Product Knowledge Document

Automotive Timing Belt

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INTRODUCTION

HISTORY OF THE TIMING BELT

The lineage of the timing belt can be traced back all the way to the 1940's when a sewing machine manufacturer replaced its noisy and expensive timing chain with a rubber timing belt. After several decades and various material and profile changes, the timing belt was introduced to the automobile.

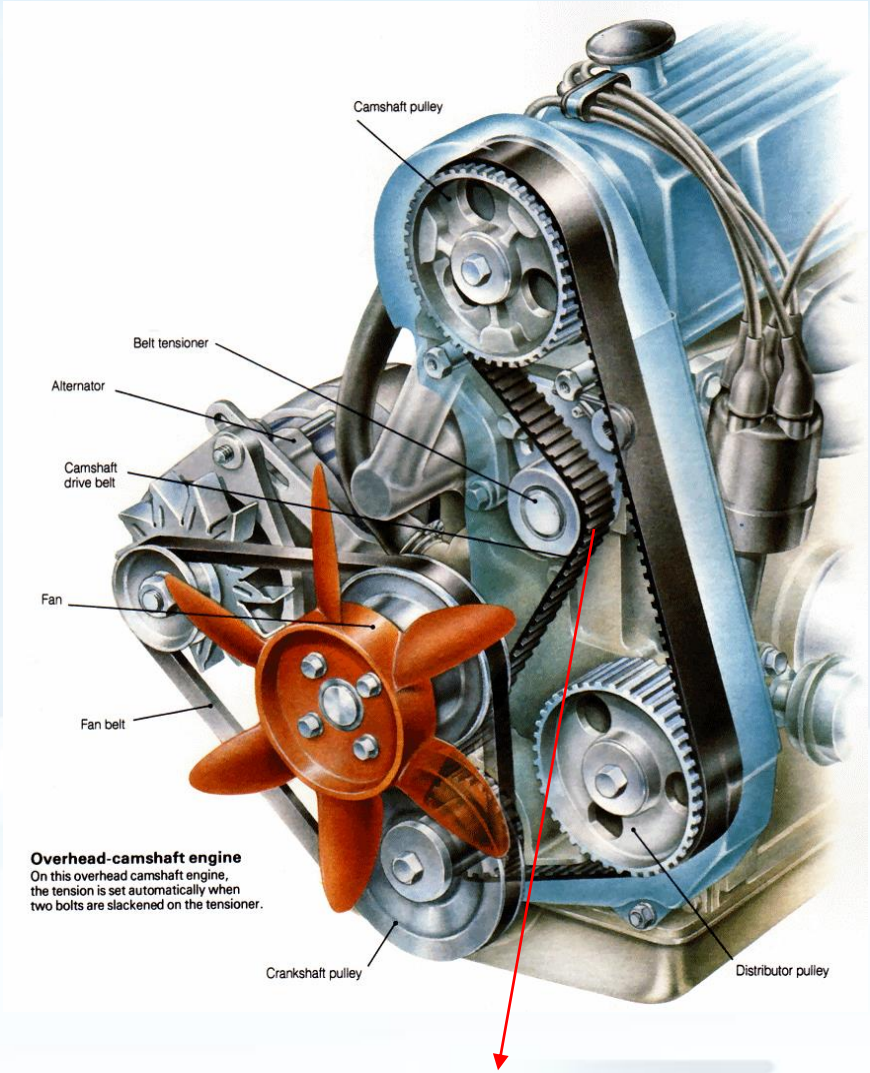
In 1961, GLAS, introduced the S 1004 which became the first production car credited with using a timing belt. Timing belts were introduced to American vehicles when Pontiac manufactured the first belt driven engine in the mid-1960's.

While trends in the automotive industry have fluctuated to and from the use of the timing belt, it offers several advantages over the timing chain. Some advantages of the timing belt are that it does not require lubrication like the timing chain, it is lighter, less expensive, and operates more quietly reducing engine noise.

INTRODUCTION

WHAT IS A TIMIMG BELT ?

A timing belt synchronizes the rotation of the crankshaft and camshaft(s) ensuring the proper timing and allows the engine's valves to open and close during each cylinder's firing. The operation of this belt is critical in preventing the pistons from striking the valves causing damage in an 'interference' engine. This rubber belt is inside the engine behind the external belt drives. It is important to note that a timing belt should be changed at the OE Manufacturer's recommended replacement mileage found in the vehicle's owner's manual.



STANDARDS FOR AUTOMOTIVE TIMING BELT

The present automotive standard is prepared to provide specification for Automotive Timing Belts for incorporating construction, quality control and performance requirements of timing belts. It is recommended for safety related components.

The below mentioned are the Standards –

Sr. No.	Standard	Description
1	JASO E 105-92	Dimensions of Synchronous Belts for Automotive Engines
2	JASO E 110-92	Test Methods of Synchronous Belts for Automotive Engines
3	ISO 9010-1997	Synchronous Belt Drives - Automotive Belts
4	ISO 12046-1975	Synchronous Belt Drives - Automotive Belts - Determination of Physical Properties
5	ISO 17396-2017	Specifies the principal characteristics of synchronous endless and open belts and pulleys of the profile systems T and AT for use in synchronous belt drives for mechanical power transmission and where positive indexing or synchronization can be required

STANDARDS FOR AUTOMOTIVE TIMING BELT

❖ SCOPE :

This standard is applicable to the endless timing belts, which are also known as synchronous belts, used in driving the automotive engine parts such as camshafts, fuel injection pumps, balancing shafts etc.

❖ PURPOSE :

This standard aims to specify the characteristics such as the nominal tooth dimensions, pitch spacing, width and width tolerance, pitch length and pitch length tolerances, and test methods for checking belt pitch length, breaking strength, fabric, and cord adhesion strengths of endless timing belts used in automotive engine drives.

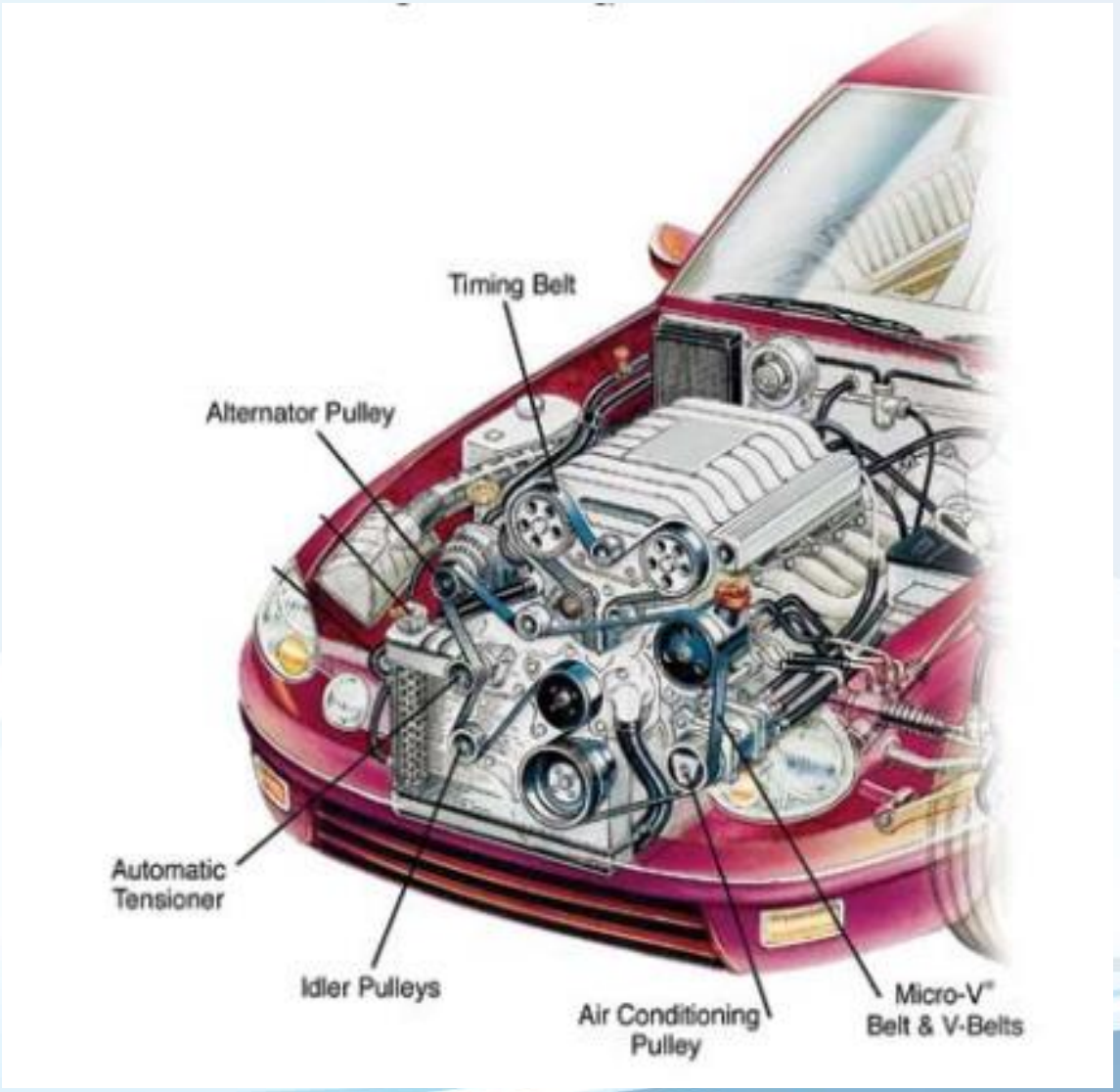
Automotive Timing Belt System

TIMING SYSTEM OVERVIEW

Why a Synchronous Belt in Automotive Engines?

Synchronous belt drive systems, used to synchronize cam and crank shafts, replaced the classical chain drives when overhead camshafts were introduced into engine technology in the 1970s.

The first belt was made of polyurethane with steel cord tension members. During ongoing ‘developments, polyurethane was replaced by very strong and temperature-resistant rubber materials. In addition, the tension member was changed to fiber glass, which provided excellent flex and very low elongation behavior.



TIMING SYSTEM OVERVIEW

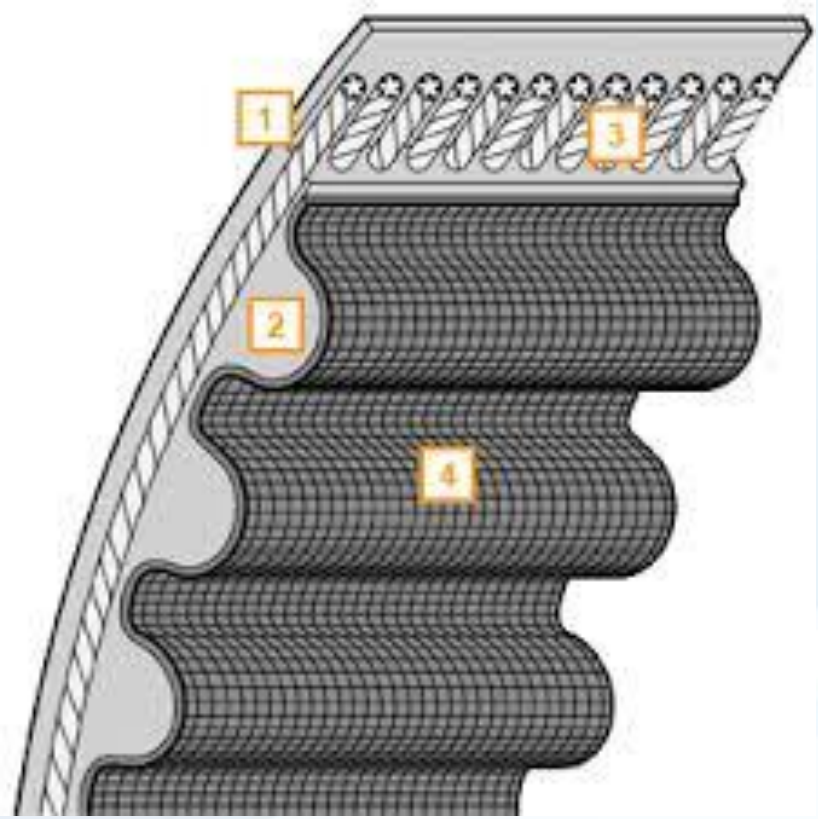
Why a Synchronous Belt in Automotive Engines?

During further engine developments, supported by the trend to overhead camshafts, synchronous (toothed) belt drive systems became more common in engines. This trend was also supported by the many advantages of toothed belt drives, including:

- More simple drives
- Flexible belt routing
- Lower cost
- Low elongation behavior and friction losses
- Constant timing over engine life
- Lower fuel consumption
- Less emissions

A timing belt is a flat, toothed rubber belt that synchronizes an engine's valve and piston movement.

TIMING BELT CONSTRUCTION



Cross Section of Typical Automotive Timing Belt

Sr. No.	Component
1	Back rubber
2	Teeth rubber
3	Tension member
4	Teeth cover fabric

TIMING BELT CONSTRUCTION

Back rubber –
The back rubber compounds shall have uniform composition based on Polychloroprene or heat resistant hydrogenated nitrile rubber (HNBR) as designed by manufacturers and or users. Provides maximum flexibility as the belt bends. Protects top surface from wear.

Teeth rubber –
The teeth rubber compounds shall have uniform composition based on Polychloroprene or heat resistant hydrogenated nitrile rubber (HNBR) as designed by manufacturers and or users. Bonds to the cord for protection against grit, grease, oil, ozone & other harsh environmental elements. Supports cord & resists flex fatigue.

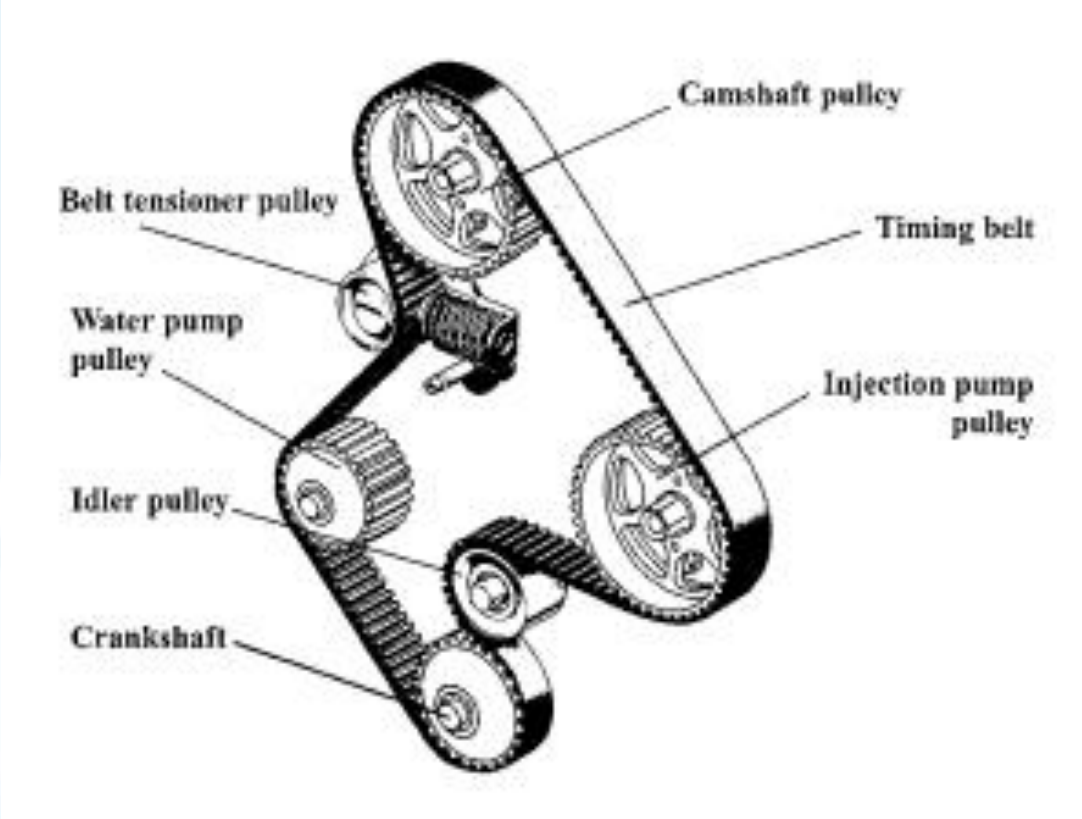
Tension member –
The tension member shall be glass fibre or aramid fibre of Z and S twist placed evenly one after another and treated with bonding agent for better compatibility with rubber compound. Specially treated to provide strength, added flex life and resistance to stretching.

Teeth cover fabric –
The fabric shall be a specially woven expandable polyamide fabric free from flaws, distortions or any other foreign matter. The fabric shall be rubberized on both sides.

TIMING SYSTEM OPERATION

In an engine, the crankshaft drives the camshaft(s) and actuates the valves via a belt or a chain. The timing belt is widely used by car manufacturers because of its advantages over chain, namely reduced space, as well as lighter and quieter running.

Today, one out of every five passenger cars and light trucks use a timing belt to transmit power from the crankshaft to the camshaft(s). Most 4-cylinder and V-6 engines, as well as a few V-8s, use a timing belt. The timing belt is critical to the engine because it sets the engine's intake and exhaust valves in motion.



Note: Most belt drives on current production engines have recommended change intervals of 160,000klms or more

TIMING SYSTEM OPERATION

Belt or Chain?

The benefits of using a belt include:

- **Efficiency –**

A belt drive system can reduce up to 4.5 horsepower in friction loss.

- **Less Vibration –**

A chain drive system shows lower transmission error. A belt drive system can be optimized to be equal or better than chain.

- **Reduced Noise**

- **Creep/Wear –**

Current belt technology provides less than 0.1 percent total length change.

- **Durability/Capability –**

Similar applications with belt drive systems are proven in the industry.

- **Package -**

A belt drive system fits within the chain drive package.

TIMING SYSTEM OPERATION

Belt or Chain?

The benefits of using a belt include:

- **Weight –**

A belt drive system can save approximately 1.5 kg/3.3 lbs. per engine.

- **Cost –**

Overall costs of implementing a belt drive system are generally lower than chain.

- **Complexity –**

A belt drive system uses less components and part numbers.

If the belt tensioner pulley and idler pulleys are not changed together with the belt, early breakdown may occur, resulting in serious damage to the engine.

HOW DOES A TIMING BELT WORK ?

The timing belt is a belt made of rubber that keeps your camshaft and your crankshaft synchronized so that your valve timing is always right. Some vehicles have a timing chain instead of a belt, but it serves the same purpose. If your valve timing is off, your engine won't run properly. In fact, it may not run at all. The belt also regulates the power steering and the water pump.

HOW DOES A TIMING BELT WORK ?

In the four-stroke engine, there are four strokes, or phases. They are:

- **The intake stroke**:
  The piston moves downward, and the intake valve opens to allow the mixture of air and fue to enter the cylinder. At this stage, the exhaust valve remains closed.

- **The compression stroke**:
  The piston moves up and compresses the fuel and air mixture. All valves are closed.

- **The combustion stroke**:
  The piston moves down, allowing the spark plug to ignite the fuel and air mixture, delivering power to the vehicle. All valves are closed.

- **The exhaust stroke**:
  The exhaust valve opens, allowing excess fuel and air to leave the engine. The intake valve is closed.

HOW DOES A TIMING BELT WORK ?

While all this is going on, the timing belt works to turn the camshaft pulley (some vehicles have two camshaft pulleys) in conjunction with the crankshaft pulley. A bad timing belt can cause the camshaft and crankshaft to be out of synchronization, and this can be catastrophic for the car's engine. It throws the valve timing off, and you can end up with bent valves, bent piston rods, or completely destroyed pistons.

You may notice problems in time. Timing belt noise can be a red flag – it usually sounds like squeaking in the belt, or rattling if you have a timing chain. A timing belt problem should never be ignored, so watch for signs that there could be something wrong. The last thing you want is to have to rebuild your engine. As a general rule of thumb, you should plan on replacing the belt every 60,000 to 90,000 miles, or at least have it checked.

For this reason, your manufacturer will have recommendations as to how often your timing belt should be replaced. Generally, around the 80,000 mile mark it is prudent to get a mechanic to replace your timing belt to ensure that the engine continues to run efficiently.

Automotive Timing Belt Classification

TIMING BELT CLASSIFICATION

The automotive timing belts, based on their tooth profile, are classified into the following types:

a. Trapezoidal tooth – There are two types of trapezoidal tooth profile belts:

- Type ZA
- Type ZB

b. Curvilinear tooth – There are two types of curvilinear tooth profile belts:

- Type ZH
- Type YH

Timing belt classification
Trapezoidal tooth

TRAPEZOIDAL TOOTH

- **Trapezoidal tooth belts of types ZA and ZB**

The nominal belt tooth profile dimensions for trapezoidal tooth belts of types ZA and ZB, as shown in Figure 1 are given in Table 1.

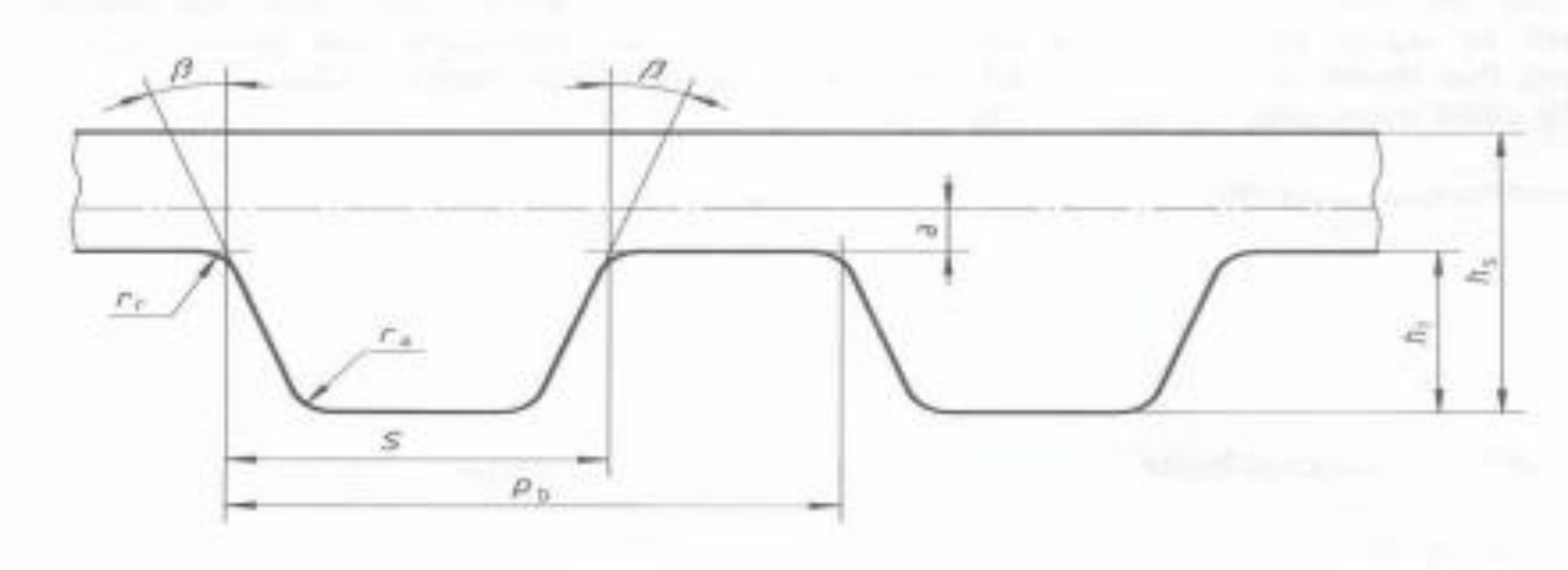


Figure 1

TRAPEZOIDAL TOOTH

- **Trapezoidal tooth belts of types ZA and ZB**

Dimensions in millimeters, angles in degrees

Term	Symbol	Nominal profile	
		Type ZA	Type ZB
Tooth pitch	P_b	9.525	9.525
Tooth angle	2β	40	40
Height	h_s	4.1	4.5
Pitch line differential	a	0.686	0.686
Root radius	r_r	0.51	1.02
Tip radius	r_a	0.51	1.02
Tooth height	h_t	1.91	2.29
Tooth width	S	4.65	6.12

Table 1

Timing belt classification
Curvilinear tooth

CURVILINEAR TOOTH

❖ **Curvilinear tooth belts of types ZH and YH**

The nominal belt tooth profile dimensions for curvilinear tooth belts of types ZH and YH, as shown in Figure 2, are given in Table 2.

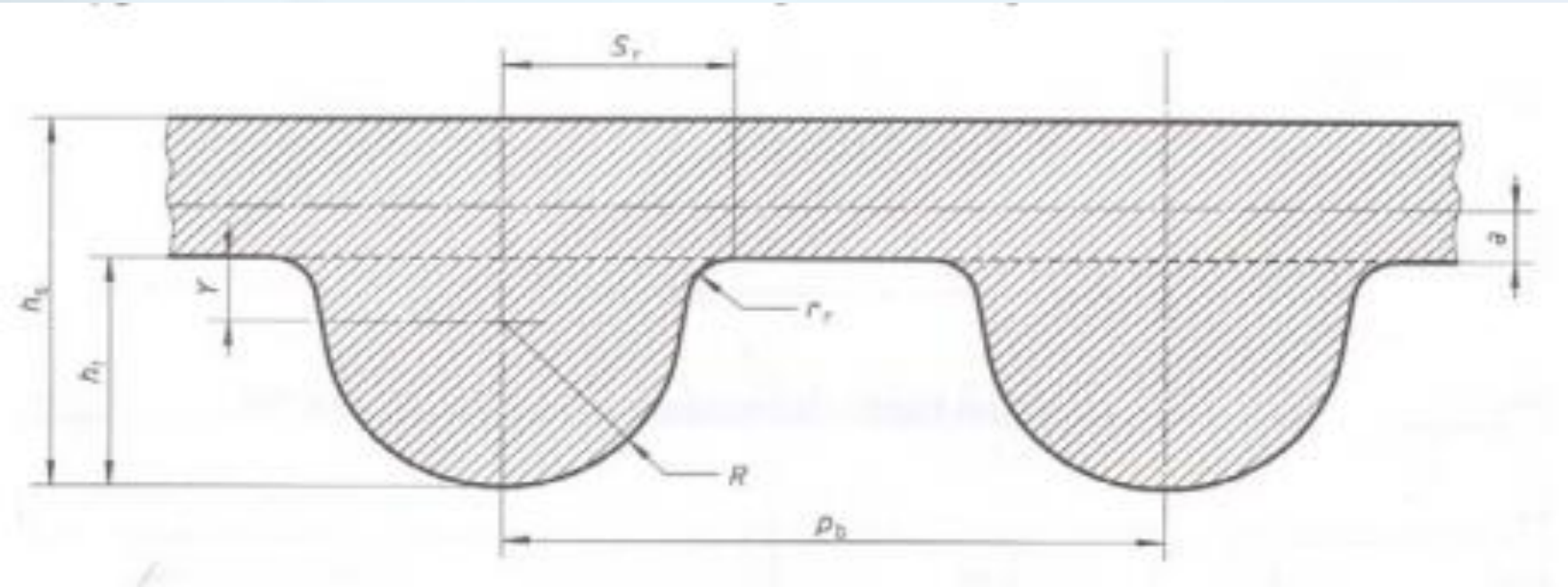


Figure 1

CURVILINEAR TOOTH

- **Curvilinear tooth belts of types ZH and YH**

Dimensions in millimeters, angles in degrees

Term	Symbol	Nominal profile	
		Type ZH	Type YH
Tooth pitch	P_b	9.525	8
Height	h_s	5.5	5.2
Pitch line differential	a	0.686	0.686
Root radius	r_r	0.76	0.64
Tooth height	h_t	3.5	3.04
Tooth radius	R	2.45	2.11
Vertical offset	Y	1.05	0.93
Root radius distance	Sr	3.27	2.84

Table 2

Comparison between Trapezoidal and Curvilinear tooth profile

- **Trapezoidal belt tooth profiles**

Belts with a trapezoidal tooth profile are probably the most widely used in timing belt applications, especially for linear positioning and conveying applications. They have good force transmitting capabilities and low backlash. But the trapezoidal tooth shape results in high stress concentrations at the belt-pulley interface, which can lead to high wear rates when the transmitted torque or speed is high.

- **Curvilinear belt tooth profiles**

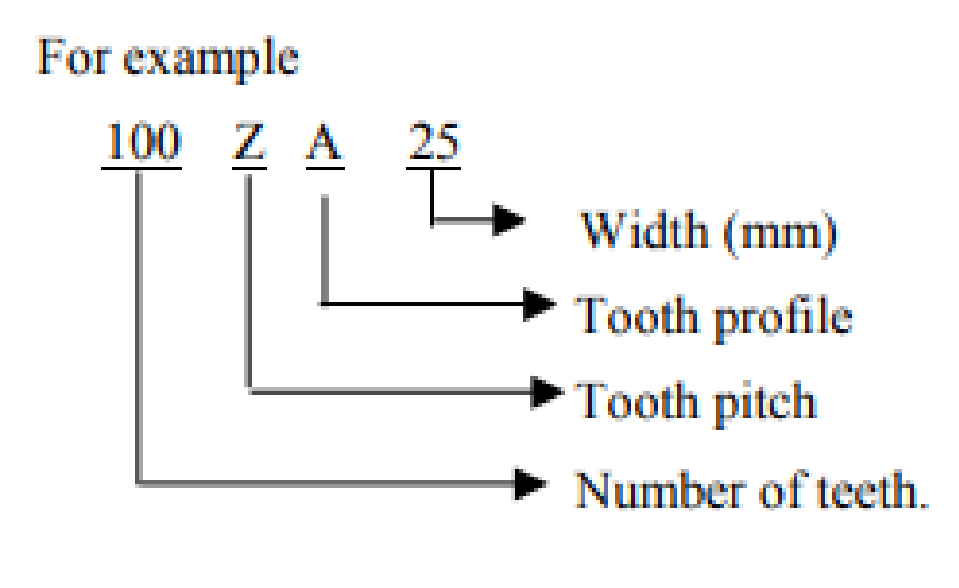
The curvilinear tooth profile was developed to alleviate the stress concentrations found in trapezoidal profiles and improve on torque and speed capabilities. Curvilinear profiles also have a larger tooth depth than trapezoidal designs, so belt ratcheting is less likely. And the smoother transition that curvilinear teeth provide during mesh means these profiles are quieter than their trapezoidal counterparts. The tradeoff, however, is that curvilinear designs have higher backlash than trapezoidal profiles.

Timing Belt Designation

DESIGNATION

The automotive timing belt is designated by a combination of numerals and alphabets as given below:

a) the first set of numerals indicates the number of teeth;
b) the first alphabet indicates the tooth pitch;
c) the second alphabet indicates the tooth profile;
d) the second set of numerals indicates the belt width in millimeters;



Replacement Interval

OEM RECOMMENDED REPLACEMENT INTERVAL

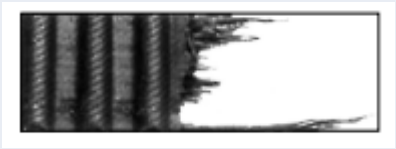
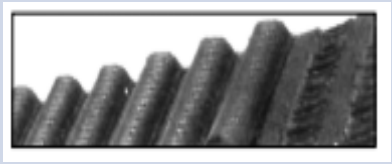
Whether your customer's vehicle utilizes a free-running or interference engine, timing belt failures can be avoided by adhering to the OEM recommended replacement intervals and preventative maintenance. Most OEM-quality belts can be expected to last at least 100,000 kms, as long as there are no problems found with the other components that may cause premature system failure. Also, severe conditions such as towing, aggressive driving and maintenance history need to be considered.

Be aware that some manufacturers do recommend inspecting the timing belt without specifying a replacement interval. But it is not advisable, as many timing belts that have failed or are about to fail may look as new as the day they were installed. Even if the belt doesn't look cracked, worn or oil-contaminated, it should be replaced at a reasonable mileage interval.

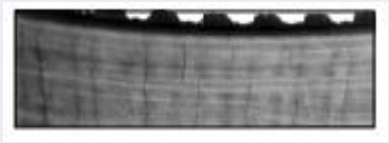
If an aftermarket belt is found on the application and is beyond its recommended change interval, the belt has likely been replaced. Inspect the related components along with the timing belt in this situation. As mentioned previously, if the timing components are not replaced with the timing belt, the life of the newly replaced timing belt can be reduced by 50%.

Troubleshooting Guide

TROUBLESHOOTING

Failure Mode	Symptom	Probable cause	Concern / Corrective action
	Noise	1. High tension 2. Low tension 3. Misalignment	1. Install at correct tension 2. Install at correct tension 3. Correct alignment
	Tensile failure	1. Excessive shock load. 2. Improper belt handling and storage prior to installation	1. Excessive RPMs; modified engine. 2. Follow proper storage and handling procedures.
	Tooth shear	1. Seized drive component(s). 2. Excessive shock loads.	1. Replace component(s): tensioner, idler/pulley, water pump, camshaft, oil pump. 2. Excessive RPMs; modified engine.

TROUBLESHOOTING

Failure Mode	Symptom	Probable cause	Concern / Corrective action
	Tooth wear	1. Too low or high belt tension. 2. Belt running partly off unflanged sprocket.	1. Adjust tension to recommended value. 2. Correct alignment.
	Backside cracks	1. Extreme high temperature. 2. Extreme low temperature at start-up.	1. Overheated engine; seized or partially seized pulley. 2. Install engine heater.
	Contamination	1. Oil, fuel or coolant leak.	1. Replace faulty seals and/or gaskets; check timing cover for improper installation, replace if cracked or worn.

FAQ'S

FAQ'S

Balance Shafts

Balance shaft is a special shaft with eccentrically mounted weights used in an internal combustion engine to reduce vibrations. Balance shafts are most common in straight four or six cylinder engines. Though due to their design asymmetry, have an inherent second order vibration (vibrating at twice the engines RPM) that cannot be eliminated no matter how well the internal components are balanced. Balance shafts use timed eccentrically mounted weights to counter the vibration.

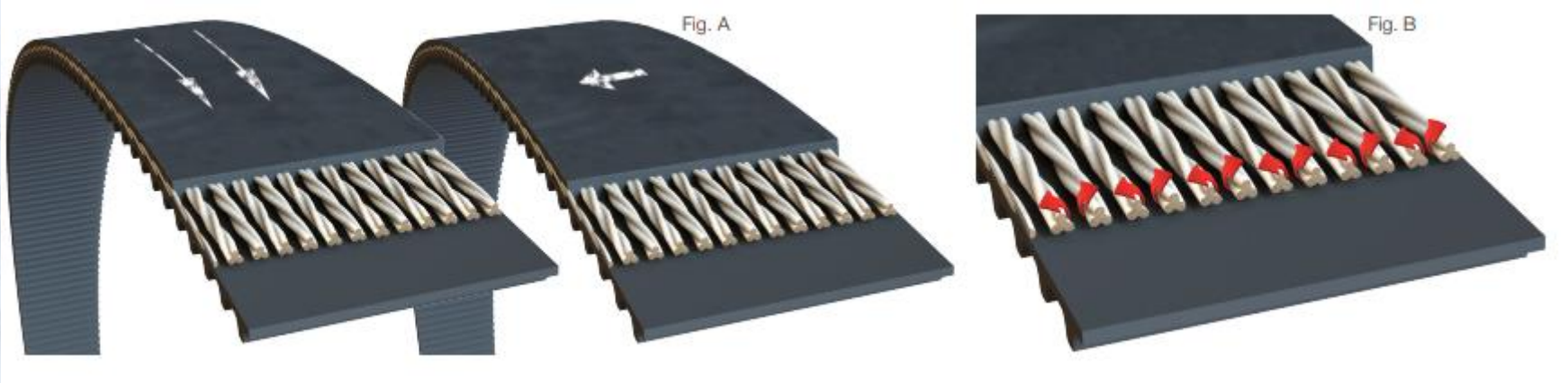
Timing Marks

Different engines have different timing patterns depending on the firing pattern used by their ignition system, the length of travel of their pistons, and other engine design factors. Timing marks are critical to help ensure a new timing belt is installed so that it correctly synchronizes the movements of the cylinder heads and crankshaft during the operation of the engine. If the timing marks are not in the correct position the vehicle may not start OR hard start, the vehicle may experience a lack of power OR dieseling, or there may be indications of a rough idle. Improper installation can also cause an error code to appear on your dashboard, like the check engine light.

FAQ'S

Arrows

Arrows (Directional Install) Arrows on timing belts are used to establish the direction of travel of the timing belt (Fig. A). The arrows should point with the belt, or across the belt depending on manufacture. This is to ensure once a direction is established on the belt, it should always rotate the same direction after any system maintenance is performed utilizing the old belt. Timing belts by design are neutral tracking by dual spinning belt cord in opposing directions (one cord wound one direction and the one next to it wound in the opposite direction (Fig. B)).



BENEFIT OF A COMPLETE REPLACEMENT JOB TO THE VEHICLE OWNER

Cam Shaft Seal

Leaking or worn seals will contaminate the timing belt causing premature belt failure leading to major engine damage.

Timing Belt

A timing belt is a wear item and must be replaced within the recommended OE replacement interval. When a timing belt breaks, severe engine damage can occur and your engine will no longer run.

Tensioner & Idler Pulleys

One of the most common causes of timing belt failures is worn tensioners or idler pulleys. Additional labor costs are minimal when changing a timing belt.

Hydraulic Timing Belt Tensioner

Hydraulic timing belt tensioners help set or maintain constant tension on the system. Loss of timing belt tension may lead to major engine damage.

Water Pump

Water pumps driven by a timing belt should be replaced when changing the timing belt. Engine coolant from a worn leaking water pump can contaminate and destroy a new timing belt.

Crank Shaft Seal

Leaking or worn seals will contaminate the timing belt causing premature belt failure leading to major engine damage.

THANK YOU

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Are there any Questions?