



Belt Drive Components

Technology
Failure Diagnosis



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1 Belt drive systems in motor vehicles

Belt drive systems in motor vehicles perform two tasks: the timing belt drive controls the valves by means of a toothed belt which transmits the radial movement of the crankshaft to the camshaft with a ratio of 2:1, thus ensuring that piston motion and valve timing are perfectly synchronised.



The so-called accessory drive is used to drive auxiliary equipment, such as alternator, coolant pump, power steering pump or A/C compressor. This function used to be performed by the V-ribbed belt which ensured a non-positive transmission of the torque from the crankshaft to the alternator and the coolant pump.

However, in state-of-the-art vehicles more and more electronic equipment is used for enhanced driver comfort. As a result, one V-ribbed belt is no longer sufficient to drive the high-power alternator and front-end accessories, such as A/C compressor or power steering pump. To remedy this problem, a poly V-belt is used, allowing for reduced wrap radii and therefore increased transmission ratios. With particularly small installation space available, accessories can be driven by the front and reverse side of the poly V-belt.



1.1 Timing belt drive/Toothed belt systems

The toothed belt is made from rubber, with the belt structure being reinforced by a glass fibre cord and backed with a polyamide fabric.

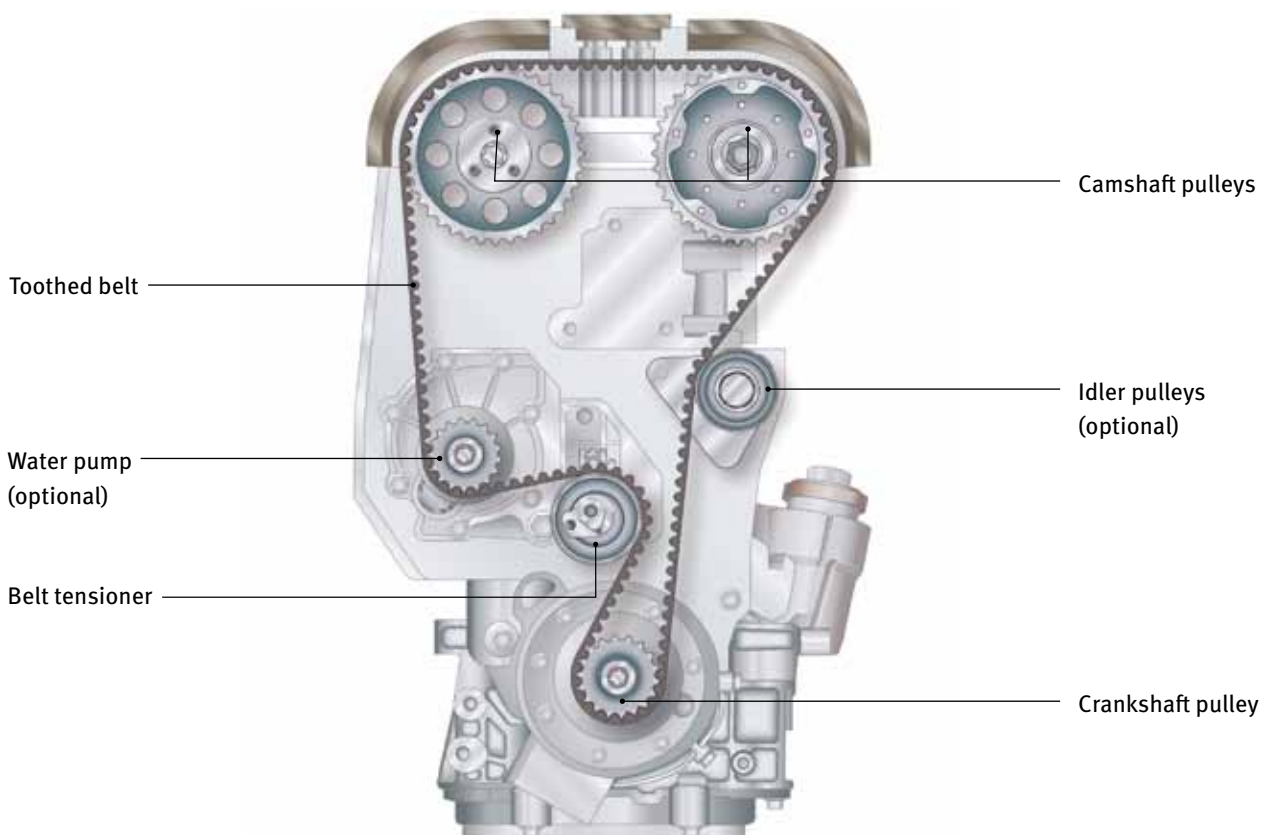
A temperature-resistant intermediate layer ensures ideal performance of the materials used. The teeth are also polyamidereinforced in order to increase resistance to wear. Since the toothed belt, unlike in the timing chain, does not require lubrication, the environment in which it is operating need not be sealed. A simple plastic cover provides sufficient protection against intrusion of impurities.

Characteristics of toothed belt systems:

- Link the crankshaft to the camshaft(s).
- May be used to transmit driving power to injection and water pump
- Drive balancer or intermediate shaft
- May consist of one, two or several separate systems

Benefits/advantages of state-of-the-art toothed belt drive systems:

- Excellent valve timing precision over the entire service life
- Long service life/low noise levels during operation
- Easy and cost-effective servicing and fitting
- Dry operation, no oil feed required
- Compact design
- Minimal friction
- High efficiency rate



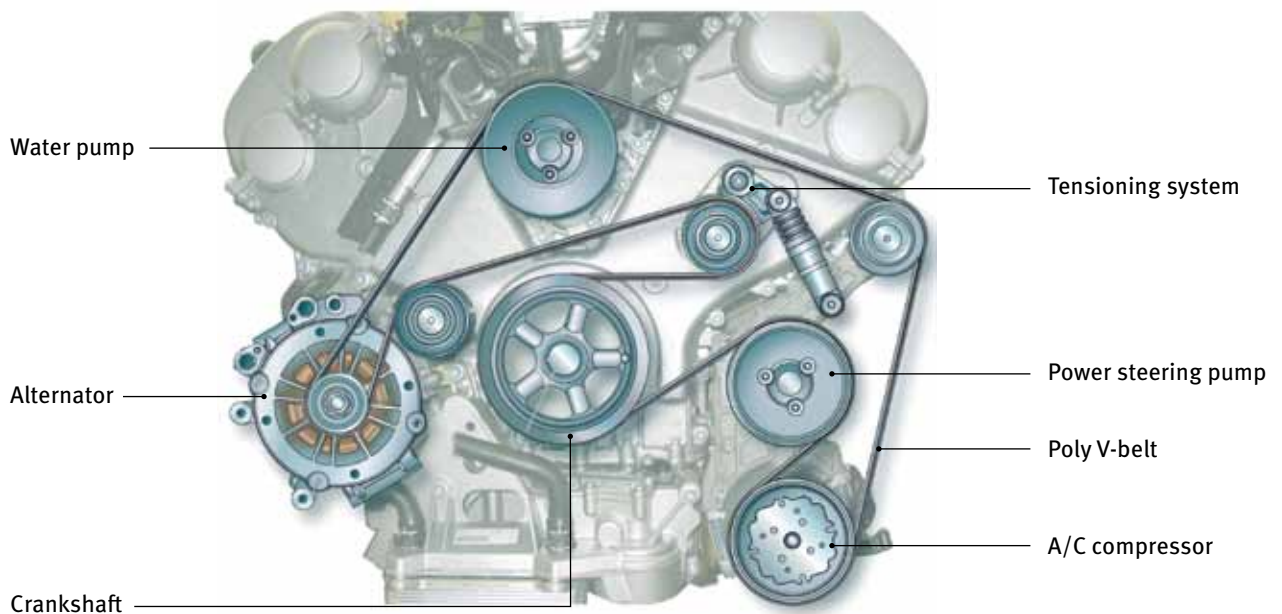
1.2 Accessory belt drive/Accessory belt drive systems

Accessory belt drive systems can be composed of one, two or several separate systems, but normally are designed as a serpentine belt. Accessories are driven by a PK profile multi-ribbed or poly V-belt the tension of which is precisely adjusted to the required loads using a mechanical or hydraulic tensioning system. Guide pulleys are used to create the required wrap angle around the front-end accessories. They may also be used as stabilizers to eliminate belt vibration (collision).

Poly V-belts are designed to perform at high loads transmitting the engine torque – up to 350 Nm is not unusual in modern cars, without slip from the crankshaft to all its accessories.

Benefits/advantages of state-of-the-art accessory belt drive systems:

- Enhanced slip control in the accessory drive,
- Long service life (160,000km or more),
- Reduced noise emission during operation,
- Require small installation space,
- Simple servicing.



2 Tension rollers and idlers for the timing and accessory drives

Tension rollers and idlers are used for both the timing and accessory drives. Tension rollers transmit the force from the belt tensioner to the belt, thus ensuring constant belt tension. Idlers are used to change the belt routing according to the existing front-end accessories or serve to stabilize the belt and to eliminate belt vibration in excessive belt span lengths.

Tension rollers and idlers consist of a steel or plastic pulley with integral single or double row deep groove ball bearing. The running surface can be either smooth or grooved. After mounting the roller, a protective plastic cover is snapped on the unit.

Especially formed covers made of steel may also be used to protect the idler bearing. These are bolted to the idler.



Single-row deep groove roller bearing ECO III

- Ball bearings re-engineered to run more smoothly
- Broadened design and increased grease volume,
- Enhanced rated load compared to similar bearings,
- Plastic pulleys with knurling on the outer race to ensure torsional resistance



Double-row deep groove ball bearings

- Withstand extreme loads,
- Broadened design and increased grease volume,
- Plastic pulleys with knurling on the outer race to ensure torsional resistance



Tension rollers and idlers

Benefits/advantages of tension rollers and idlers:

- Ensure precise routing of the belt,
- Allow for individually designed and optimised belt drive layout,
- Are matched to the specific application,
- Reduced grease losses,
- Reduced noise emission during operation,
- Resistant to temperature and environmental influences,
- Recyclable (marked as plastic material),
- Knurls ensure positive engagement between outer ring and plastic running pulley.

2.1 Tensioning units for the toothed belt drive

A critical prerequisite for trouble-free operation of the timing belt drive is the correct tension of the toothed belt. Only the correct belt tension can ensure positive engagement over the entire service life. Just one tooth skipped will impair precise valve timing which – especially in diesel engines – can cause the valves to “collide” with the piston and eventually the engine to fail.

During long-term operation, the timing belt will slightly elongate due to the tensile load of the crankshaft and the normal temperature fluctuations, resulting in late valve timing as the rotation speed of the camshaft falls behind the rotation speed of the crankshaft. Temperature fluctuations occurring during normal operation may also cause the belt to

elongate and shorten periodically. For this reason, the latest generation of tension rollers has an “adjustment range” allowing the tensioner to self-adjust to length differences of the belt. However, it is imperative during vehicle inspection to check the functioning of the tension roller and check the tension of the timing belt and correct it if required.

There are three different types of timing belt tensioners – manual, semi-automatic and automatic designs.

For manual belt tensioning units, the correct belt tension at ambient temperature is set manually according to the specifications of the manufacturer and needs to be checked in the specified service intervals and adjusted if required.

Designs

Benefits of manual tensioning units:

- Compact design

Drawbacks of manual tensioning units:

- Belt tension needs to be adjusted manually
- No self-adjustment to temperature fluctuations, load changes and belt elongation due to long-term operation

On semi-automatic tensioning units the specified belt tension is set at ambient temperature. A spring with predefined spring force is used to compensate for belt elongation. However, belt tension needs to be checked at every service interval and re-adjusted, if required.

Benefits of semi-automatic tensioning units:

- Temperature fluctuations, load changes and belt elongation resulting from continued operation are compensated.

Drawbacks of semi-automatic tensioning units:

- Belt tension needs to be adjusted manually

Auto-tensioning units tighten the belt automatically during installation. An internal set of springs ensures that the belt tension remains almost unchanged throughout the

entire service life by self-adjusting to temperature and load changes. Another benefit of an automatic tensioning unit consists in its ability to damp out belt vibration under all operating conditions of the belt drive. As a result, the belt tension can remain very low thus reducing noise emission whilst increasing service life.

Double eccentric principle



Cylindrical helical coiled spring

Tension roller

Working eccentric

Adjusting eccentric

Friction bearing

Adjusting shim

Base plate

Benefits of automatic tensioning units:

Automatic tensioning systems provide an additional integral mechanical damping function. They ...

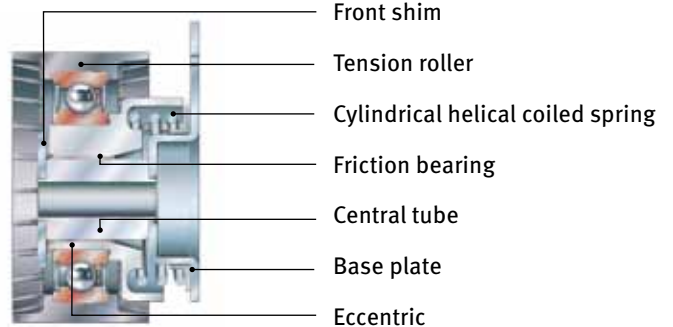
- Tighten the belt automatically during installation,
- Compensate manufacturing tolerances (diameter, positions, belt length),
- Provide constant belt force (irrespective of temperature, load and service life),
- Eliminate nearly all drive train resonance under all operating conditions,
- Prevent “tooth jump”,
- Reduce noise owing to improved adjustability of required belt preload,
- Extend service life of the system.

The double eccentric principle separates the dynamic tensioning function of the tolerance compensation system and can be precisely adjusted to the dynamic requirements of the toothed belt drive.

The single eccentric principle simplifies fitting of the tensioning system on the engine assembly line and prevents setting errors.



Single eccentric principle



2.2 Tensioning units for the accessory belt drive

In order to avoid excessive slip and belt vibration, the correct tension of the poly V-belt in the accessory drive is crucial just as much as the correct setting of the toothed belt tension in the timing drive.

There are two different types of tensioning systems

The belt tensioning units will compensate for tolerances, thermal expansion of the driving components, belt elongation and normal wear and tear.

Unlike mechanically adjusted belt tensioners, the belt preload on semi-automatic designs is set automatically during installation and service.

Further benefits of belt drive systems with auto-tensioning units:

- Load peaks of the belt dynamics are eliminated,
- Slip, noise and belt wear are reduced

2.2 Tensioning units for the accessory belt drive

Belt tensioning unit with mechanical damping function, e.g.



Long-arm tensioner



Short-arm tensioner



Cone-shaped tensioner

Belt tensioning units with hydraulic damping function, e.g.



Tensioner with bellows seal



Tensioner with piston rod seal

Mechanically damped belt tensioning units

Belt tensioners with mechanical damping function use a cylindrical helical coiled spring or torsional spring to generate the required preload of the belt.

The damping effect is achieved by means of mechanical friction.

The damping component of a long-arm or short-arm tensioner is a flat friction plate; that of the tapered tensioner pulley is a friction cone.

Installation space available will decide which type of mechanical tensioner is used.

Function of belt tensioning units with mechanical damping function

Belt preload

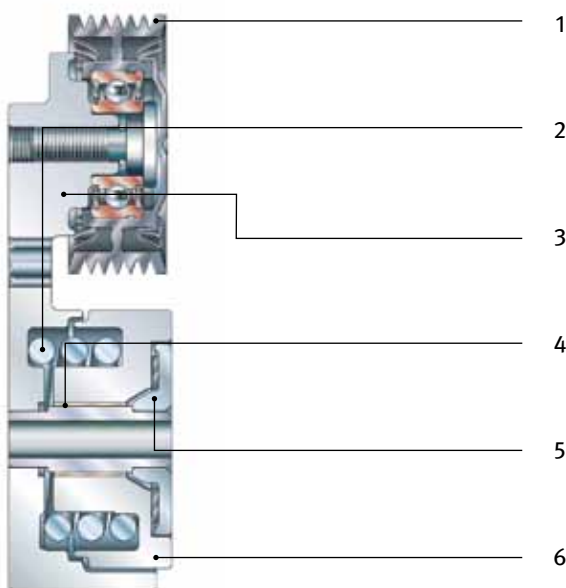
- The belt preload required is generated by the torque of the cylindrical helical coiled spring and the lever arm. Belt preload and damping independently adjust to the respective operating conditions.

Damping

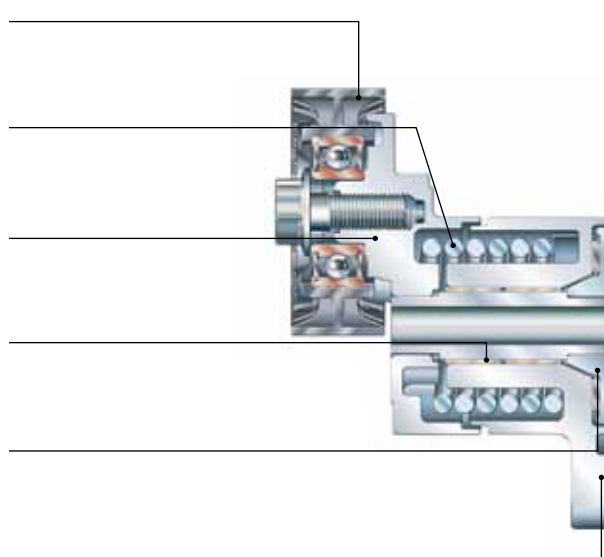
- The axial force of the spring generates the preload in the damping assembly (spring and friction plate/cone).
- With each movement, the lever arm creates relative motion in the damping assembly thereby creating friction and thus damping.

Mechanically damped belt tensioning units

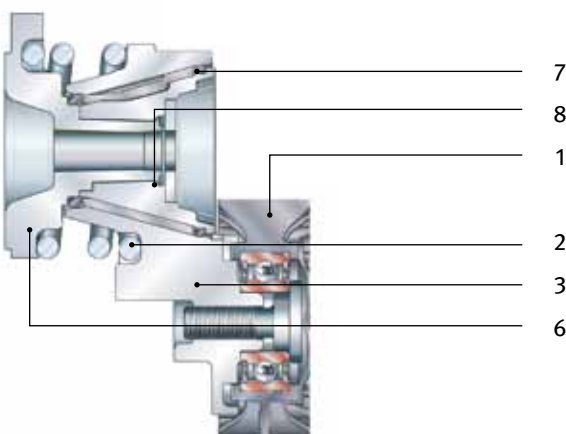
Long-arm tensioner



Short-arm tensioner



Cone-shaped tensioner



- 1 Tension roller
- 2 Cylindrical helical coiled spring
- 3 Lever
- 4 Friction bearing
- 5 Friction plate and friction material
- 6 Base plate
- 7 Friction cone with seals
- 8 Inner cone

2.2 Tensioning units for the accessory belt drive

Belt tensioning units with hydraulic damping function

Tensioning units with hydraulic damping function use the pressure spring in the hydraulic element to generate the belt preload which is transmitted via the lever to the tension roller.

The damping of the hydraulic element happens in a controlled manner and proportionally to the speed (hydraulic leakage gap damping).

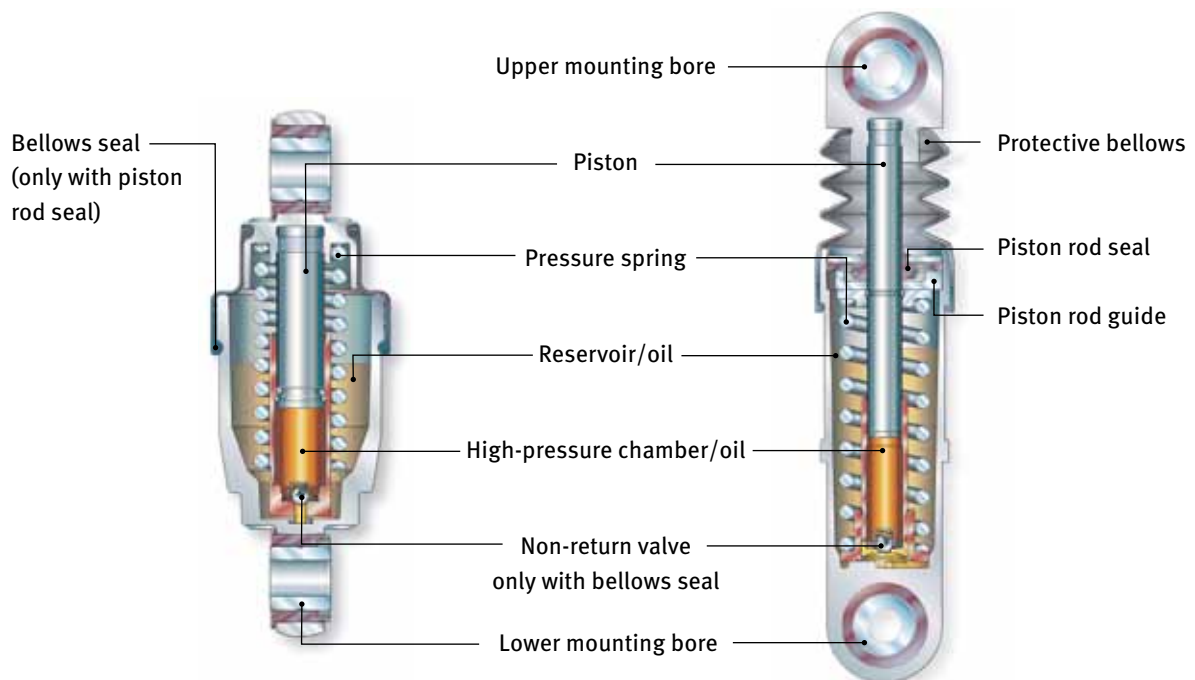
Owing to the controlled damping function, hydraulic systems are especially suited to stabilize more dynamic belt drive systems (cyclic irregularities of the engine, for example diesel applications). Furthermore, the controlled damping allows for an optimisation of the belt preload.

Installation space available and operating conditions are key factors for the decision as to which hydraulic belt tensioner is to be used.

Operating principle of mechanically damped belt tensioning units

- Compressing the hydraulic element will force the oil out of the high-pressure chamber through the leakage gap thus generating damping.
- With the non-return valve separating high-pressure chamber and reservoir, there is only one direction the oil can flow (controlled damping).
- When relaxing the hydraulic element, oil is drawn from the reservoir into the high-pressure chamber via the nonreturn valve.
- Tensioning and damping forces are transmitted via the lever and the tension roller to the belt.
- The tensioning force can be adjusted by choosing a different pressure spring and lever ratio.
- The damping force is adjusted through the size of the leakage gap:
 - the smaller the leakage gap, the stronger the damping force.

Belt tensioning units with hydraulic damping function



3 Overrunning alternator pulleys

The periodic combustion processes of IC piston engines cause a substantial rotational irregularity of the crankshaft which the belt drive transfers to the engine accessories. Irregularities result from the engine's power and compression strokes. The power stroke "1" accelerates the crankshaft while the compression and exhaust strokes "2" slow it down.

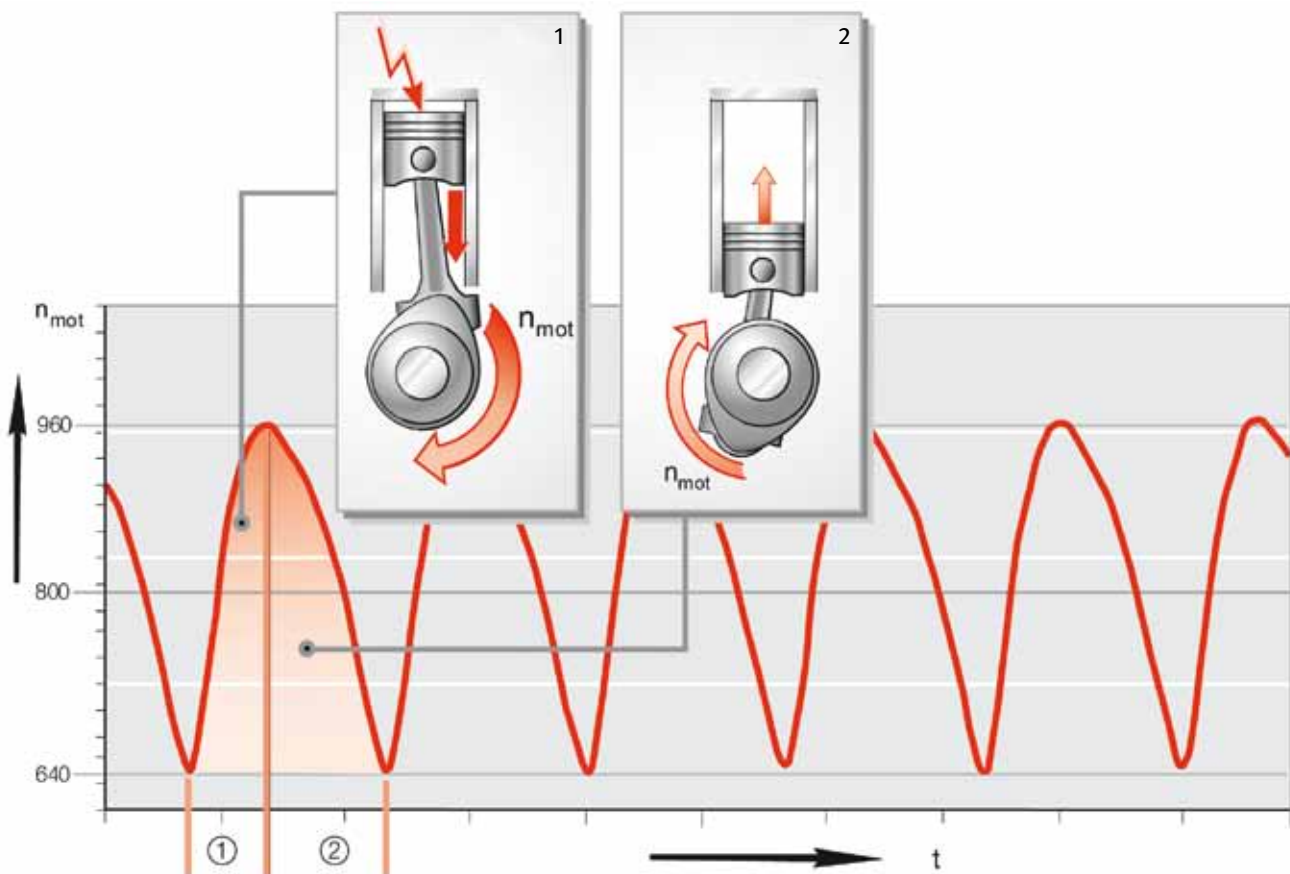
In a four-cylinder engine the frequency of the rotational irregularity corresponds to the second engine order; i.e. two ignition processes per revolution. Thus for example, the speed of a diesel engine with a 40% rotational irregularity and an average engine speed of 800 rpm varies between 640 rpm and 960 rpm at a frequency of 26.7Hz.

This causes the rotational masses in the accessory drive to speed up and slow down continually. This has undesirable effects on the accessory drive, e.g.

unacceptable noise behaviour, high tensioner and belt forces, excessive belt vibration and premature belt wear.

Each of the front-end accessories has a different impact on the overall behaviour of the FEAD system. The component with the highest mass moment of inertia, the alternator, has the biggest impact on the accessory drive. The growing demand for electrical power, in addition, brings ever higher performance alternators with a generally higher mass moment of inertia and therefore greater impact on the belt drive. To decouple the alternator from the rotational irregularities of the crankshaft state-of-the-art cars use either an OAP (overrunning alternator pulley) or OAD (overrunning alternator decoupler).

Causes of the rotational irregularities of the crankshaft



Overrunning alternator pulley on the alternator:

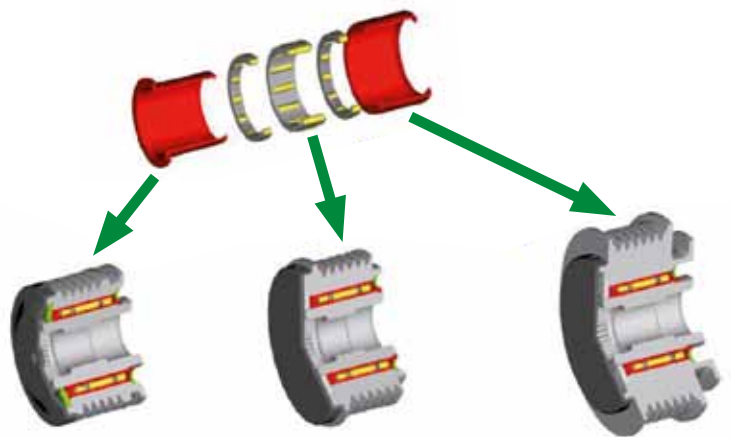
- Decouple the alternator from the rotational irregularities of the crankshaft induced by internal combustions engines
- Damp out belt vibration
- Reduce the load level in the belt drive
- Improve the noise behaviour of the belt drive
- Increase the average alternator speed in the idling speed range
- Have an economical modular design, which includes the standard decoupling unit



Modular design – Standard decoupling unit

Overrunning alternator pulleys are predominantly used on:

- Diesel engines and DI petrol engines
- Systems with low idling speeds
- Applications with increased noise requirements in the idling speed range (use of a dual mass flywheel)
- Alternators with high mass moment of inertia



3.1 Technical characteristics

Overrunning alternator pulleys

- Are modular assemblies consisting of:
 - a belt pulley with poly V-belt profile
 - sleeve-type overrunning clutch with two radial support bearings (OAP), or torsion-damped overrunning clutch with plain bearings (OAD)
 - an inner ring with centring bore to receive the transmission shaft stud, and serrated profile to transmit the tightening torque during installation
 - seals on the alternator and front sides
 - a protective cap on the front
- Decouple the alternator in internal combustion engines from the rotational irregularities of the crankshaft and, in so doing, reduce the influence of the alternator mass on the belt drive
 - In this way, the alternator is driven only by the acceleration movement of the rotational irregularity of the crankshaft.
- Possess no natural frequency unlike belt pulleys with springs or elastomer components between inner and outer ring
- Reduce tensioner load and movement
- Optimise noise behaviour at idling speeds and during start/stop operation
- Prevent possible belt slip when changing up under full load
- Unlike rigid belt pulleys, cannot be extracted from the alternator shaft (self-locking)

3.2 Overrunning alternator pulley design

OAP design

- Belt pulley with poly V-belt profile
- Overrunning clutch unit with double bearing support
- Inner ring made from steel
- Lip-type seal on both sides
- Belt pulley surface with anti-corrosion protection

An overrunning alternator pulley consists of the following components: belt pulley, overrunning clutch unit with integrated radial support bearings and inner sleeve with ramp profile, inner ring with serration, elastomer seal, thrust plate with lip-type seal and plastic protective cap. Both inner ring and belt pulley are machined to match the required geometries. Thanks to the axial play, the belt track is self-adjusting.

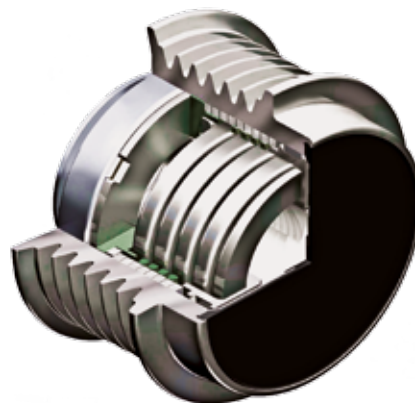
This significantly improves the noise behaviour of the belt running in the pulley profile, since the belt is not positively driven on the alternator drive pulley. The overrunning alternator bore is designed in a way that requires no changes to the alternator shaft stub. The inner ring is mounted on the shaft by a fine thread. The purpose of the serration is to transfer the tightening torque. A protective cap on the front protects the overrunning clutch unit against dirt and water splash. The visible surface of the belt pulley has an anti-corrosion coating.



OAD design

- Ball bearing
- Clutch
- Friction bearing
- Torsional spring
- Profiled outer ring raceway
- Protective cap

A decoupler is an alternator belt pulley that powers the alternator “gently” by means of a torsion spring. It absorbs rotational irregularities, thus preventing torque fluctuations and reducing dynamic forces on the component’s bearing points within the assembly drive.



Effects on the front-end accessory drive

Depending on the accessory drive concept as well as the load level of the engine and the front-end accessories, the acceleration and deceleration of the masses can entail undesirable reactions in the belt drive system.

This includes for example unacceptable noise levels, high tensioner and belt forces, increased belt vibration and premature belt wear.

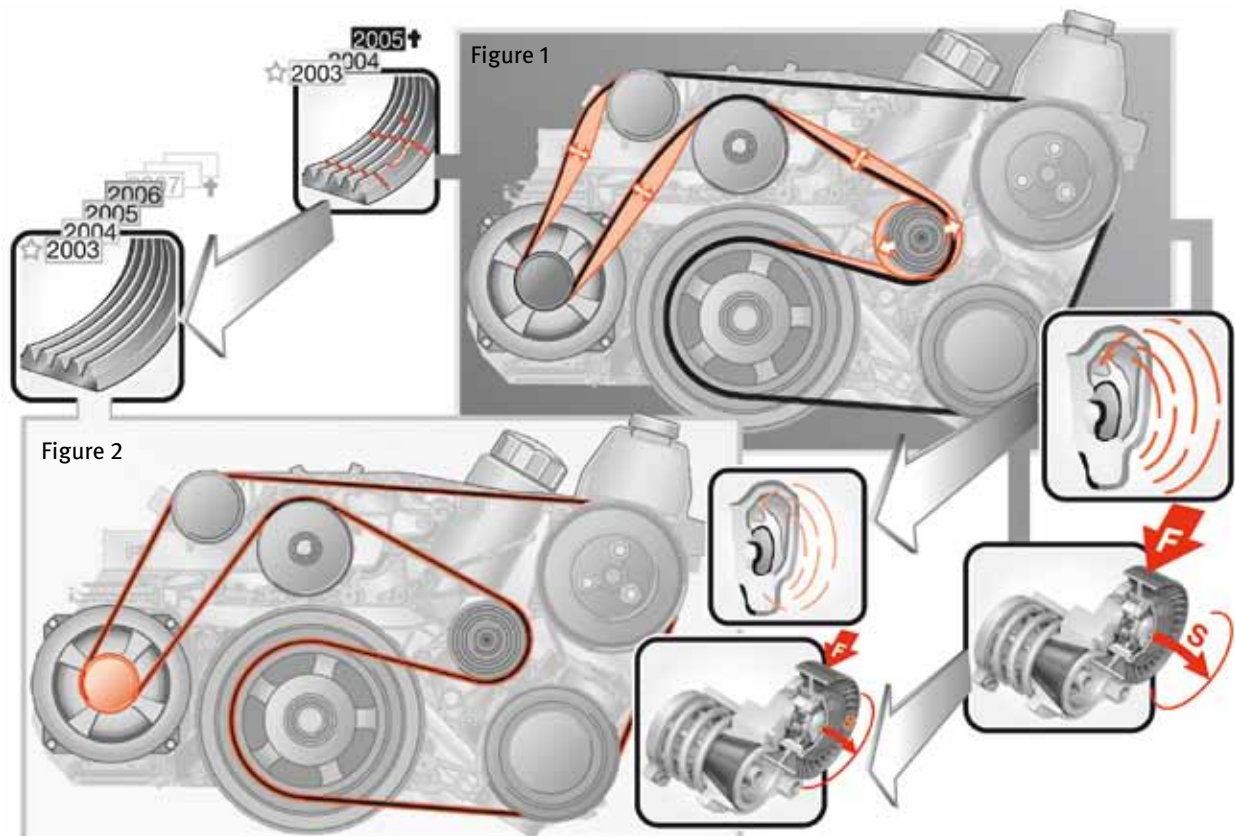


Figure 1 shows the belt vibration in the accessory drive during operation without overrunning alternator pulley. Strong vibration “S” frequently causes unpleasant noise in the belt drive. The high forces “F” generated by an oscillating belt act on all front-end accessories and lead to increased wear. As a result, belt life is considerably reduced and the tensioner can break.

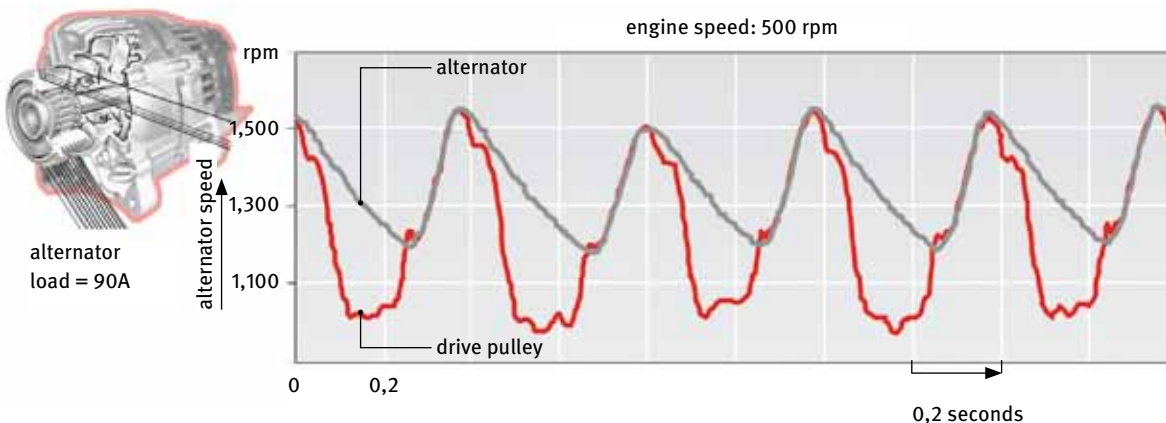
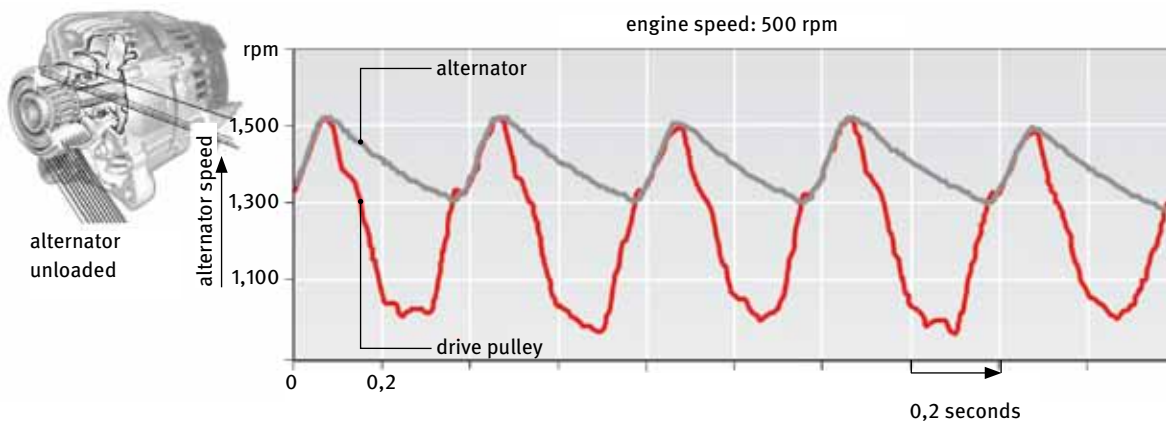
Using an overrunning alternator pulley helps reduce belt vibration “S” (see Figure 2) and takes strain off the front-end accessories. In addition, the engine’s noise behaviour improves.

3.3 Operating principle

The decoupling effect results from the kinetic energy of the alternator rotor overrunning the belt pulley accelerated by the belt, and mainly occurs at engine speeds below 2,000 rpm. It is highly dependent on the drive concept, the amplitude of the rotational irregularities of the crankshaft, the flexibility of the belt, the electric load of the alternator and its mass moment of inertia. As a result, the alternator is driven only by the acceleration movement of the rotational irregularity of the crankshaft.

During shifting (transmission) the alternator shaft is also decoupled from the decreasing engine speed. This prevents unwanted noise due to belt slip. The current output slows down the alternator. Consequently, the speed differential between the alternator shaft and the belt pulley is slightly reduced as the load on the alternator increases. However, this does not impair the optimization effect achieved by the overrunning alternator pulley.

Impact of the overrunning alternator pulley on the alternator speed



3.3 Operating principle

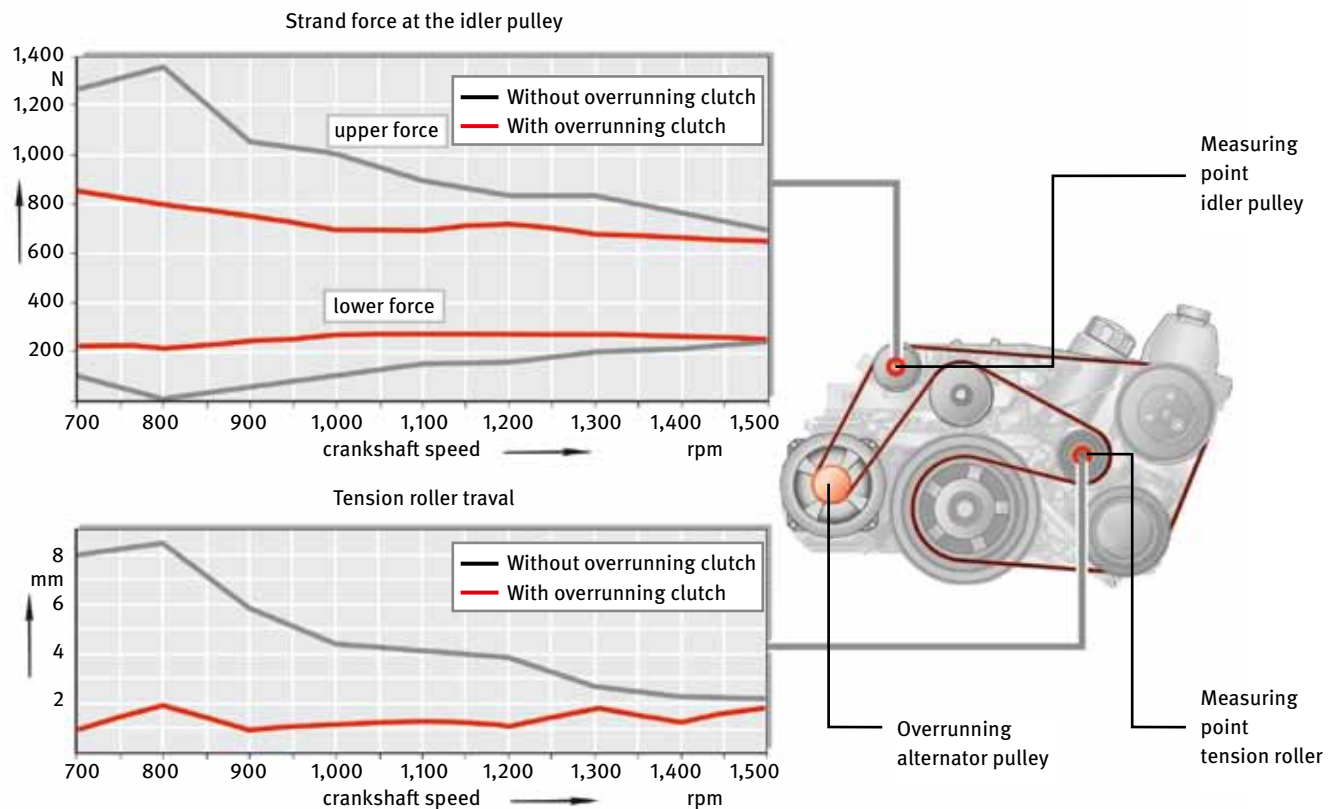
Combustion engine measurements

Sample measurements of the dynamic forces applied on the accessory drive reveal the advantages of the overrunning alternator pulley over concepts with a fixed belt pulley. Measurements were taken to determine the belt force at the idler pulley and the travel of the tension roller.

Depending on the firing order, the belt force varies between upper and lower force. The results show that thanks to the overrunning alternator pulley the maximum loads could be reduced from 1,300Nm to 800Nm.

In addition, the minimal loads were slightly increased which prevents the risk of belt slip. The vibration amplitude of the belt tensioner is reduced from 8mm to 2mm. As a result, the load on the belt is considerably reduced which in turn extends belt life significantly. Load and wear reduction also increases the service life of the belt tensioner.

Idler pulley strand force and tensioner shaft travel – measured on a fourcylinder diesel engine



3.4 Overrunning alternator pulley storing and handling

Overrunning alternator pulleys must be handled with great care before and during installation. They must be installed with utmost care to ensure correct functioning.

Storing

Overrunning alternator pulleys come dry-preserved and packed in VCI paper.

Store the product:

- in the sales packaging
- in a dry, clean room at constant ambient air temperature
- at a relative air humidity below 65%

The storage life is limited due to the limited shelf life of the grease. Remove the sales packaging only immediately before installing the overrunning alternator pulley. When using products from a multipack with dry-preservation, make sure you re-seal the packaging immediately after use. The protective vapour phase generated by the VCI paper can only be maintained, if the multipack is thoroughly closed.

Removal

To remove an overrunning alternator pulley one of the following tools must be used – depending on the installation situation and on the space available use either the long or short special tools.

Installation

Depending on the customer requirements, overrunning alternator pulleys are supplied in either singularly or in multi packs. The belt pulley and inner ring of the overrunning alternator pulley are lathecut non-cured components made from free-cutting steel. To avoid damage, in particular on the poly V-profile, handle the parts with great care.

To install the belt pulley apply a minimum tightening torque of 80Nm and a maximum of 85Nm.

The inner or outer snap-fit protective cap requires a force of approx. 10N. It is easy to install by hand and is fitted to in a number of volume production items. The protective caps must only be used once, since they can easily be damaged during removal. Do not use an overrunning belt pulley with missing or damaged protective cap as this will result in insufficient sealing.



12-piece INA tool case for the OAP and OAD installation (Part # 400 0241 10)

3.5 Function test

It is recommended you use a suitable tool to make testing with the adapter easier. In doing so, you will achieve better leverage.

Grasp the outer ring of the overrunning pulley with one hand. With your other hand, twist the tool.

Characteristics to look out for when testing an overrunning alternator pulley (OAP):

- The tool jams immediately and cannot be turned when moved in an anti-clockwise direction
- The tool can be continuously turned in a clockwise direction with slight resistance



Characteristics to look out for when testing an alternator decoupler (OAD):

- You will notice an increasing spring force when the tool is moved in an anti-clockwise direction
- The tool can be continuously turned in a clockwise direction with slight resistance



Note:

A small number of overrunning pulleys have a left-handed thread instead of a right-handed thread. The functions of the left-handed thread are exactly the same as those for the right-handed thread, but reversed.

Caution:

If one of the two functions is not evident during testing, the OAP/OAD must be replaced!

4 Water pump

4.1 Cooling circuit

Besides generating the desired kinetic energy, internal combustion engines unfortunately also produce considerable thermal energy during operation. The resulting excess heat can destroy the engine components, such as piston, valves or cylinder head.

To avoid this, engines must be cooled. In modern internal combustion engines this is done almost exclusively by means of water. Hence the name water or fluid cooling system.

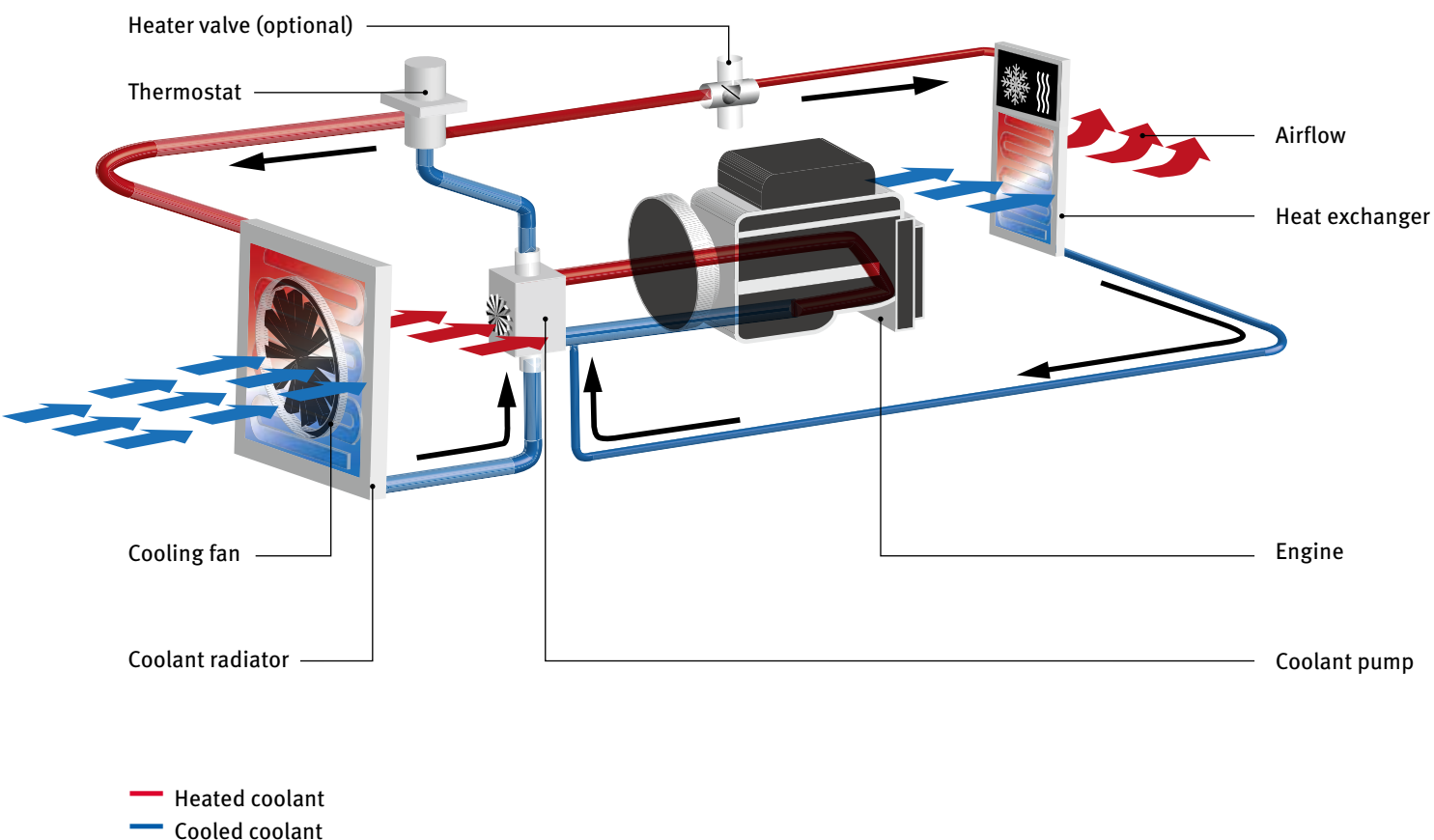
Antifreeze (e.g. monoethyleneglycol) is added to create a coolant mixture as there is a risk of the engine block bursting if the water freezes.

Additionally, the antifreeze mixture raises the boiling point of the coolant mixture thus protecting the system from overheating. The coolant acts as a protective layer preventing water-induced furring and corrosion.

This is why it is so important to use a coolant that has been approved by the manufacturer and the recommended mixing ratio. The ideal water-to-antifreeze mix ratio is generally 1: 1.

Along with the coolant mixture, the key components of the cooling system are the pump which circulates the coolant within the system and the thermostat which controls the switching between the small and large cooling circuits.

Design and operating principle of the cooling circuit



4.2 Design and operating principle

The water pump circulates the coolant in the coolant circuit, thereby ensuring even engine heat dissipation and supplying the heater circuit with warm coolant. The water pump can be integrated in the front-end accessory drive or the timing drive. As a front-end accessory it is driven by either a V-belt or a poly-V-belt.

Depending on the application, the pump is assembled with or without belt pulley which can be profiled or flat depending on whether it is driven by the belt's backing or face.

The belt pulley profile on water pumps integrated in the timing drive is either flat or geared to the profile of the toothed belt, again depending on which side of the belt drives the pump.

Water pump



Impeller

The impeller is a key component of the water pump. Engineered and designed to deliver optimal performance, the water pump reduces the risk of vapour lock, also referred to as cavitation.

The material from which the impeller is made has a major influence on the pump performance.

Until a few years ago, impellers were made from cast iron and steel. Modern designs use plastic materials.

This helps reduce overall impeller weight, minimise stress on the bearing and prevent the risk of cavitation.

Plastic impellers



Water pump bearings

Water pump bearings are double-row bearings, yet without the inner race which is typical of this bearing type. Instead the raceways are built directly into the shaft. This creates more space for the rolling body, thus yielding a higher specific load-carrying capability than conventional single-row bearings.

Additionally, this bearing design offers a cost-effective way of combining ball and roller rows. This approach offers many load-carrying capability options while requiring little space.

Water pump bearing with ball/ball bearing



Using one outer race for two rolling body rows eliminates alignment errors and prevents the risk of undesired tension build-up within the bearing.

Normally, the shaft journals on water pump bearings protrude on both sides of the outer race. The length and diameter of the protruding ends are geared to each specific application making this design simple and easy to install.

The decision on where to install which bearing is dependent on the loads applied on the respective belt drive. A factor of crucial importance for water pump durability and service life is the use of high-grade bearings.

Water pump bearing with ball/rolling bearing



Sealing

Sealing between the engine housing and water pump is achieved by means of paper seals, O rings or, in many cases, silicone sealants.

When using paper seals and O rings reliable sealing is ensured without the need for extra sealant. However, sparing use of sealant is essential on engines using silicone sealant as a standard. In addition, the manufacturer's instructions must be followed at all times.

Applying a thin film of sealant is absolutely sufficient to ensure reliable sealing. If too much sealant is used, excess sealant may be washed into the coolant system, with the risk of clogging the radiator and heat exchanger or damaging the sealing on the drive side.

The drive shaft is sealed by means of a mechanical face seal engineered as an axial seal. The sliding partners made from silicone carbide and hard carbon are pressed against one another by a pressure spring, thereby ensuring efficient sealing of the cooling system. A conventional radial seal cannot be used due to the pressure in the cooling system.

The coolant also lubricates and cools the mechanical face seal.

Sealing variants



4.3 Thermostat

Operating principle and task

The thermostat (an expansion element) is always immersed in coolant and controls the coolant flow between the small and large circuits. As the temperature increases, the thermostat diameter opens allowing coolant to flow into the radiator. At low ambient temperatures this helps bring the engine to optimal operating temperatures faster, positively influencing the engine's running characteristics and reducing average fuel consumption.

Owing to the installation position of the thermostat in some engine types, it is advisable to replace it along with the timing belt.

Function test

Start the engine and let it warm up. The coolant hoses of the large circuit remain cold until the thermostat opens gradually. With the thermostat open and the engine temperature rising the coolant hose must also warm up.

When disassembled, the function of the thermostat can be checked simply by putting it in hot water. If the valve opens in hot water and closes again at ambient temperature, the thermostat is working properly.

Thermostat



5 Failure Diagnosis

5.1 Toothed belt

Abrasion marks on the belt backing and friction material deposits

Cause

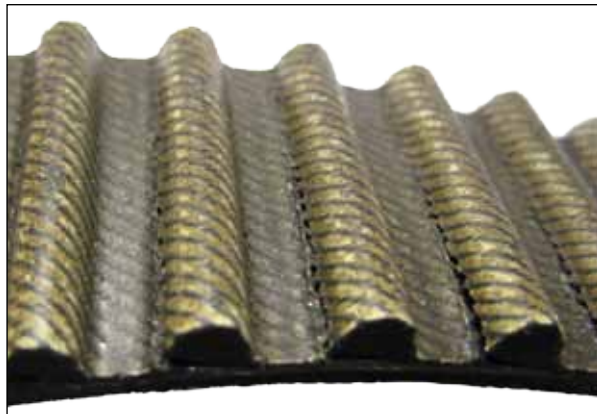
- Misalignment
→ e.g. due to assembly error



Teeth sheared off and detached, worn tooth flanks

Cause

- Insufficient tension
→ e.g. due to assembly error



Cause

- Severe misalignment
→ e.g. due to assembly error

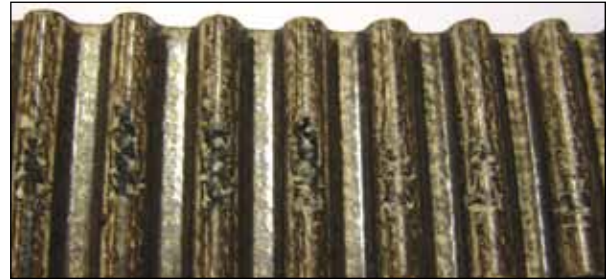


5.1 Toothed belt

Damaged teeth

Cause

- Damaged by foreign body



Cracks in the belt backing

Cause

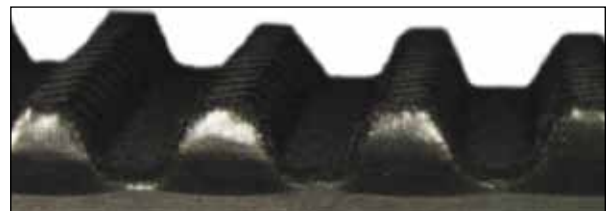
- Belt ageing
- Excessive thermal load



Polishing marks / side wear

Cause

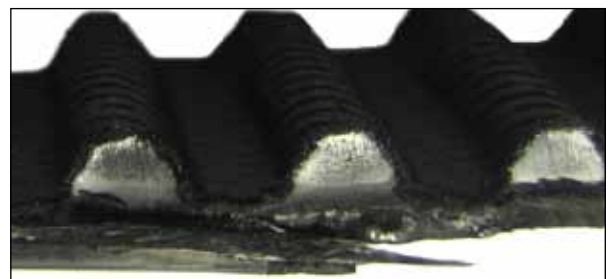
- Misalignment
 - e.g. due to assembly error



Side scoring with tissue abrasion

Cause

- Misalignment
 - e.g. due to assembly error



Dents/cutting marks in the tooth gaps

Cause

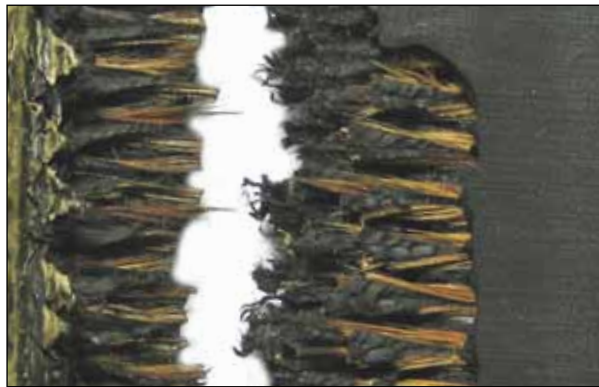
- Damaged by foreign body



Clean belt break (front and back)

Cause

- Belt excessively kinked
 - Damaged during installation



Ragged belt break

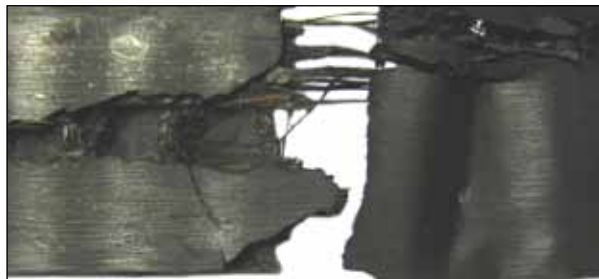
Cause

- Abrasion/weakening of the belt backing



Cause

- Seized components
- Tensile strength of belt exceeded
- Damaged by foreign object



Cause

- Damaged by foreign body



5.1 Toothed belt

Belt backing severely damaged due to heat build-up

Cause

- Seized components



Heavy abrasion of the belt backing

Cause

- Tension problems in the belt drive
- Damage caused by foreign body with resulting fluctuations in belt tension
- Misalignment
 - e.g. due to assembly error



Cause

- Seized components



5.2 V-ripped belt

Severe tooth flank wear

Cause

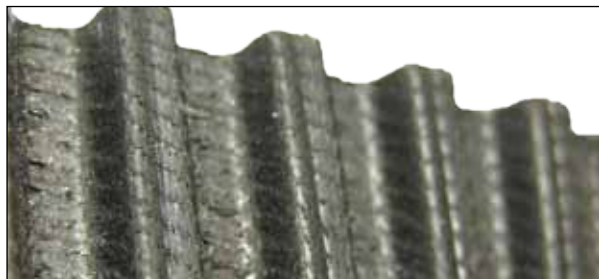
- Excessive tension
- Poor teeth meshing
- Misalignment
 - e.g. due to assembly error



Worn tooth gaps and tooth flanks

Cause

- Excessive tension
 - e.g. due to assembly error



Belt material swelling

Cause

- Contamination with oil and grease



5.2 V-ripped belt

Severe dirt deposits

Cause

- Belt drive cover defective or improperly mounted



Deposits of belt material caused by heavy abrasion

Cause

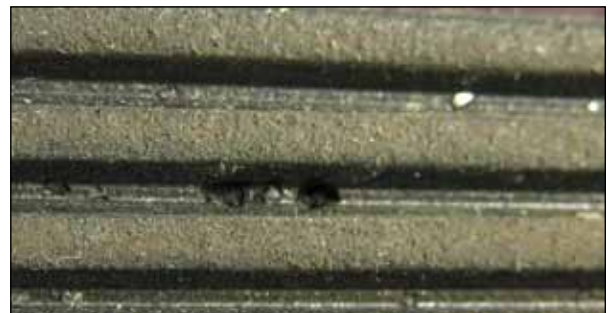
- Belt vibration
- Damaged by foreign body
- Misalignment
 - e.g. due to assembly error



Indentations

Cause

- Damaged by foreign body



Lateral material detachment

Cause

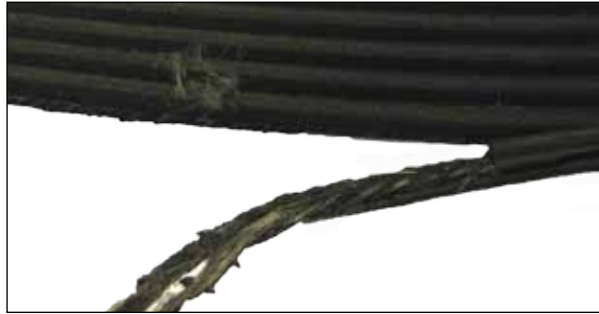
- Strong belt vibration
- Misalignment
 - e.g. due to assembly error



Detachment of ribs

Cause

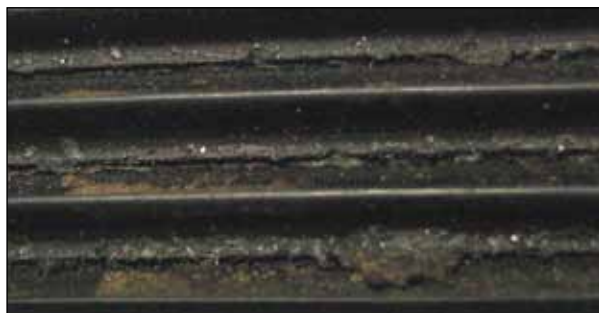
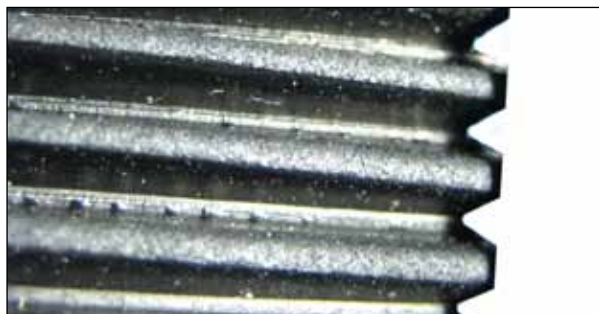
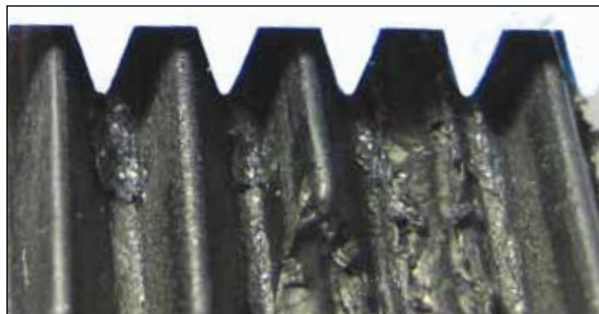
- Damaged during installation
- Misalignment
 - e.g. due to assembly error



Severe rib wear

Cause

- Strong belt vibration
- Faulty belt tensioner
- Faulty overrunning alternator pulley
- Misalignment
 - e.g. due to assembly error



5.3 Tension rollers and idlers

End stop damaged, stop-pin distorted/broken

Cause

- Incorrect setting of tension roller.
 - Incorrect fitting



Signs of “temper colour” leading from fringe to centre

Cause

- Belt slip
 - Defect in the belt drive caused by front-end accessory not working properly, for example water pump, or insufficient belt tension.



Fouling marks on the outside of the tension roller/idler caused by the belt

Cause

Misalignment

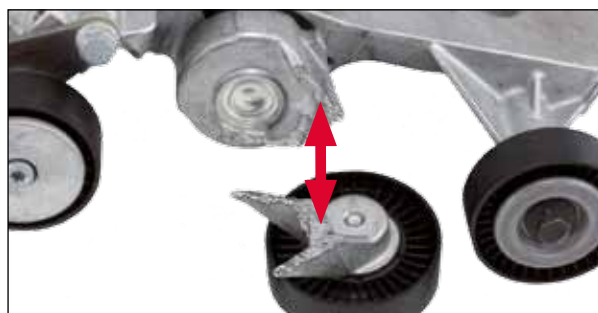
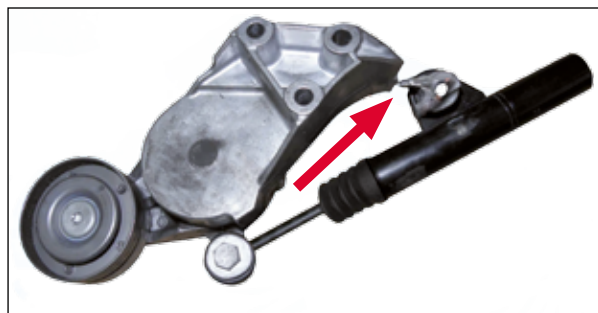
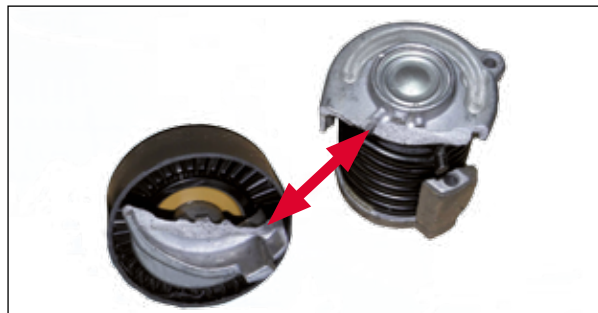
- Belt runs off centre, may be caused by a faulty water pump bearing etc.



Tensioner broken

Cause

- Heavy vibration of the poly-V-belt caused by worn overrunning alternator pulley

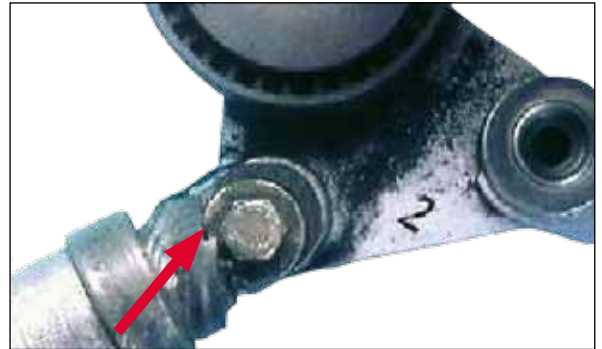


5.3 Tension rollers and idlers

Mounting bore of hydraulic belt tensioner damaged

Cause

- Belt tensioner unit life exceeded
- Fixing bolt on mounting bore was released and not torqued down again correctly



Oil loss at bellows seal of hydraulic belt tensioner

Cause

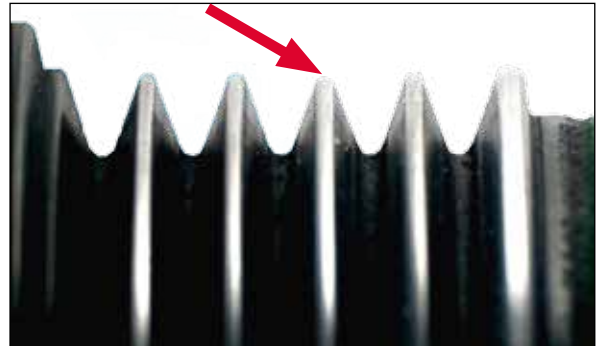
- Split in the bellows
 - Incorrect fitting:
Bellows was damaged during installation



Profile tips heavily worn

Cause

- Insufficient tension in the FEAD makes the belt slip over the overrunning alternator pulley
- The OAP is not functioning correctly



Guides worn off

Cause

- Misalignment between the rollers and accessories
- Belt installed incorrectly



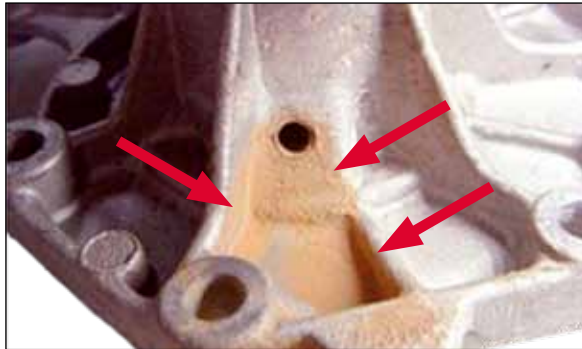
5.4 Water pump

Leakages

Small amounts of fluid or vapour can egress at the mechanical face seal even under normal operating conditions and are no reason for complaint.

Water pump leakages can occur as a result of:

- Normal wear and tear after 50,000–100,000 driven kilometres, depending on the operating environment,
- Cooling system contamination, e.g. with rust, deposits and rubber or plastic particles entering the mechanical face seal,
- Using improper cooling fluids or adding too much tap water (calcification)
- Excess pressure in the cooling system caused by defective pressure valves in the radiator cap,
- Defective cylinder head seals, allowing pressurised combustion gases to enter the cooling system.



Signs of coolant egress

Improper use of sealant

Improper use of sealant is a frequent cause of water pump failure. The use of excessive amounts of sealant in particular can cause sealant to be washed into the cooling system where it can enter the mechanical face seal and adversely affect sealing performance. The result: Coolant leaking from the water pump bearing eventually destroying the bearing.



Sealant entering the radial seal

If the pump's vent hole is clogged with sealant, coolant vapour accumulates in the pump housing with the risk of escaping through the pump bearing. This will also destroy the bearing.

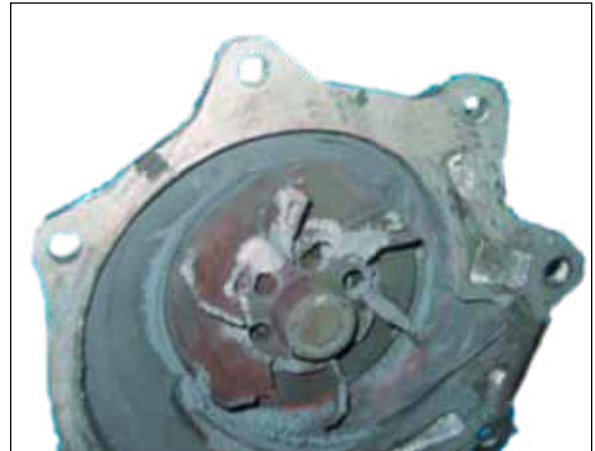


Vent hole clogged with sealant

5.4 Water pump

Cavitation damage caused by unsuitable coolant

Cavitation is a physical effect, resulting from currents and subsequent pressure fluctuations. Strong fluid currents can create vacuum bubbles which may collapse, for example at the housing wall. Jets of fluid hit the wall with high speed, gradually eroding the housing material.



Impeller showing cavitation damage

Corrosion damage caused by unsuitable coolant

Corrosion and calcification damage occurs, if the coolant contains too much mineralised water.



Water pump showing corrosion/calcification damage

Damage caused by foreign body contamination

Foreign body contamination is one of the most frequent causes of coolant circuit failure. It results from abrasive (surface-attacking) substances, such as rust, lime or abrasants, which can enter the cooling circuit e.g. during engine repair or when using dirty water and cause considerable damage.



Water pump showing abrasion damage

Mechanical damage

Failure to apply the specified tightening torques or excessive belt tension can damage the pump severely.



Bearing outer race with damaged raceways as a result of excess pressure.

The use of appropriate tools and implements is an absolute must. Ball bearings and roller bearings are extremely sensitive to shock. Never apply pressure on the bearing raceways during installation.



Water pump showing hammer marks on the pulley flange and housing

6 Service

Important:

Always observe the scheduled intervals for checking and replacing of belt drive components as specified by the manufacturer

Timing drive – servicing checklist

1. Check the condition of the toothed belt.
2. When has the toothed belt last been replaced and at what mileage?
3. Do you have the vehicle's inspection record? Has the car been serviced regularly?
4. Is the vehicle used in demanding operating environments, requiring shorter replacement intervals for components of the timing belt drive?
5. Are accessory components in the environment of the toothed belt in good shape, for example camshaft, water pump, power steering pump or does a part emit noise?
6. Use a measuring device to measure the belt tension in systems with "rigid" tension rollers and adjust if necessary.
7. Check plastic running pulleys for signs of wear.
8. Check bearing seals for signs of leakage.
9. Check parts for signs of corrosion.
10. Does the overall condition of the toothed belt allow you to guarantee for a failsafe operation until the next scheduled service?

Note:

A faulty toothed belt can cause enormous damage to the engine and entail considerable repair costs. The costs for the replacement of a toothed belt are by far lower than the repair costs of a damaged engine caused by a faulty timing belt. There must not be any doubt as to the reliability of the timing belt. If unsure, always advise the customer to have the belt replaced.

Timing drive – possible causes of failure

- Belt tension too tight or too slack,
- Impurities in the belt drive,
- Belt edges worn out,
- Tooth flanks of the belt worn out,
- Dry bearing sealing lip causes seal squeal,
- Reduced bearing clearance below limit caused by the deformation of the bearing inner ring:
→ Wrong tightening torque,
- Pulleys' running surface damaged,
- Bearing grease too old.

Accessory drive – servicing checklist

1. Check the condition of the poly V-belt.
2. Check the settings of the automatic belt tensioners.
3. Use a measuring device to measure the belt tension in systems with "rigid" tension rollers and adjust if necessary.
4. Check the condition of the grooved rollers.
5. Make sure, protective covers are used.
6. Check the mounting bores of hydraulic tensioning units for damage and the bellows seal for oil loss.
7. Check the belt tensioner is free to rotate through its range of movement.
8. Check parts for signs of corrosion.

Accessory drive – possible causes of failure

- Belt tension too tight or too slack,
- Impurities in the belt drive,
- Poly V-belt worn out,
- Belt profile partially fractured,
- Dry bearing sealing lip causes seal squeal,
- Pulley bearing lost grease:
→ Protective cover missing!
- Hydraulic belt tensioner damaged:
→ Oil loss of the belt tensioning unit,
- Defective alternator belt pulley:
→ Poly V-belt flaps and squeals.
→ Check alternator belt pulley (see page 20).

Note:

When replacing the poly-V-belt we recommend replacing the other components in the front-end accessory drive (idlers, tensioners and OAP) at the same time, as all parts are subject to same level of wear.

Water pump/cooling system – servicing checklist

- Check content of antifreeze in coolant
- Watch for contaminants in coolant
- Check pressure valve in header tank/radiator cap
- Check cooling system for leaks

[illegible]