ANALYZE YOUR WAY TO LONGER LASTING, BETTER PERFORMING V-BELT DRIVES

Introduction

Imagine replacing the belts under your car hood every time you changed the oil. Wouldn't you suspect a problem? Yet plant and maintenance managers often find themselves replacing V-belts every few months, or even weeks, without ever asking why.

Premature V-belt replacement carries a cost, both obvious and hidden. The cost of the V-belt itself may be nominal. But shutting down the drive to replace and retension the belt may disrupt operations and impact plant productivity. So the less frequently you need to replace a belt, the better.

V-belts, as simple as they seem, are marvels of technology. A properly designed and installed V-belt drive should deliver a long service life—unless there's an undiagnosed problem.

How do you know if a V-belt is failing prematurely? By examining the clues. In the same way that physical symptoms in the body reflect an underlying disease, the physical signs on a V-belt and sheaves reflect underlying problems with the drive system. Finding and correcting the cause relieves the symptoms. The resulting benefits include:

- Better drive performance
- Longer belt life
- Improved drive efficiency
- Energy cost savings
- Reduced maintenance and downtime
- Improved productivity

Analyzing V-belt failures doesn't take a lot of complicated tools. The knowledge you will gain from this paper about what goes on in a V-belt drive system is enough to reap the benefits.

What Is “Normal” Failure for a V-belt Drive?

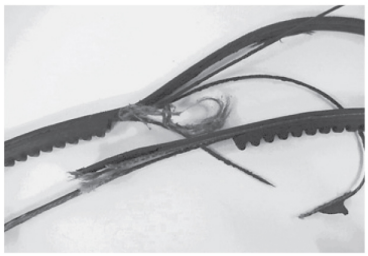

Figure 1 - Normal V-belt failure is characterized by a break or separation.

Before you can tell whether a V-belt drive is behaving badly, chewing up belts before their time, it helps to know the performance characteristics of a “normal” drive.

When properly installed and tensioned, a V-belt drive will operate at 93% - 97% efficiency. This level of efficiency can be sustained as long as the belt drive is properly tensioned and the other drive components well maintained.

The frequency of belt replacement depends on the speed, load, and hours of operation of the drive. This interval can vary significantly. The V-belt on a well maintained drive could deliver up to 3-5 years of service. In harsh conditions, the life of a belt might be reduced to one year or less.

Any mechanical component fails eventually. When a V-belt has reached the end of its useful life, it will pull apart, or break, indicating that it can no longer carry the load it was designed to carry in the drive system. (See Figure 1)

This type of break can also occur for other reasons. The drive could be under-designed, subject to extreme or cyclical shock loading, or contaminated by debris. Or, the belt may have experienced damage to the tensile cords.

Time is the key differentiator. If the belt is failing more often than expected, the cause is abnormal wear. If it fails in this manner after years of service, consider it “normal” failure.

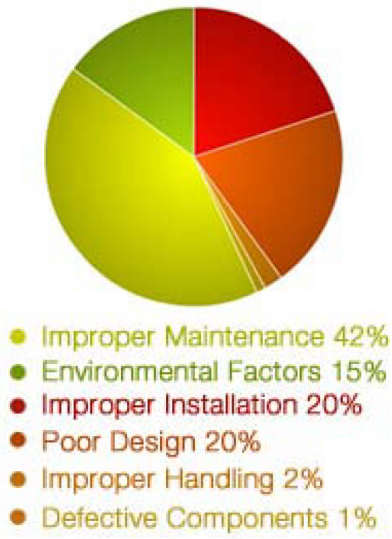

Figure 2 - Factors affecting V-belt life

Factors Affecting V-belt Life

Improper Maintenance

Poor maintenance is the major cause of premature V-belt failure. To transmit power efficiently, V-belts need a large surface area of contact, a high coefficient of friction (grip), and tension. A drive that has been properly designed for the application, installed correctly with new components, tensioned properly, and retensioned after a run-in period will meet these requirements.

Time and neglect, however, can compromise these principles. Too much or too little tension, worn pulleys (sheaves) and misalignment are key indicators of improper maintenance.

Regular inspection and maintenance to ensure proper alignment, correct tensioning, and prompt detection of signs of abnormal wear are needed to keep a drive performing as it was designed.

Poor Design

Poor drive design accounts for 20% of early V-belt failures. The drive may not have been designed properly for the original equipment. Or changes could have been made by the end user that increased the load or the speed of the equipment.

Most belt manufacturers provide free software (such as Gates Design Flex® Pro™ drive selection tool) to help users design or redesign V-belt drives. Required information for a properly designed drive includes desired belt type, motor rpm and horsepower, service factor, gearbox information (if needed), desired driven pulley rpm or speed ratio, and center distance between shafts.

The software returns all the possible drive designs that meet the given parameters. This method ensures obtaining a drive suited to the application.

Improper Installation

Another major cause that can lead to premature V-belt failure is improper installation. V-belt drive performance depends on applying and maintaining recommended installation tension levels. The ideal level is the lowest tension at which belts will not slip under peak loads. These levels are established by belt manufacturers and published in their design specifications.

In addition to having proper tension, the drive must be properly aligned. Misalignment causes belt instability and shortens V-belt life. Common causes of misalignment include the following:

- Driver and driven shafts are not parallel (both horizontal and vertical planes)
- Sheaves are not located in line axially with respect to one another on the shafts.
- Sheaves wobble or tilt while running due to improper mounting

These conditions cause either parallel or angular misalignment (see Figure 3). Proper alignment can be checked with a straight edge and string, or ideally with a laser alignment tool. A properly aligned V-belt drive has four points of contact between belt and sheaves (see Figure 4).

Total angular and parallel misalignment in a V-belt drive system should be kept within ½-degree or 1/10-inch per foot of belt span.

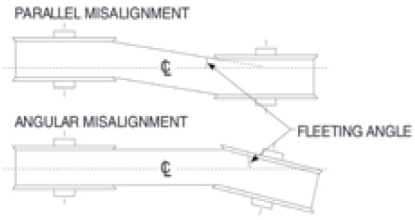

Figure 3 - Misalignment between belt and sheave is a major cause of abnormal V-belt wear.

Figure 4 - Properly aligned V-belt drive with four points of contact.

Environmental Factors

Excessive heat and contamination are two additional major causes of abnormal V-belt wear.

The ideal operating temperature for a V-belt is approximately 140°F (60°C). Standard construction V-belts typically can withstand ambient temperatures up to 165°F (74°C) without sustaining appreciable damage. Gates V-belts with EPDM construction are specified to go up to 230°F (110°C). Beyond these temperatures, every 18°F (8°C) increase in internal belt temperature can reduce V-belt service life by half.

At its ideal operating temperature, you should be able to hold a V-belt comfortably in your hand. A belt that is hot to the touch is operating above its ideal temperature range.

V-belts that operate in dusty, gritty environments (sawmills, sand and gravel operations, etc.) are subject to debris collecting between the belt and the sheave. This condition causes excessive wear on the belt and shortens belt service life.

Improper Handling and Defective Components

There's a right and wrong way to store a V-belt until it is ready for use. Where possible, belts should be stored on a flat surface to avoid crimping. Hanging V-belts on hooks, especially large and heavy belts, can cause crimping and shorten life. You should also avoid storing belts in an excessively hot environment. Excessive heat also shortens belt life.

When mounting a V-belt, avoid prying or rolling the belt onto the sheave. Doing so can damage tensile cords and reduce belt life.

Always check sheaves for wear and damage before mounting a V-belt. Nicks and sharp edges can damage belts. So can worn sheaves. Using a plastic groove gauge is a simple method to check for wear (See Figure 5). If the clearance between the sheave and groove gauge exceeds 1/32 inch, replace the sheave.

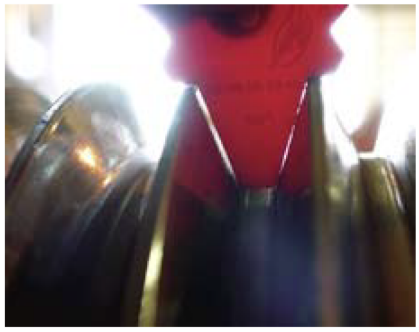

Figure 5 - Inspect sheave grooves for wear with a plastic groove gauge, available from most belt manufacturers.

› Recognizing Problems

How do you know when your V-belt drive has a problem? First, use your senses. Obvious symptoms of a problem drive include excessive noise, vibration and heat; so a preliminary examination involves looking, listening and touching.

A belt that squeals or chirps, makes a slapping, rubbing or grinding sound, or even an unusually loud drive is a sign of trouble. So is unusual or excessive vibration or a belt flopping in the sheave. A belt that is hot to the touch is another warning sign.

Figure 8 - Wear on top corners

Figure 9 - Wear on belt sidewalls

Figure 10 - Wear on belt bottom corners

Figure 11 - Bottom surface wear

When inspecting a V-belt, look at these locations for signs of unusual wear:

- Top surface
- Top corners
- Belt sidewalls
- Bottom corners
- Bottom surface
- Undercord cracking
- Sidewall burning or hardening
- Belt surface hard or stiff
- Belt surface flaking, sticky or swollen

Top surface wear might be caused by the belt rubbing against the guard, or by a malfunction of the idler. Check these locations, and repair or replace the guard and/or idler to correct the problem.

Wear on the **top corners** (see Figure 8) of the belt may indicate that the belt is too small for the groove in the sheaves. Matching the belt to the correct sheave will solve the problem.

Excessive wear along the **belt sidewalls** (see Figure 9) could be caused by several factors. The belt could be slipping due to incorrect tension. If so, retension the drive until the slipping stops. Another potential problem is sheave misalignment, which requires realigning the drive. In this case, replace the sheaves. Or the belt may simply be the incorrect size and needs replacement with the correct size.

Wear on the **bottom corners** of the belt (see Figure 10) could be due to worn sheaves or an incorrect fit between belt and sheave. Check the sheaves for wear and replace them if necessary, or find the correct belt/sheave match.

Bottom surface belt wear (see Figure 11) could be caused by debris in the sheaves, sheave wear, or the belt bottoming out against the sheave grooves. Bottoming out is caused by an incorrect match between belt and sheave, and can be corrected by finding the proper match. If the sheaves are worn, replace them, and if debris has gotten into the sheaves, clean them.

Undercord cracking (see Figure 12) may be due to a number of factors. Environmental conditions (excessive heat or cold) or improper storage could be to blame. Solutions involve controlling the belt drive environment and following proper storage and handling procedures. Another cause might be belt slip, corrected by retensioning the belt to the manufacturer's recommendations. A sheave that is too small for the belt section, causing the belt to wrap too tightly around the sheave, could crack the undercord. Replacing the small sheave with a larger one could correct the problem. Similarly, a backside idler with too small a diameter could be the problem, fixed by increasing the size of the backside idler.

Further diagnosis involves inspecting the belt. Any sign of unusual wear points to a potential problem with the drive. Check for uneven wear patterns, cracking in the back, undercord or notches, frayed covers, burned spots, swelling and hardening.

Detailed troubleshooting requires shutting down the drive and conducting a thorough inspection of all components: belt(s), sheaves, belt guard, bearings, and shafts.

In the next sections, we'll describe the clues that point to specific kinds of abnormal belt wear, and how to make corrections.

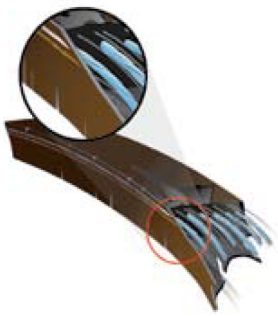

Figure 6 - Broken belt

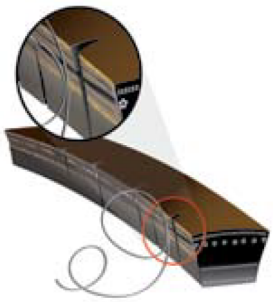

Figure 7 - Edge cord failure

Premature V-Belt Failure

When a V-belt fails prematurely it may break (see Figure 6), delaminate, or slip to the point where it can't carry the load. These signs are almost identical to normal failure at the end of a belt's useful life, so how do you tell the difference? Time. If the drive design projects a two-year service life and the belt breaks after two months, you can be sure the failure is abnormal. Start looking for a problem with the drive and correct it before replacing the belt.

An under-designed drive or severe shock load also might cause the belt to break prematurely. Solving this problem involves redesigning the drive. Another cause of a clean break might be an object falling into the drive, which could be solved by providing better guard protection. Or the installer may have pried or rolled the belt onto the sheave, damaging the tensile cords. This problem is solved by providing adequate take-up when installing a new belt.

Another type of premature failure is edge cord failure (see Figure 7) due to sheave misalignment or a damaged tensile member. Correcting this problem involves checking and correcting the alignment, and following correct installation procedures when installing a new belt.

When a belt fails to carry the load for no visible reason, the drive may have been under-designed. Go back and check the manufacturer's drive design recommendations. A tensile member may have been damaged, which requires following correct installation procedures to fix. Or the sheave grooves may be worn and the sheaves need replacement. Another possible cause is center distance movement, which must be re-checked during operation.

Severe or Abnormal V-Belt Wear

A V-belt doesn't have to fail prematurely to be under duress. Your detective work may uncover signs that something is not right with the drive.

Figure 12 - Undercord cracking

Figure 13 - Sidewall burning or hardening

Figure 14 - Belt surface hard or stiff

Figure 15 - Belt surface flaking, sticky or swollen

Sidewall burning or hardening (See Figure 13) is a sign of belt slip, worn sheaves, an under-designed drive or shaft movement. A slipping belt should be retensioned to the manufacturer's recommendations. A worn sheave should be replaced. If the drive is under-designed and can't carry the load, redesign it to the manufacturer's recommendations. Shaft movement might be caused by changes in the center distance between the sheaves, and should be checked and adjusted.

If the **belt surface** is hard or stiff (see Figure 14), it might be due to an excessively hot environment or to belt slip. Correct the problem by providing more ventilation to the drive or adjusting belt tension.

A **belt surface that is flaking, sticky or swollen** (See Figure 15) may have become contaminated by oil or chemicals. Eliminate the source of the contamination, and never use belt dressing.

Banded (Joined) V-Belt Problems

Banded V-belts (multiple belts with a common cover that serves as a tie-band) may exhibit signs that point to a drive problem. The following symptoms call for investigation:

- Tie-band separation
- Top of tie-band frayed, worn or damaged
- Banded belt comes off sheaves repeatedly
- One or more belt ribs run outside the sheave

Tie-band separation (See Figure 16) might be the result of improper groove spacing. Check the sheaves to ensure that they have been manufactured to industry specifications. Another cause might be worn or incorrect sheaves, which requires replacing the sheaves. Also check to see if the sheaves are misaligned, which could force a separation of the tie-bands. Realign the drive to correct the problem.

If the **top of the tie-band is frayed, worn or damaged** (See Figure 17), determine if the belt is interfering with the guard and adjust the guard as needed. Another possible cause is worn or incorrect sheaves. Replace the sheaves to fix the problem. Debris in the sheaves might also damage the tie-band, so clean the sheaves if needed.

When a **banded belt repeatedly jumps off the sheaves**, two possibilities might be to blame. Either debris has gotten into the sheaves, or they are misaligned. Align the drive to correct any misalignment problems. If debris is a problem due to the type of application, clean out the sheaves and use single belts rather than a banded belt.

A belt that has **one or more ribs running outside the sheaves** (see Figure18) could be undertensioned. Check the manufacturer's specifications and retension the belt. Another possible cause is sheave misalignment. Realign the drive to correct the problem.

Figure 16- Tie-band separation

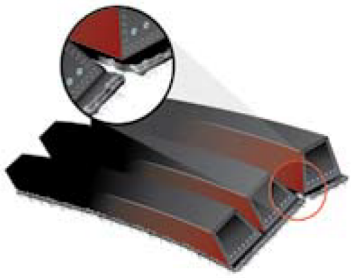

Figure 17 - Top of tie-band damaged

Figure 18 - Belt rib runs outside sheave

Figure 19 - Belt turns over or comes off sheave

Problems Common to Single and Multiple V-Belts

Two problems common to both single V-belts and multiple V-belts include belts turning over or coming off the sheave (See Figure 19), and belts stretching beyond the available take-up.

There are a number of probable causes and corrective actions for single or multiple V-belts turning over or coming off the sheave:

Table A

Probable Cause	Corrective Action
Shock loading or vibration	Check drive design; use banded (joined) belts
Foreign material in grooves	Shield grooves and drive
Sheave misalignment	Realign drive
Worn sheave grooves	Replace sheaves
Subminimum diameter sheave	Replace sheaves with correct diameter

When multiple V-belts stretch unequally beyond the available take-up, the probable cause and corrective action could be:

Table B

Probable Cause	Corrective Action
Misaligned Drive	Realign drive and retension belts
Debris in sheaves	Clean sheaves
Broken tensile member or chord	Replace all belts, install properly
Mismatched belt set	Install matched belt set
Belts from different manufacturers	Replace all belts with belts made by the same manufacturer

When a single V-belt (or multiple belts) stretches evenly beyond the available take-up, check for the cause and corrective action:

Table C

Probable Cause	Corrective Action
Insufficient take-up allowance	Check take up; use allowance specified by manufacturer
Grossly overloaded or under-designed drive	Redesign to manufacturer's specifications
Broken tensile members	Replace belt or entire belt set and install properly

Sheave and Other Drive Component Problems

Figure 20 - An investigation into a customer's belt failure complaint identified this severely worn sheave.

Figure 21 - Gates sheave gauge, product number 7401-0014

Broken or damaged sheaves, severe sheave groove wear, bent or broken shafts, and extremely hot bearings are also problems that impact V-belt life.

It seems improbable that a rubber V-belt could wear out a metal sheave, but it's a fact (see Figure 20). Many users replace V-belts several times without bothering to check the sheaves for wear. Signs of sheave wear include groove sidewall cupping and/or a polished groove sidewall with ridges. Use a sheave gauge (See Figure 21) to detect excessive sheave groove wear, and replace sheaves immediately when worn.

A broken or damaged sheave also decreases belt life. Sheave damage could result from incorrect installation, such as over tightening the bushing bolts. Or the belt may have been pried onto the sheave, causing the damage. Another probable cause of sheave damage is debris falling into the drive. Install a drive guard to correct the problem.

Bent or broken shafts could be caused by a number of factors, including the following:

- Extreme belt overtension
- Overdesigned drive
- Accidental damage
- Machine design error
- Sheave mounted too far away from outboard bearing

Retensioning the belt, redesigning the drive and drive guard, checking the machine design and moving the sheaves closer to the outboard bearing are solutions to these problems.

Hot bearings also indicate a problem with the drive. If sheave grooves are worn and the belt is bottoming out, it cannot transmit power. The belt slips and the bearings heat up. Replace the sheaves and retension the belts to solve the problem. Undertensioned belts also slip and cause the bearings to heat up.

Bearings may also overheat when sheaves are mounted too far out on the shaft. Correct the problem by moving the sheaves as close to the outboard bearings as possible.

Other probable causes for hot bearings include sheaves that are too small or bearings that are in poor condition. Check sheave diameters and redesign the drive to correct the first problem. Check bearing selection and align and lubricate the bearings to correct the second.