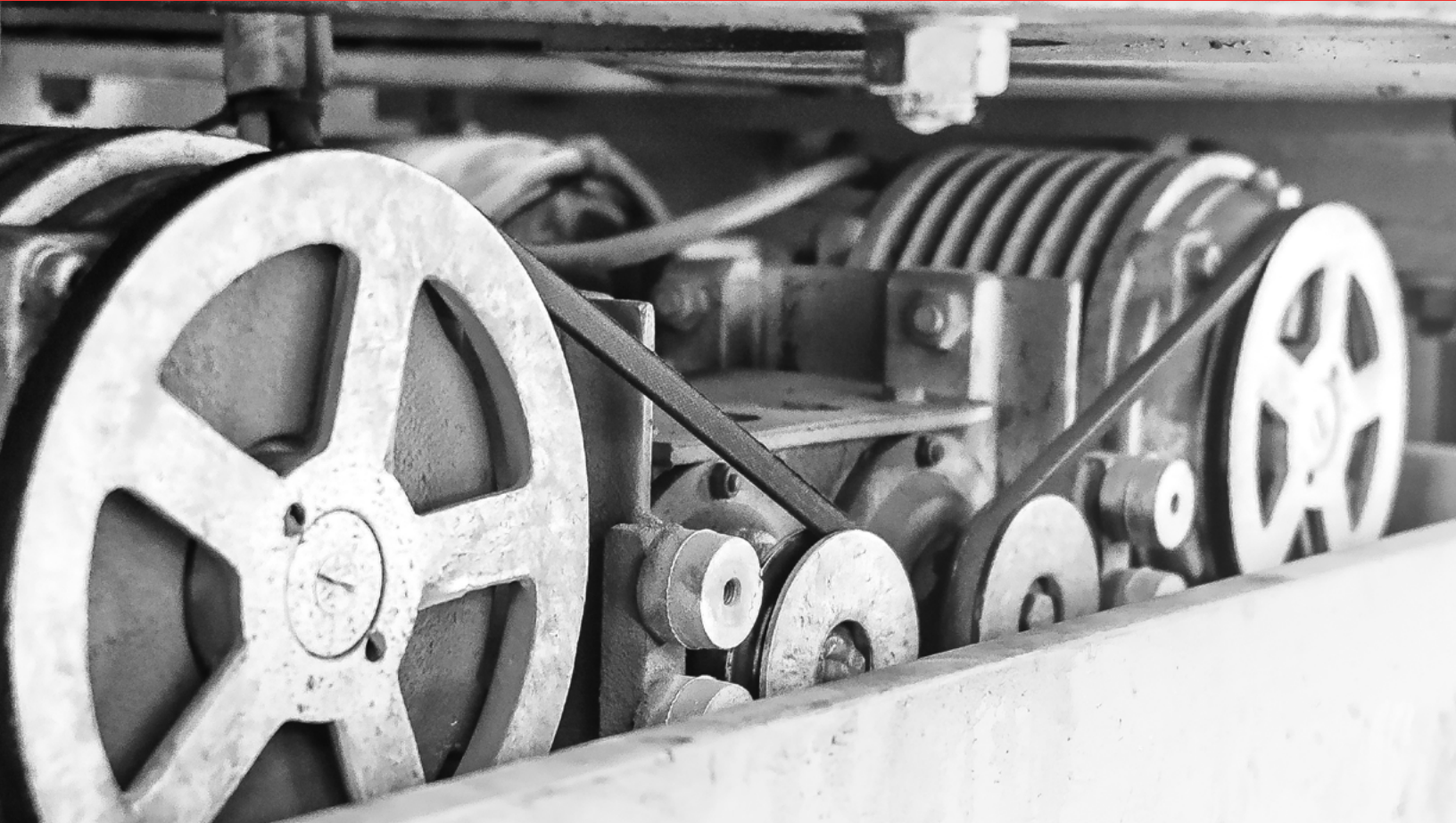




**MEGADYNE**



*E-BOOK*

*AM-EN*

SAVING ENERGY  
WITH EFFICIENT  
BELT DRIVES

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# INTRODUCTION

The cost of energy in manufacturing operations has a major effect on the overall cost of a product. In fact, energy cost is currently one of the main drivers in reshoring, the growing movement of bringing manufacturing operations back to the United States from offshore locations.

In addition, rising energy costs mean that, over time, inefficient drives will waste profits that could be otherwise invested.

By introducing energy efficient belts on electric motor drives, you can implement a simple, cost-effective solution to achieve energy savings in your facility.

A combination of best practice approaches — including proper maintenance and the latest drive belt technology — can improve efficiency through reduced energy consumption and enhance drive performance, protecting your product prices and securing company profits





# ABOUT TENSIONING

## **PROPER TENSIONING**

One third of electric motors employed in industrial and commercial applications use belt drives. The majority of these drives use wrapped (fabric covered) V-belts, relying on the friction between the belt and sheave groove to transmit power.

Relatively inexpensive, wrapped V-Belts are designed to allow for limited slippage and intended to slip only in potentially problematic situations. This slippage prevents damage to expensive driven equipment by acting as a safety fuse. The belt can slip or break preventing damage to more expensive drive components.

However, without frequent periodic maintenance, v-belt drives tend to slip excessively during normal operation and result in reduced efficiency and increased operating costs.

A correctly installed wrapped V-belt drive can attain 95-98% efficiency upon installation, but rapidly declines to approximately 93% efficiency during the course of normal operation. Without periodic tensioning maintenance, efficiency will decrease even further while belt and pulley components will wear more quickly.

Belt drive tensioning maintenance is often neglected due to higher maintenance priorities, meaning that belt drives tend to receive attention only when a belt finally breaks.

This situation can be avoided by periodically adjusting the tension, which will increase the lifespan of your belts and reduce the frequency of service interruptions.



# ABOUT TENSIONING

## **UNDER-TENSIONING**

Under-tensioning is the most common problem in V-belt drives. In addition to reduced efficiency, under-tensioning of the V-belts can cause slippage (resulting in lost power and reduced belt life), noise and premature sheave wear. Energy loss from under-tensioning can be high, so keeping V-belts properly tensioned is a worthwhile time investment.

### **HOW CAN UNDER-TENSIONED DRIVE BELTS BE IDENTIFIED?**

#### ***V-Belts: Look for a “glazing” effect on the sidewalls of the belt***

Glazing, a shiny appearance on the sidewalls, is the result of the V-belt moving independently of the sheave and sliding within the sheave groove. Glazing reduces the friction even further, decreasing drive efficiency. Other noticeable signs include the belt and pulley both being hot to the touch — especially the pulley — and excessive rubber dust from belt wear collecting either on the floor or within the safety shrouding. Finally, you may notice cracks on the underside of the belt caused by excess material stress. Under-tensioned V-belts will harden due to excess heat from the lost energy, making the belts inflexible and requiring even more energy to make the V-belt bend around the pulleys.

#### ***Synchronous Belts: Look for belts stripping or jumping teeth***

With Synchronous Belts, under-tensioning may result in stripped teeth or the drive ratcheting/jumping teeth, which creates a noticeable noise. Should either of these faults be present, the belt is likely already damaged and will need to be replaced.

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## **OVER-TENSIONING**

Over-tensioning of a belt drive is equally as undesirable as under-tensioning. By causing undue stress on the motor, belt, shaft, and bearings from the increased load, over-tensioning accelerates wear of these components far more quickly than normal.

It also decreases drivetrain efficiency, which in turn increases power consumption and leads to increased heat output. The additional heat generated will also harden the belt and reduce its lifespan.

### **SYMPTOMS OF AN OVER-TENSIONED BELT DRIVE**

Broken belts are a common sign of over-tensioning.

Breakage can also result from misaligned pulleys which increases load and reduces efficiency. Finally, the increased stress on the bearings will lead to early or recurrent bearing replacement, another typical indicator of over-tensioning.



# PULLEY CONDITIONS

To achieve an energy-efficient system, it is also important to keep the pulleys in good condition. Misaligned or worn pulleys will contribute to inefficient operation and increased downtime to allow for servicing, making them an important and costly consideration.

## PULLEY MISALIGNMENT

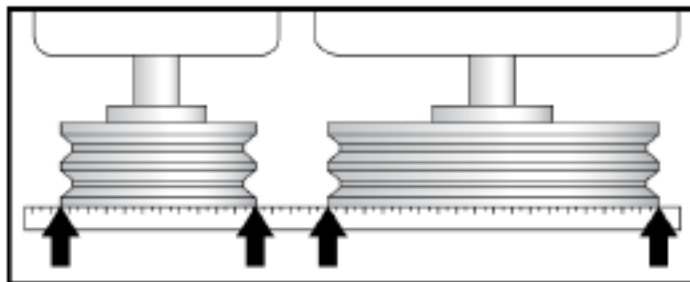
While proper alignment between pulleys is a prerequisite for achieving the correct tension, it also contributes to increased efficiency and reduced maintenance. Pulleys can have parallel misalignment, in which the pulleys are not in a straight line, or angular misalignment, in which one pulley is at a different angle to the other. Misaligned pulleys will quickly wear down belts, shortening the operational lifespan of both and creating damaging stress on other drive components.

On misaligned drives, belts can roll or shift within the pulleys or throw the load to one side, stretching and damaging the belt. The pulleys will also wear unevenly, resulting in reduced lifespan. Angular misalignment can cause differential tension on the belt, wearing it out more quickly. Finally, bushings that have deteriorated or become loose can also affect alignment by causing the pulley to shift.

To address these problems, regular checks on the pulleys will help increase drive lifespan and efficiency.

### *Unsure if the pulleys are misaligned?*

Check the pulleys with a yardstick or other straight edge; this is a quick and simple way to assess potential alignment issues. The straight edge should make contact at four points across the driver and driven pulleys.





## WORN PULLEYS

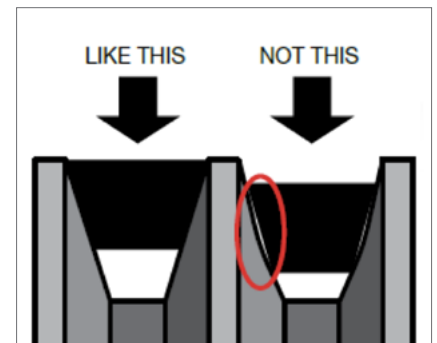
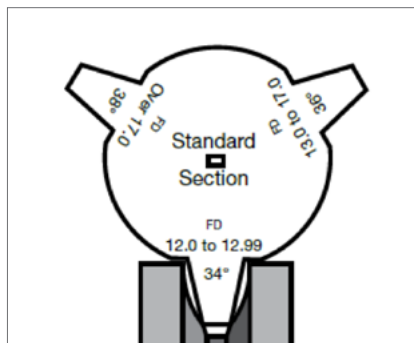
Over time, friction between pulleys and the V-belt will gradually erode the groove material. This leads to reduced surface contact between the belt and the sheave groove, resulting in limited friction, unwanted slippage and increased energy consumption. Worn sheave walls will also cause the V-belts to generate more heat, which reduces their lifespan.

Ensure that the sheave grooves are checked every time a V-belt is replaced. It's best to check the grooves with a sheave gauge rather than by touch, as the dished profile of a worn groove can be easily missed; even as little as 1/32" of wear within the grooves can significantly impact efficiency. A major component such as the pulley can be an expensive outlay but a worthwhile investment that should last several years through proactive maintenance.

### *Uncertain if the pulleys are worn?*

If V-belts are wearing down or failing sooner than anticipated, it could be a sign that the pulley is damaged. In addition to the groove wearing, damaged pulleys can have small nicks that create a burr issue. These burrs lead to abrasion cuts and other damage, which can be another way to identify a damaged sheave.

Synchronous pulleys also experience wear through normal use and require periodic inspection to determine replacement intervals.



### Replace V-Belts with Notched or Synchronous Belt Drives

Approximately one-third of the electric motors in the industrial and commercial sectors use belt drives.<sup>1</sup> Belt drives provide flexibility in the positioning of the motor relative to the load. Pulleys (shafts) of varying diameters allow the speed of the drives equipment to be increased or decreased relative to the motor speed. A properly designed belt power transmission system offers high efficiency and low noise, requires no lubrication, and possesses low maintenance requirements. However, certain types of belts are more efficient than others, offering potential energy cost savings.

The majority of belt drives use V-belts, which use a trapezoidal cross section to create a wedging action on the pulleys to increase friction and improve the belt's power transfer capability. Joined or multiple belts are specified for heavy loads. V-belt drives can have a peak efficiency of 95% or more at the time of installation. Efficiency is dependent on pulley size, pulley wear, V-belt alignment, transmitted torque, under or overizing belts for load requirements. Efficiency can deteriorate by as much as 5% over time if slippage occurs because the belt is not periodically retensioned.

The most important operational and maintenance issue in a V-belt drive is its tension. If belts are too loose, they tend to vibrate, wear rapidly, and waste energy through slippage. If belts are overtightened, they will show excessive wear. An increased belt load may shorten bearing life through excessive lateral loading and could possibly result in shaft failure. The proper tension of a V-belt is the lowest tension at which the belt will not slip at peak-load conditions. After the break-in period, belt tension should be checked every 3 to 6 months.

A notched belt has grooves or notches that run perpendicular to the belt's length, which reduces the bending resistance of the belt. Notched belts can use the same pulleys as cross-section standard V-belts. They run cooler, last longer, and are about 2% more efficient than standard V-belts.

Synchronous belts (also called cogged, timing, positive-drive, or high-torque drive belts) are toothed and require the installation of mating grooved sprockets. These belts operate with a consistent efficiency of 98% and maintain their efficiency over a wide load range.<sup>2</sup> In contrast, V-belts have a sharp reduction in efficiency at high torque due to increased slippage. Synchronous belts require minimal maintenance and retensioning, operate in wet and oily environments, and run slip-free. However, synchronous belts are noisier than V-belts, less suited for use on shock-loaded applications, and transfer more vibration due to their stiffness.

#### Example Energy Savings Calculations

A continuously operating, 100-horsepower (hp), supply-air fan operates at an average motor load of 75% while consuming 527,000 kilowatt-hours (kWh) of electrical energy annually. What are the annual energy and dollar savings if a 95% efficient (η) V-belt is replaced with a 98% efficient (η<sub>s</sub>) synchronous belt? Electricity is priced at \$0.08/kWh.

Energy Savings = Annual Energy Use x (1 - η<sub>s</sub>/η)  
 = 527,000 kWh/year x (1 - 95/98) = 16,130 kWh/year

Annual Cost Savings = 16,130 kWh x \$0.08/kWh = \$1,290

#### Suggested Actions

- Conduct a survey of belt-driven equipment. Gather application and operating-hour data. Then determine the cost effectiveness of replacing existing V-belts with notched belts or synchronous belts and sprockets.
- Consider synchronous belts for all new installations; the price premium is minimal due to the avoidance of conventional pulley costs.
- Consider having a power transmission specialist determine the energy and cost savings potential from retrofitting all V-belt drives with synchronous belts. Synchronous belts rely on tooth grip instead of friction to efficiently transfer power and provide a constant speed ratio.
- Install notched belts where the retrofit of a synchronous belt is not cost effective.

# BELT CONSIDERATIONS

The U.S. Department of Energy recommends replacing V-belts with proven belt drive solutions, including cogged raw edge V-belts and synchronous belts, as best practice for increasing belt drive energy efficiency.

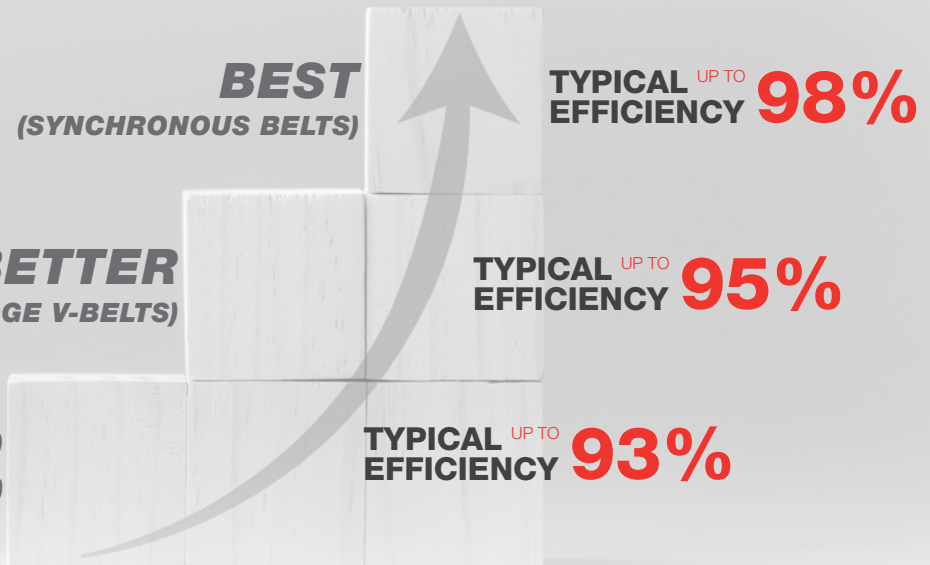
Upgrading from a wrapped V-belt to a raw-edge cogged belt yields an average 2% increase in efficiency, a good return for a very low-cost investment.

For new drives, using synchronous belts can provide an average 5% efficiency increase compared to V-belts.

While increases of 2–5% may seem insignificant, when considering the energy cost savings over multiple drives and longer running times (24/7), the savings soon become substantial.

The following overview of the available belt options, as well as the pros and cons of each solution, is a useful guide for evaluating and selecting the best belt for the task.

Ultimately, there is a balance between achieving the best performance for the lowest cost, so Megadyne offers the following solutions for belt drives, rated by energy efficiency.



## **GOOD:** **STANDARD WRAPPED V-BELT**

Wrapped V-belt is typically the standard belt utilized in many applications. The excellent mechanical characteristics and high transmission efficiency make this type of belt a popular choice.



### **PROS**

The wrapped V-belt will protect the drive from shock loads where torque spikes are present, by allowing some slippage and act as a safety fuse reducing risk of damage to valuable components

Any application where some slippage is desirable will be better suited to using a wrapped V-belt

A wrapped V-belt offers more protection against contamination as the cover offers protection to the rubber body of the belt

### **CONS**

Among available belt drive options, wrapped V-belts are the least efficient

This type of V-belt requires frequent tensioning to maintain its initial efficiency. If not properly maintained on a regular basis, it will lose up to 20% efficiency

**TYPICAL** UP TO **EFFICIENCY 93%**

## **BETTER: COGGED RAW EDGE V-BELT**



“Raw Edge” construction differs from wrapped v-belt in that it does not have external fabric on the sides of the belt. This puts rubber in direct contact with the pulley grooves greatly reducing slippage. The cogged raw edge V-belt also has a cogged underside for cooler operation and greater flexibility, making it ideally suited for smaller diameter pulleys. More efficient than a wrapped V-belt, it is the best choice when a synchronous drive is not cost-effective but greater efficiency is desired. Cogged Raw Edge belts use the same pulley as the Standard Wrapped V-Belt eliminating the cost of changing pulleys to upgrade the drive.

### **PROS**

The cogged or notched construction reduces bending resistance in the belt, so it is able to bend around smaller diameter pulleys than a wrapped V-belt. Smaller pulleys require less material to produce, meaning they are generally cheaper than larger versions

The raw edge sidewall construction (meaning no fabric cover) has a greater coefficient of friction than a wrapped V-belt, making it more slip-resistant and allowing it to transmit more power

A cogged V-belt runs cooler than a wrapped V-belt, and, as a result, will last longer. The US DoE estimates that this belt type is 2% more efficient than standard V-belts

This belt runs on the same pulleys as a standard V-belt, so upgrading is a simple process of changing the belt without incurring the cost of new components

Unlike a synchronous belt, a cogged V-belt provides better vibration damping where excessive vibration is a concern

### **CONS**

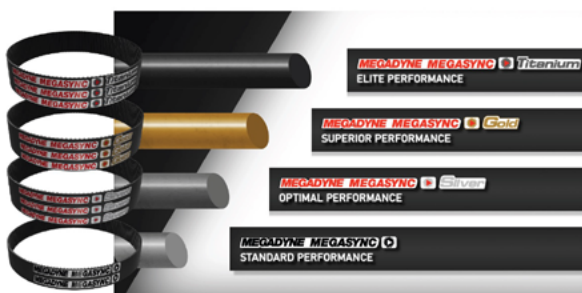
Initial cost of raw edge v-belt is higher although return on investment is rapid

**TYPICAL EFFICIENCY** UP TO **95%**



## **BEST:** **SYNCHRONOUS BELT**

Also known as a timing belt drive, a synchronous belt features teeth that engage with corresponding pulley teeth. This belt eliminates slippage and provides the highest efficiency, thus offering consistently predictable results. However, it is not a direct replacement for existing v-belt drives as it requires a new drive design that will require all new components (belts and pulleys).



### PROS

The teeth in a synchronous drive create positive engagement with the pulleys for zero belt slippage and maximum efficiency

A synchronous belt is the best choice for new drive applications, as the initial cost is offset against the increased efficiency and reduced downtime for maintenance that it offers

This belt maintains its efficiency over its lifespan, unlike a standard V-belt, which loses efficiency over time

This type of drive runs cooler and with less tension than V-belts, which extends the life of both bearings and belts

Capable of operating in wet and oily conditions that would hinder a V-belt, a synchronous belt requires only minimal maintenance and re-tensioning

### CONS

Installation of a synchronous belt will require both new belts and pulleys, making it a higher initial cost than other options

Synchronous belt generates more noise than V-belt

A Synchronous drive is less suited for applications where some slippage is desirable

Alignment and tension of this drive is critical, as it is not as tolerant as a V-belt and is more sensitive to misalignment due to the teeth. If the teeth do not engage correctly, the drive will generate excessive noise and experience rapid wear and early failure

**TYPICAL** <sup>UP TO</sup> **EFFICIENCY 98%**



## **POTENTIAL SAVINGS**

An example of potential energy savings achieved by replacing a V-belt with a synchronous belt:

A continuously operating, 100-horsepower (hp), supply-air fan operates at an average motor load of 75% while consuming 527,000 kilowatt-hours (kWh) of electrical energy annually.

***What are the annual energy and dollar savings if a 95% efficient ( $\eta_1$ ) V-belt is replaced with a 98% efficient ( $\eta_2$ ) synchronous belt?***

Electricity is priced at \$0.08/kWh.

Energy Savings = Annual Energy Use x  $(1 - \eta_1/\eta_2)$  = 527,000 kWh/year x  $(1 - 95/98)$  = 16,130 kWh/year

Annual Cost Savings = 16,130 kWh x \$0.08/kWh = \$1,290

# CONCLUSION

Inefficient drives and infrequent equipment maintenance often contribute to lost profits; forced to spend more money than planned on replacement parts, new operating equipment, and increased energy usage, manufacturers waste budget that could have been invested elsewhere in the business.

By reducing your energy consumption and maintenance expenditures, innovative drive designs achieve the most significant gains in production while keeping spending low.

Rising energy costs, increasing raw material prices, and growing pressure to reduce energy consumption make drive efficiency more important than ever.

Finally, good periodic maintenance programs play a key role in keeping equipment in peak operating condition. Establish a regular maintenance schedule to keep all equipment in working order and running efficiently.

During these maintenance checks, look for tension, alignment, vibration, and wear to identify drive issues before they lead to more serious problems.

## References:

US Department of Energy Advanced Manufacturing Office: Motor Systems Tip Sheet #4 The Importance of Motor Shaft Alignment.

US Department of Energy Advanced Manufacturing Office: Motor Systems Tip Sheet #5 Replace V-Belts with Notched or Synchronous Belt Drives.



## **HAVE A BELTING CHALLENGE?**

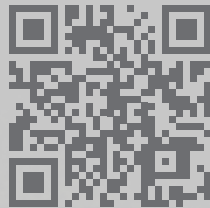
We can help you identify the right type of drive for your application and provide innovative drive designs for the most energy-efficient belting solutions.

### **Megadyne Product Selection Pro**

Discover our online drive design software featuring an Energy Savings Calculator demonstrating the economic impact of upgrading from wrapped v-belts to raw edge cog v-belts or gaining maximum efficiency with a complete change to a non-slip synchronous drive system.

The program calculates:

**Annual Energy Cost**  
**Annual Energy Savings**  
**Payback in months**



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