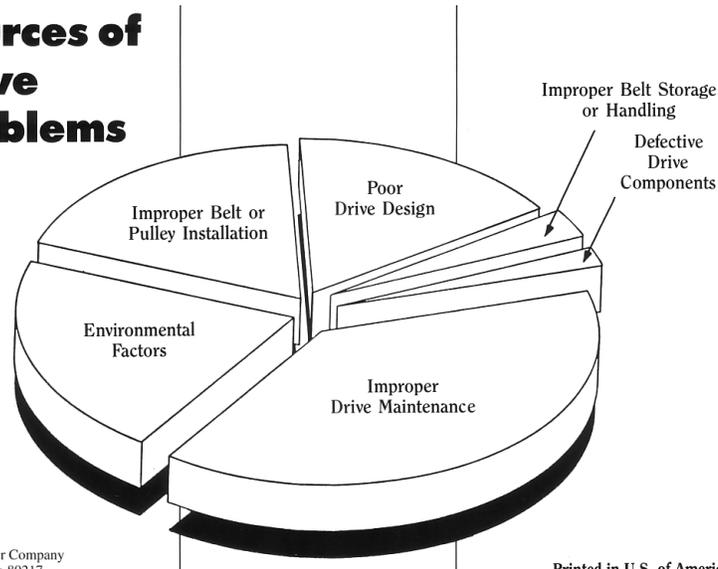
Good drive maintenance involves a number of steps, roughly half of which involve aligning the drive. These are, in order: Removing old belts, inspecting all components for wear and damage, checking for bent shafts and correcting sheave runout, installing new belts, performing the alignment, and tensioning the belts.

Your foremost concern should always be safety. *Never* allow loose neckties or long hair anywhere near belt-driven machinery, and make *certain* all equipment is locked out and tagged out.

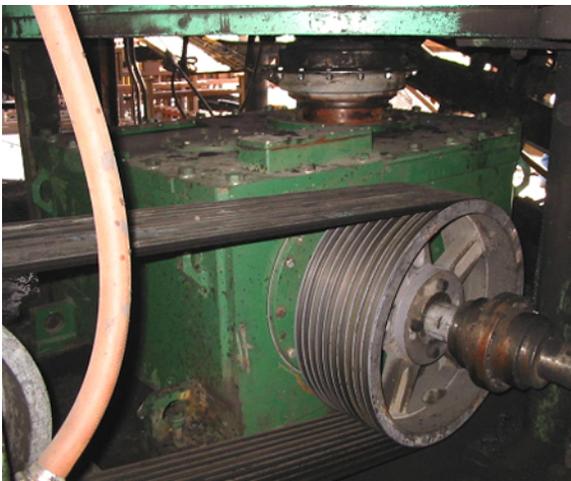
Prior to beginning sheave alignment, it is a good idea to try to determine (if possible) the cause(s) of your belt or sheave failure, and correct it to prevent unnecessary reoccurrence. FMEA (Failure Modes and Effects Analysis) and RCA (Root Cause Analysis) are very helpful tools in this process. The cause of failure could be associated with poor drive maintenance (improper belt tension, poor sheave alignment), environmental factors (sunlight, harsh temperature fluctuations), improper installation (wrong belts/sheaves, belts pried on by force), or operating factors (overload, shock load.)



Sources of Drive Problems



Belt and Sheave Maintenance and Storage

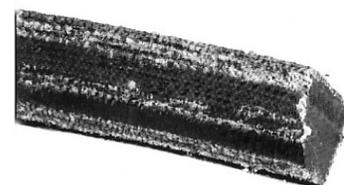


When embarking on belt drive maintenance, one important step, often forgotten, is to perform a close inspection of the belts and of each sheave and its grooves. This inspection should include looking (and feeling) for cracks, chips, or excessive groove wear, and checking for proper contact between the belts and the sheaves. Problems of this nature *must* be corrected before proceeding with anything else, to prevent premature or catastrophic failure.

Replacing belts only requires moving one sheave toward the opposing sheave, to slacken the belts. Replace a belt with a new belt of the correct length, material, and pitch angle. Never force a belt onto a sheave as this will damage the tensile member of the belt, or damage the sheave itself. If aligning a multiple-belt drive, replace all of the belts together, not singly, since new and used belts that are otherwise identical have greatly different operating and tensile characteristics. Only combine belts from the same manufacturer, and preferably use a factory-matched set.

Larger sheaves can increase belt life. If it is feasible, consider increasing both the driver and driven pulley diameters by the same percentage. Speeds will remain the same. Larger pulleys reduce bearing loads since they allow for more contact area between the belt and pulley thereby permitting the equivalent drive force to be transmitted with less belt tension.

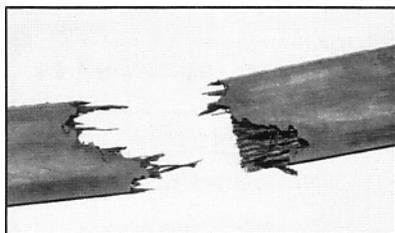
Inspect the removed belt for any noticeable defect (cracking, gouges or crumbling) and signs of slippage (glazing). Notice *where* the belt is worn. This may be a good indication of what type of misalignment or other problem might be in play. It is appropriate to change a belt anytime undue wear is detected. When replacing a belt, make sure you



Rubbing

Image courtesy of The Gates Rubber Company

replace it with one that has been properly stored. Belts should be stored in a cool, dry place with no exposure to direct sunlight or heater drafts. Do *not* hang belts from a single peg; this may damage the tensile member and distort the belt over time. Preferably hang them from two pegs, or better yet pile them on shelves. Coil long belts, and don't make the piles too big or heavy, to avoid distorting the bottommost belts.



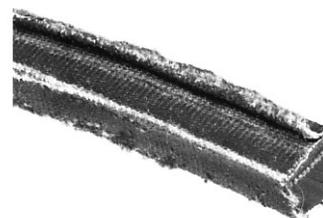
Tensile failure

Image courtesy of The Gates Rubber Company

Operating temperature is also extremely important. Try to keep operating temperatures below 140°F. To this end, make sure that protective covers and belt guards are well vented. The purpose of these covers is to keep fingers and debris out, not heat in!

Another factor to consider is bearing life: the lower the radial load on a bearing, the longer its lifespan. Bring pulleys in as close to the bearings as possible. This will reduce load, increasing bearing life by the cubed(!) factor of the reduction. In other words, to use an extreme example, if you cut bearing load in half you will increase its lifespan by eight times!

The next step of the process is to inspect the sheaves. Belts should run flush with the outer diameter of the sheave lips. If the top of the belt protrudes radially beyond the outer diameter of the sheave, it is too large for the sheave. Also make sure the belt is not contacting the bottom of the groove. Drive torque from pulley to belt should be transmitted by the friction between the sides of the belt and the inner faces of sheave groove, and never between the bottom of the groove and belt. If the bottom of the groove is shiny, the belt is touching it.



Turnover damage

Image courtesy of The Gates Rubber Company

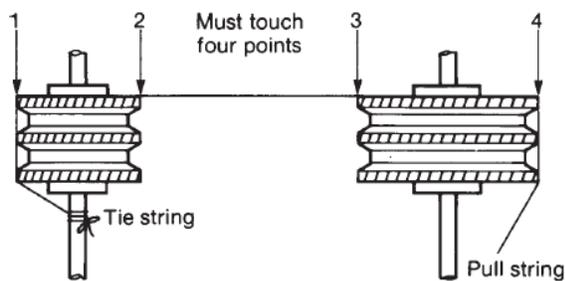
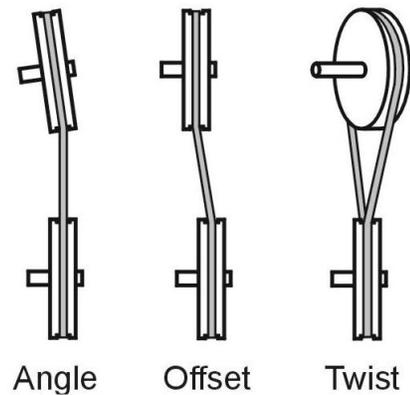
Next measure sheave runout. There are two types of run-out: rim (radial) and face (axial), both of which must meet tolerance prior to actually performing final alignment corrections.

The tolerance for radial or rim runout on high speed sheaves (1800 R.P.M. and higher) should not exceed 5 mils total indicated reading (T.I.R.) on average, and may be increased to up to 10 mils on slower sheaves. The tolerance for axial or face runout should not exceed 0.5 mils per inch of sheave diameter (T.I.R.) for high speed sheaves, and may be increased to up to 1 mil per inch for slow sheaves. Always follow the sheave or machine manufacturer's tighter tolerance recommendations, if given. Start by checking for radial runout. If unsatisfactory, check for shaft runout. If excessive runout is also present on the shaft, it may be bent. If so, you must replace the shaft and check radial runout on the sheave again. If no runout on the shaft is detected, replace the sheave instead. If the sheave is mounted on a tapered shaft bushing, remember to inspect and clean the bushing both inside and out to ensure proper seating. Next check for face (axial) runout (wobble) and if necessary correct it by repositioning the sheave on its shaft. Once runouts are in tolerance, proceed to install new belts.

Place the new belts into the sheave grooves, reposition the sheaves to rough alignment, and check that the belts are properly seated within their grooves.

Pulley Alignment

Now for the alignment. Misalignment consists of three types: Vertical angularity (twist), horizontal angularity, and axial offset, all of which can coexist in any combination. The best way to correct offset misalignment is by moving the pulley axially on its shaft, or by moving the adjustable machine (usually the motor) axially. Horizontal angle is corrected by moving the adjustable machine laterally to change its angle with respect to the opposing pulleys. Jackscrews on the machine feet make this task much easier and the alignment more controllable. Lastly, twist angle is controlled by shimming the front or back feet of the adjustable machine as needed to eliminate the twist angle.



There are several sheave alignment methods, the most common of which is the string and straightedge method, wherein these must touch each sheave at two diametrically opposite positions simultaneously (totaling four contact points). The sheaves should be rotated half a turn and checked again. Since a string can bend around corners, you cannot easily differentiate between offset and horizontal angle when only three-point contact is made; nor will a straightedge or a string detect twist angle under certain conditions. These methods are also very labor and time intensive.

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**Easy-Laser® XT-190
Belt Alignment System**

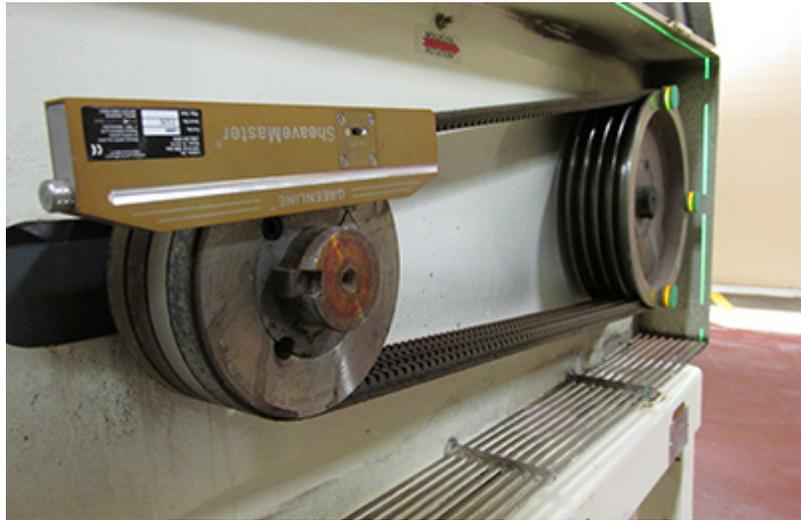
A fan-type laser overcomes all of these problems. One such system (the Easy-Laser® XT 190) mounts magnetically to the face of sheaves as small as 2.5" diameter and projects a laser fan line onto a sensor unit magnetically attached on the other pulley.

The laser emitter unit generates a laser plane parallel to the reference sheave. The detector reads the position in relation to the laser plane and provides a live digital display of offset and both angular values.

This makes the alignment of the adjustable machine very simple. The accuracy of the digital readout lets you easily align within prescribed tolerances. The system also connects to the Easy-Laser's XT-11 Alignment computer (used for the XT440, XT660 and XT770 series laser shaft alignment systems) to make performing the alignment even easier.

Other systems (such as LUDECA's SheaveMaster® Greenline) feature a green laser fan line whose greatly increased visibility is ideal for bright light conditions, especially outdoors

on a sunny day, where red wavelength lasers can be harder to see. One such system projects a laser line onto three small targets that are mounted to the face of the opposing pulley; additional targets can be mounted to idler pulleys in the belt path for a complete overview of the belt drive alignment. The mounting position of the targets is important: two should be mounted near the top and bottom to allow twist angle to be detected. The third should be mounted at the back of the opposing pulley



**LUDECA SheaveMaster® Greenline
Belt Alignment System**

(on the far side) to give maximum angular resolution to be able to visually detect horizontal angle. For maximum visual resolution and hence alignment accuracy, try always to mount your fan line laser emitter on the smaller pulley and the targets on the larger pulley.

One important consideration in the use of laser pulley alignment systems is safety. It is important to ascertain the laser class utilized in these systems. The best use a Class II laser which requires no special safety precautions beyond not staring into the beam.

Before beginning the alignment process, first ascertain that the motor has no soft foot. Soft foot is machine frame distortion that can occur due to a variety of reasons, but primarily from improper shimming, uneven foundation surfaces, or conduit strain. Check for soft foot by loosening only one foot at a time on the motor and check for any gaps that may appear under motor feet with a feeler gauge. Maximum permissible gaps are 0.002". Anything greater needs to be dealt with. Shim as needed to eliminate any potential frame distortion.

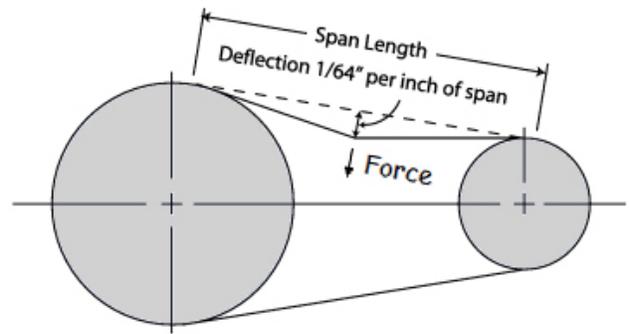
Always correct vertical (or twist) angle first, by shimming the driver, then correct horizontal angularity by moving the driver laterally with jackscrews, and lastly correct offset by moving the driver with axial jackscrews, or by repositioning one of the pulleys axially on its shaft. (Be careful not to cock the pulley in doing so!) Since performing one alignment correction almost invariably affects the other alignment conditions, this process may have to be repeated several times. This is where the fan-line laser systems mentioned previously really pay off, since they allow you to monitor all three alignment conditions simultaneously as you work. This makes the job far easier and faster, as well as increasing the accuracy of the alignment.

Belt Tension

After the sheaves have been aligned, the next step is the proper tensioning of the belts. Incorrect tension (as well as misalignment) will adversely affect the life of the belts and the efficiency of the drive as a whole. Using a spring scale, press down on the belt in the approximate center of its span (on the tight side), to deflect the belt by 1/64" per inch of span length, and, while doing so, observe the force required to do so. If you are not sure of the belt span length you may also use the center-to-center distance of the pulleys, which

will be similar. For example, if your span length is 30", apply sufficient force to deflect the belt by 30/64", or 15/32" and observe how much force is required to do that.

Now either increase or decrease tension on the belts until the force required for this deflection equals the belt manufacturer's maximum recommended force values for the specific belts you are using. Also make certain this force does not exceed the machinery's design loads. The force values for all belts in a multiple belt drive should fall within 10% of one another. Using a matched set of belts and having a good alignment are essential in achieving this goal. It is tricky to move the driver to slacken or tighten the belts without changing the alignment! Here again a fan laser like the Easy-Laser® XT190 pulley alignment tool is invaluable, since all three of the alignment parameters can be monitored simultaneously for the sheave set while adjusting the tension on the belts.



The final step is to run the machines for about two hours to allow the belts to stretch and seat themselves properly in the grooves. The belts must then be retensioned to the recommended values for new belts. Now run the machines for at least 72 hours, but not more than 10 days, and retension once again, this time to the manufacturer's recommended force values for used belts.

Following, we present our 5-Step Sheave/Pulley Alignment Procedure as a handy and quick guide on a single page of all the things to consider in pulley alignment. Enjoy!☺

- Pie chart and belt damage images courtesy of The Gates Rubber Company, *Belt Preventive Maintenance Manual*, Denver, 1996.
- Easy-Laser® XT 190 image courtesy of Easy-Laser AB, Mölndal, Sweden.
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5-STEP SHEAVE/PULLEY ALIGNMENT PROCEDURE



LUDECA

1



Pre-Alignment Checks



Safety:

Lock-out and tag-out the machines.



Visual inspection of the sheaves, belts, foundation and baseplate.

Replace sheaves if needed.



Clean up: remove rust, scale, paint, dirt from under and around the feet. Clean sheaves as well.



Replace damaged shim packs with new, corrosion and crush resistant shims.

2



Runout and Soft Foot



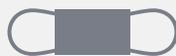
Check and correct shaft runout.



Check and correct sheave rim runout (radial) and face runout (axial).



Using feeler gauges find obvious gaps under the motor feet and fill them with shims, to eliminate any soft foot condition.



Install new belts, if needed. *Always replace all belts together with a new matched set.*



Torque bolts to specifications.

3



Laser Alignment



Set up laser alignment system and measure misalignment.



Correct **twist** misalignment by shimming the motor feet.

Recommended tolerance: ±0.5 degrees. (9 mils/inch)



Correct **angular** misalignment by moving the machine horizontally.

Recommended tolerance: ±0.5 degrees. (9 mils/inch)



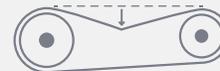
Correct **offset** misalignment by moving the machine axially.

Recommended tolerance: ±8 mils (thou) per inch of span length.

4



Belt Tensioning



2x

Take two sets of belt tension measurements.



Set the belt tension to manufacturer's specifications.

Typically, set tension to recommended force to deflect belts 1/64 inch per inch of span length (tight side).

Be careful not to affect the alignment during these adjustments.



Re-check the alignment.



2 HRS+

Run machines for two hours to allow belts to stretch and seat themselves then recheck tension. Readjust as necessary.

5



Documentation



Save the alignment file, if your system allows for it.



Print the report to document the alignment, if your system allows for it.

72-240 HRS

Run the machines at least 72 hours, but not more than 10 days and retension again, this time to manufacturer's recommended force values for used belts.