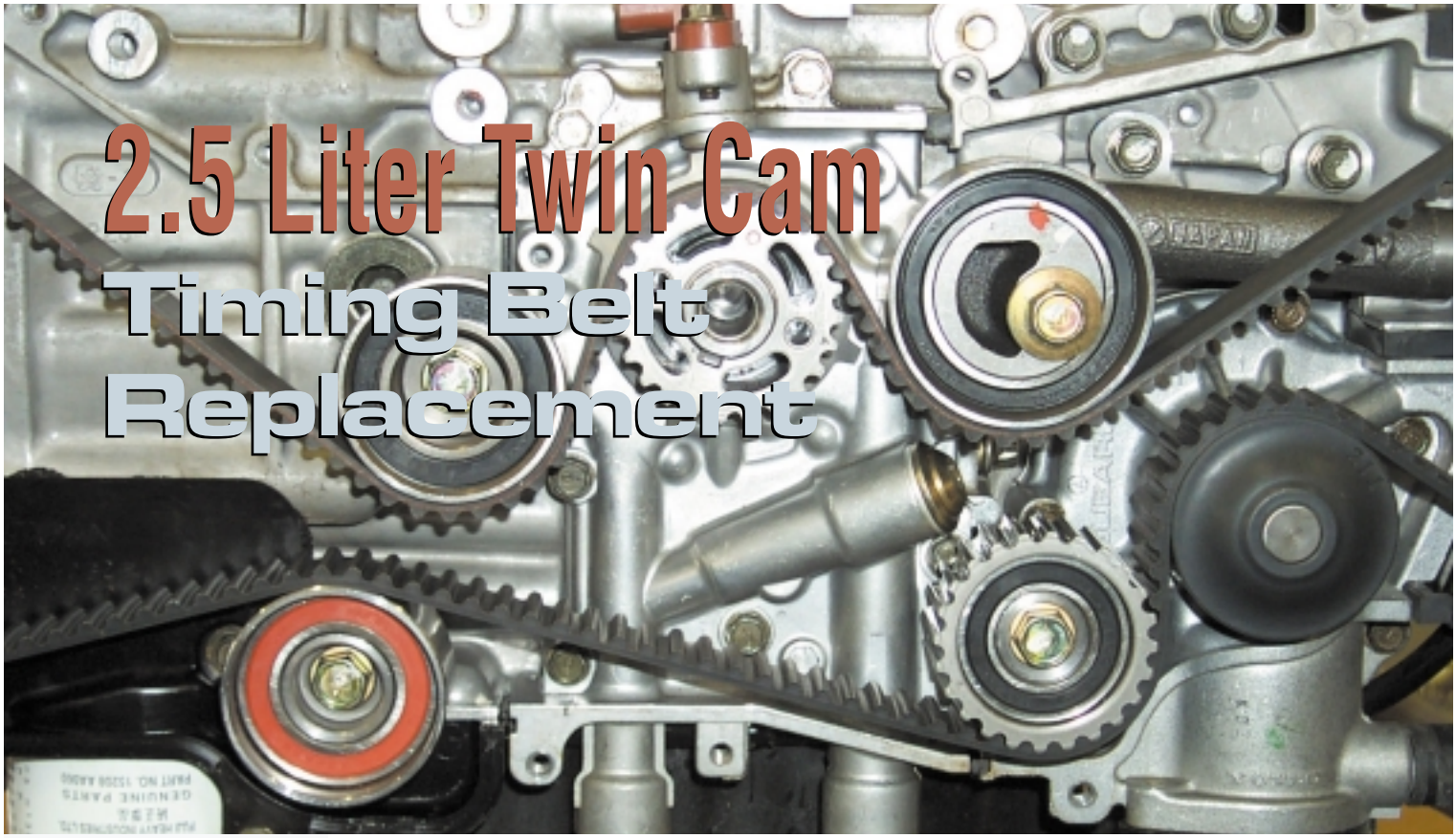


2.5 Liter Twin Cam Timing Belt Replacement

On most overhead cam engines, a timing belt replacement is a pretty straightforward procedure: You take the old belt off, make sure the timing marks are lined up, then you put the new belt on. You've probably replaced more timing belts during your career than you could count, and most of them probably fall into the same ho-hum category. But there are some engines out there that demand your full attention. We call these engines *interference engines*, an innocent-sounding term that understates the importance of the matter at hand.

Very simply, the internal parts of an interference engine (valves and pistons primarily) can *interfere* with one another if the timing belt either breaks or is incorrectly installed. In this case, the word *interfere* doesn't mean something as benign as interrupting another person during a heated conversation. What it actually means is the internal parts can *run into* one another, causing expensive internal engine damage that is not easily repaired without further disassembly.

The Subaru 2.5 liter twin cam engine is an interference engine. If its timing belt breaks or if it is incorrectly installed, intake and exhaust valves can collide with one another. The same circumstances can also cause the valves to collide with the tops of the pistons as the pistons rise in the cylinders. So this is one engine that requires your full attention during a timing belt replacement.

The factory-recommended timing belt replacement interval for the 2.5 liter twin cam engine is 105,000 miles. While that may seem like a lot of miles, owners of vehicles equipped with this engine may be reaching the replacement interval sooner than you might think. Also, the belt may require inspection or replacement before the recommended replacement interval, due to possible belt damage during a front end collision. Either way, it pays to learn as much as possible about this procedure, *before* you have to do your first one on an actual vehicle.

To make this procedure as clear as possible, all photographs in this article were taken with the engine removed from the vehicle. It's unnecessary to go to these lengths when you're doing the job for a paying customer. There is room to work

(continued on page 10)

at the front of the engine, after disconnecting the battery, then removing the radiator cooling fans, fan shrouding, v-belt cover, v-belts and air conditioning compressor drive belt tensioner. You'll have plenty of room for your hands and wrenches — there just isn't enough room to squeeze a camera in there.

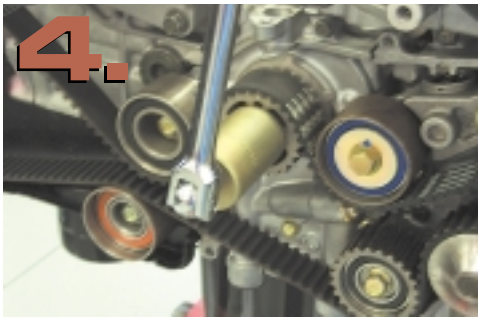
This article will follow a step-by-step format. We'll provide photograph of each important step, and point out special cautions or additional information along the way.

We've removed a 2.5 cylinder head to show just how crowded it is in the combustion chamber area. Each intake valve has its own cam lobe. The intake valve timing is slightly staggered, so one intake valve begins to open and close slightly ahead of its partner. If the intake and exhaust cams are allowed to get out of time in relation to one another, intake and exhaust valves will collide in the combustion chamber area. Intake valves in four-valve heads are necessarily small, and more easily damaged than similar components on two-valve engines. A collision between valves, even when the engine is not running (during a timing belt replacement for example), can cause valve damage. The object is to finish the job with the engine running at least as well as it was before you started, which is why it's so important to approach this job with the necessary caution and the proper tools.

A special crankshaft pulley wrench (ST 499977100) is necessary to lock the crankshaft while removing and installing the crankshaft pulley bolt. If you don't own this tool, you may be tempted to blast the pulley bolt with an impact wrench. While this method may *remove* the bolt, using an impact wrench to *reinstall* the bolt may cause serious engine damage. Over-tightening the bolt may cause the bolt to stretch and/or break. Over-tightening may also cause damage to the crankshaft snout. There have been reports of crankshaft snouts that have sheared off after incorrect pulley bolt installation. Use the proper tools and torque the bolt to the proper specification.

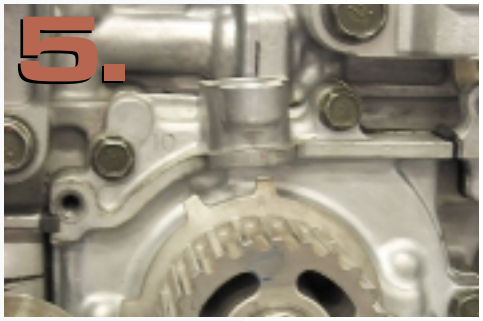
A three-piece outer belt cover set protects the timing belt. Fourteen bolts hold the covers in place. The left and right covers must be removed first, then the center section. Most of the bolts thread into captive nuts in the back sides of the cover set. Use a 1/4-inch drive socket set to remove the bolts and take your time. If the bolts feel tight, try tightening slightly before removing them. This will prevent damage to the captive nuts, which will make it easier to put the covers back in place and will make it easier for the next guy too.

The covers are designed to seal out dirt and they must be properly reinstalled to do their job. Inspect the rubber gaskets which seal the inner to the outer covers. If they have become swollen due to oil leakage, find the source of the oil leak and replace the damaged gaskets before reinstalling the covers. Even a small amount of road grit inside the timing covers will act as an abrasive that will make short work of the timing belt, resin cam pulleys and other timing components.

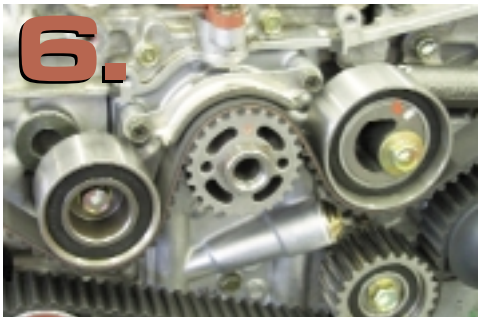


This special tool fits over the end of the

crankshaft, and provides a convenient way to turn the engine over with a breaker bar. Use the tool to turn the crankshaft until all of the timing marks are aligned. This step is especially important because we don't want to try to retime the engine after the timing belt has been removed.



There are seven different timing marks that need to be in alignment. Close doesn't count here — we're not playing horseshoes. We'll start with the crankshaft pulley. Make sure the timing mark on the crankshaft reluctor is lined up with the corresponding mark on the engine case.



Beginning with the 1998 model year, 2.5 liter engines have this sheet metal belt guide mounted above the crankshaft sprocket. The belt guide serves to maintain belt engagement mainly during the time the vehicle is being shipped. Manual transmission vehicles are shipped in gear, which transmits the rocking action of the shipment vehicle to the cambelt tensioner, compressing the oil chamber. The tensioner begins to refill the oil chamber after the engine is started and in some cases the tension of the belt was not increased in a timely manner. This would cause the torque of the engine to slip the crankshaft sprocket ahead of the timing belt, creating a crankshaft to camshaft timing problem.

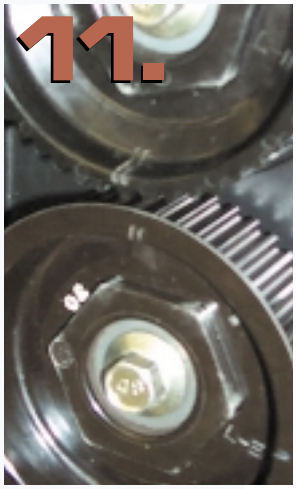
The belt guide prevents this condition from occurring by pushing the belt downward back into the crankshaft sprocket. This guide is not in constant contact with the belt. Contact only occurs if the belt begins to slip.

We'll start on the left side of the engine. Make sure the single timing mark on the left intake (upper) camshaft pulley is aligned with the notch *at the top* of the inner timing belt cover (12 o'clock).

Moving to the left exhaust (lower) camshaft pulley, the single timing mark on the camshaft pulley should be aligned with the notch *at the side* of the inner timing belt cover. That's the 3 o'clock position when facing the front of the engine.

The right intake (upper) camshaft pulley uses the same marking system as the left intake camshaft pulley. A mark *at the top* of the pulley should be aligned with a notch at the top of the inner timing belt cover (12 o'clock). Mark the notches with white paint to make them easier to see inside the engine compartment.

The right exhaust (lower) camshaft pulley uses the same marking system as the left exhaust camshaft pulley. The single timing mark on the camshaft pulley should be aligned with the notch *at the side* of the inner timing belt cover. The notch is in the 9 o'clock position when facing the engine.



The camshaft pulleys must also be aligned *in relation to one another*. To accomplish this, each camshaft pulley also has a pair of side-by-side timing marks. When the engine is properly timed, these double notches will be directly facing each other. The notches on the intake (upper) camshaft sprockets should be at the 6 o'clock position, while the notches on the exhaust (lower) camshaft sprockets should be at the 12 o'clock position. Proper alignment of the left camshaft sprocket double timing marks is shown here.

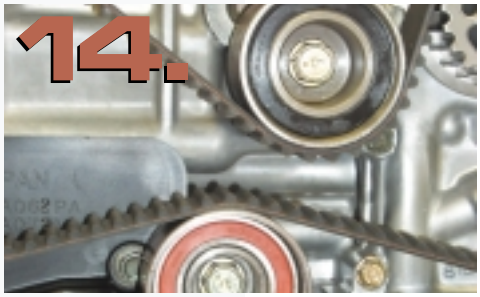
It's unlikely that you would be removing and reinstalling the same timing belt. However, if you are planning to reinstall the old belt, take the opportunity to mark the belt with a colored marker or crayon. Place a mark on the belt to correspond with each of the five external timing marks. Also mark the direction of the timing belt rotation. A used belt must never be allowed to rotate opposite its original direction.

New timing belts are marked, both for direction of rotation, and for the position of the timing marks. While these marks provide a handy reference point, they should not be considered to be the last word when it comes to belt timing, as we'll discuss later.

Okay, we're ready to blast off the old timing belt, right? Wrong! When the timing marks are in the proper position for belt replacement, several of the valves are either open or partially open. Removing the timing belt now will let the camshafts turn in a sudden and uncontrolled manner as the valve spring pressure causes the partially opened valves to slam shut. As these valves close, others will try to open. What can happen next? You guessed it — valve-to-valve interference. Before you can say 'Oops,' you could be looking at a few slightly tweaked valves. Not a pretty picture.

So do you put it all back together and close the hood? No. Not if you've got the proper tools. This tool fits over the large hexes on the upper and lower camshaft sprockets on the right side of the engine. The tool effectively locks the two sprockets together, keeping them from turning as long as it's in place.

Things are even more interesting on the left side of the engine. This is the side of the engine where things really want to move when the timing belt is removed. This tool locks onto the upper and lower sprocket bolts using small set screws. Jam nuts at the top and bottom of the tool are used to lock the cam pulleys in place, while loosening them allows the pulleys to be moved independently using a hex wrench. Everything should be locked down solidly to prevent pulley movement before removing the timing belt.

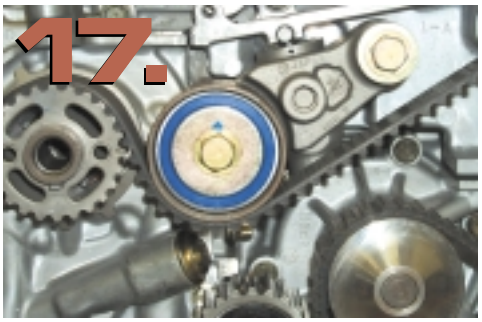


The 2.5 engine's timing belt must negotiate a combination of three idler pulleys, the water pump pulley and the tensioner pulley during each rotation. Pay particular attention to the position and appearance of the different idler pulleys, especially if you happen to remove more than one for any reason. They all look very similar to one another, but each pulley is designed for installation in a particular location. Different colors may or may not be used in different locations, but this isn't necessarily a reliable guide, as the pulleys can still be accidentally installed in the wrong location. Incorrectly installed pulleys can make unusual noises and fail prematurely. To avoid confusion, mark the pulleys with an indelible marker with the letter 'T' for top of 'B' for bottom. It's a simple step that will buy you a lot of piece of mind.

The idler pulley with the least amount of belt tension on it is the lower right idler pulley, which makes it the best candidate for removal when removing the timing belt. This is an all-aluminum engine, so it pays to be careful when removing and installing fasteners. Since the lower pulley isn't under a lot of stress, its mounting bolt can be removed and installed without risk of cross-threading or other damage.

With the old timing belt out of the way, the next order of business is the timing belt tensioner. Two different types of hydraulic belt tensioners have been used on this engine. The early style is shown here. This is the same tensioner that was previously used on the 2.2 and 3.3 liter engines. Remove the tensioner from the engine, then carefully compress its adjuster rod in a vice equipped with soft-faced jaws. Use a small pin to hold the adjuster rod in its compressed position. The pin stays in until the timing belt installation procedure is complete.

The new style cambelt tensioner was first installed during mid-1997 vehicle production. This tensioner requires careful handling and some special tools to retract its adjuster rod. A lateral vise *must not* be used to retract the tensioner's adjuster rod or damage will result. The tensioner and pulley are a single unit. The automatic belt tensioner assembly incorporates an adjuster rod, wear ring, plunger spring, return spring, check ball and silicone oil. Remove the mounting bolt, then remove the tensioner assembly.



The tensioner rod must be compressed using a hydraulic press. The pressure exerted on the rod must not exceed 66 pounds. Exceeding this pressure may bend the tensioner rod. This will keep the rod from extending fully when it is reinstalled on the engine. If the rod cannot extend fully, excessive slack may develop in the timing belt, causing it to jump teeth. Jumped teeth can mean bent valves or damaged pistons, something you'll certainly want to avoid.

Use the following procedure to inspect and service the tensioner assembly:

- Secure the tensioner in a press. This photo shows the recommended setup. An ABS brake pedal force gauge is inserted between the press road and the adjuster piston. A small pin fits between the force gauge and the adjuster rod, assuring that all press force is directed to the adjuster rod. Use press plates to make sure the tensioner assembly is square and that no press force is directed to the tensioner pulley assembly.
- Slowly press the adjuster rod down to the end surface of the tensioner surface. Repeat this motion two or three times.
- Allow the adjuster rod to extend fully, then apply a pressure of 66 psi to the rod. Check the tensioner for resistance.
- If no resistance is felt and the adjuster rod moves down freely, replace the tensioner with a new one.
- Release the press and allow the adjuster rod to move up.

- Measure the extension of the adjuster rod beyond the body. Replace the tensioner if it is beyond the specification of 6.0 mm ±0.5 mm.
- Check the condition of the tensioner and pulley contact surface, bearing operation and grease leakage. Replace the tensioner if any abnormality is found.
- If the tensioner passes inspection to this point, slowly move the rod down with a force of 66 pounds. Up to 10 minutes of slow pumps on the press lever may be necessary to fully retract the adjuster rod. Pump the lever until the pressure reaches 66 psi, then allow the pressure to drop before giving it another slow pump.
- Stop when the adjuster rod is fully retracted (flush with the tensioner body). Pushing beyond this point will damage the tensioner. A 2 mm retaining pin should fit easily through the holes in the tensioner housing and adjuster rod.

If you lack the proper tools to compress the adjuster rod, *don't improvise!* The only acceptable alternative is to replace the tensioner assembly with a new part. The new tensioner assembly is shipped with the adjuster rod in the compressed position.

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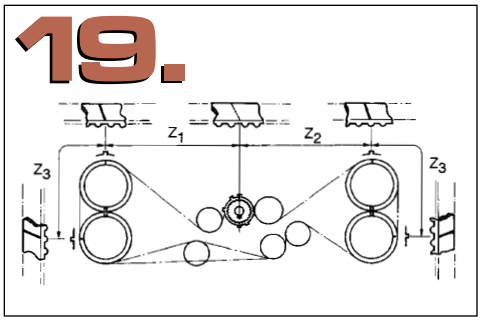

With the tensioner assembly back in place, we're ready to install the new belt. As we mentioned earlier, new belts have paint marks which correspond to the timing marks on the various sprockets. A dotted line is used for the crankshaft sprocket timing mark, all other belt marks are solid lines. This makes a handy starting point during belt installation, but remember, the paint marks are applied by a machine and may not be in exactly the right position.

By far the most accurate method of determining proper belt alignment is to count the belt teeth. This diagram illustrates the tooth counts for all five timing marks. Tooth count Z1 is 54.5 teeth. This measures from the crankshaft pulley timing mark to the right (upper) intake camshaft sprocket timing mark. Tooth count Z2 is 51 teeth. This measures from the crankshaft pulley timing mark to the left (upper) intake camshaft sprocket timing mark. Tooth count Z3 is 28 teeth. This is the number of teeth between the (upper) intake and (lower) exhaust camshaft sprocket timing marks. The Z3 tooth count is the same for both the left and right sides of the engine because the same relationship must be maintained between the upper and lower cams on both sides of the engine.

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Always refer to the diagram to see where the tooth count begins and ends. The tooth count may begin in the 'valley' of the belt and end on a 'peak,' or vice versa. This accounts for the half-tooth count in the measurement between the crankshaft sprocket and the right upper camshaft sprocket.

Everyone develops his own method of installing the new belt. Some techs prefer to start from the left side of the engine and work to the right — others just the opposite. There is no 'right' way, as long as the belt ends up properly installed and timed. The right side of the engine is far less finicky because the right side cams are not under tension when the timing marks are properly lined up. That's why the locking tool makes no provision for moving the pulleys when the tool is in place.

The holding tool on the left side of the engine is adjustable. Adjustment on this side of the engine is necessary because the tensioner is on the left side. Until the tensioner locking pin is removed, most of the belt slack will also be on this side of the engine. Counting the belt teeth and lining up the sprocket timing marks may produce what looks like a slightly 'wrong' lineup on the twin facing timing marks between the left cam sprockets. The problem is further aggravated by the fact that the holding tool blocks your view of the twin timing marks between the cam sprockets. If you've counted your teeth properly, all of the marks should come into alignment following the next couple of steps.

Reinstall the lower right idler pulley, then give your timing marks one last look. If you're confident that everything is where it's supposed to be, remove the timing belt tensioner adjusting rod retaining pin. The pin will begin to push outward to take up any slack in the timing belt. The tensioner assembly is not locked into place and has the freedom to pivot on its mounting bolt to take up for any additional stretch as the belt wears.

Remove both cam sprocket holding tools, then install the crankshaft turning socket. Turn the crankshaft 90 degrees counterclockwise, then 180 degrees clockwise, before returning the crankshaft sprocket to its alignment mark. This combination of movements allows the tensioner to take the slack out of the new belt and normalizes its position on the assortment of sprockets and idlers.

The moment of truth! Check the timing mark alignment at each of the seven spots on the engine. If you've made a mistake by a whole tooth or more, it should be fairly obvious. There's no way to fudge it. If it's wrong, it's got to be done again. A mistimed engine will run, but it will use more fuel, will lack performance and will be harder to start. A severely mistimed engine will self-destruct in just a few cranks of the starter. Get it right, now!

The timing marks on this engine lined up everywhere but here at the left cam sprocket match marks. After normalizing the belt by rotating it, the upper and lower pulley match marks didn't line up quite as precisely as we would have liked. The four marks didn't line up like four fingers pointing directly at each other. Rather, they lined up like four fingers pointing ever so slightly away from each other.

Subaru training instructor Joe Stoffa assured us that this was as close as we were going to get on this engine. Remember, four of the engine timing marks are simple notches in the inner timing cover plastic. Due to manufacturing tolerances and assembly variations, these notches may not end up in precisely the right spot. A slight variation here or there can add up to the slight misalignment we saw on our engine. Moving either of the pulleys a full tooth in either direction would not have corrected our perceived misalignment; it would only have made it worse.