CAM-04, Camshaft Chain and Tensioner Replacement (16V)

Introduction

In addition to the concern that 8V 944s have with regard to timing belt maintenance, 16V 944 owners must also be concerned with the maintenance of the timing chain and tensioner. On the 8V 944s, valve timing for both the intake and exhaust valves is accomplished by a single overhead camshaft. The 16V 944s, have two camshafts, one for the intake valves and one for the exhaust valves. On these cars, the exhaust valve camshaft is driven by a camshaft sprocket directly from the timing belt, identical to the 8V cars. However, the exhaust and intake camshafts have a toothed gear located near the center of the shaft. A chain between the exhaust and intake cam allows the exhaust camshaft to drive the intake camshaft. The drive chain tension is maintained by an oil fed tensioner. Over time, the tensioner will eventually wear out. The tensioner itself seems to be fairly reliable until around 130,000 miles. However, many 16V owners have experienced failures related to other tensioner components a just over 100,000 miles. Most of these failures can be attributed to failures of the J-Tube oil supply pipe or to the plastic guide rails on the tensioner. Until recently, the plastic rails were not available separately. They had to be purchased as part of the tensioner. However, Zim's Autoparts has recently made the tensioner pads available. The web site address to locate the tensioner pads is:

https://secure2.advwebsys.com/zimcgi/specials.pl

It's a good maintenance practice to inspect the tensioner at 45,000 mile intervals up to 90,000 and at 15,000 mile intervals thereafter.

The following procedure describes how to replace the timing chain and tensioner on a 944 S or 944 S2. It was written by Derek Holliday and, although I haven't had the opportunity to use it yet, seems to be very thorough. I've also taken the liberty of providing some part numbers to go along with the procedure. Thanks, Derek.

If it turns out you need to replace only the tensioner pads, here a link to a procedure for just replacing the pads:

http://boerger.golden-tech.com/images/cam_chain_tensioner_replacement.htm

Parts

Part	Part Number
Tensioner	944 105 049 01
Timing Chain	944 105 501 01
Oil Supply Tube (J-Tube)	944 105 167 03
Seal Rings (for J-Tube)	900 123 115 30 **OR** N 013 807 09
Cam Housing Gasket	928 104 447 09
Top Tensioner Pad *	928 105 509 01
Bottom Tensioner Pad *	928 105 347 01

* Supposedly the tensioner pads can not be purchased separately from the tensioner itself. However, a member of the old Porschefans List noticed that there were part numbers stamped on each of the tensioner pads and provided those part numbers to the list. I've yet to find anyone who's actually ordered just a set of pads and replaced them.

Procedure

1. Disconnect the battery negative lead.
2. There are two hoses that run at the back of the cam housing. You'll have to disconnect those two hose to remove the cam cover. Simply disconnect one end of the hoses and use a bungee cord to hold them out of the way. (*Tip from Erik Ohrnberger*)
3. Remove cam cover. Check inside of cam cover for signs of chain rubbing. Also check cylinder head for signs of chain rubbing.
4. Carefully stuff rags into the oil drain galleries at the lower side of the head, next to the exhaust valves. This will prevent you accidentally dropping anything down the oil ways, particularly when you remove the chain tensioner and oil feed pipe.
5. Inspect chain tensioner and oil feed pipe for signs of wear or cracking.

NOTE

In my case, the oil pipe had broken off completely. The plastic rubbing block on the chain tensioner had wear grooves in it and a hairline crack in the plastic, so I replaced it. Unfortunately you can only buy the complete tensioner (about $400 equivalent here in the UK) even though it seems that its only the plastic that is a problem. I've heard lots of advice about the plastic breaking up and taking out the chain, cams, and valves with it, so it seems good insurance if there is any doubt about it.

6. Remove air filter housing and inlet pipe, up to air flow meter.
7. Remove PAS pump and alternator belts (and a/c if fitted?).
8. Disconnect wire to Hall sensor on rear of exhaust cam sprocket rear cover and move wire clear of plastic covers at front of engine.
9. Remove bolts securing black plastic covers from the front of the engine using a 10mm socket. Remove upper and lower covers.
10. Remove the distributor cap and plug wires. (3 screws).
11. Remove the metal cover over the front of the exhaust cam sprocket.
12. Remove the ignition rotor from the cam sprocket (3 screws).
13. This next stage I only learned about after I had already done the job but it should eliminate the need to re-time the cam on reassembly (assuming that the cam timing is correct before you tear down). Remove the 3 screws from the ignition rotor and refit them to the pulley assembly and tighten. This should lock the pulley onto the three-armed "propeller" which is keyed to the cam and sits behind the pulley. If you don't do this, when you subsequently remove the pulley bolt, the pulley will rotate on the cam and you will lose the cam timing setup. Credit to Kevin Gross for this tip.
14. Remove the fan assembly from the radiator to increase the clearance when working on the cam and balance shaft belts.
15. Set the engine to top dead center by aligning the scribed mark on the cam pulley with the line on the top lip of the metal cover behind the pulley. Check that the crank is at TDC by ensuring the mark on the flywheel is aligned with the pointer. This is visible by looking at the back of the engine on the drivers side (USA). On the clutch bell housing near the top, there is a square hole through which the flywheel can be seen, and also a static pointer. There is a line scribed on the flywheel with the letters "OT" next to it. There is also nearby a circular hole so don't confuse the two. I found it quite difficult to find the correct hole due to lots of cables and pipes in the way. With the crank at TDC, the notches on both balance shaft sprockets should be lined up with the static marks on the plastic cover behind the belts. The static mark for the upper (right hand when looking at the front of the engine) balance shaft sprocket is a notch on the plastic cover at the 12 o'clock position. The static mark for the lower (left hand) balance shaft sprocket is a molded protrusion on the plastic cover, at approximately the 7 o'clock position.
16. With the crank at TDC and the cam pulley mark aligned with its static mark on the rear cover, mark the relationship of the cam and balance shaft belts to their sprockets, and also the direction of belt rotation (the crank pulley rotates clockwise when viewed from the front). I used white paint for this. If you intend to remove the balance shaft pulleys (which is necessary if you need to replace the balance shaft oil seals), then also mark the relationship of the balance shaft pulley covers to the pulleys themselves. Like I said above, this makes more sense if you have the Haynes manual to refer to.

17. Loosen the balance shaft tensioner pulley. This is the pulley to the left of the lower balance shaft pulley when viewed from the front. The tensioner pulley has an eccentric hub which is clamped in position with a nut and washer. Once the nut is loose, the belt tension will cause the tensioner to rotate and slacken off the belt. Haynes recommend you mark the position of the tensioner hub before releasing it, so that it can be refitted to the same position afterwards. In my case, the balance shaft belt was so loose that I could not rely on the original tensioner position for correct belt tension.
18. Carefully remove the balance belt from its pulleys/tensioners.
19. Locate the cam belt self tensioner mechanism. This is below and to the left of the upper (right) balance shaft pulley. The mechanism comprises a bracket with a pulley on the left and a spring behind it on the right. You should see three nuts/bolts on it. The bolt on the left attaches the tensioner pulley. The top nut is attached to the tensioner pivot stud. Loosen this with a 13mm wrench or socket. The nut on the right locks the tensioner in position. Loosen this with a 13mm wrench or socket.
20. Push downwards on the tensioner pulley to compress the spring. This will allow the belt to slacken. With the tensioner spring pressure relieved in this way, you can remove the cam belt from the cam pulley. It may help to temporarily tighten the right hand nut on the tensioner to keep it compressed while you remove the belt from the pulley.
21. Remove the tensioner mechanism from the engine. It is secured by three nuts which you can't easily see. One of the nuts requires the removal of an idler pulley located just below the tensioner, using a 17mm socket.
22. With the tensioner removed, you can carefully remove the cam belt. Removal of the crank pulley is not necessary providing you take care to ease the belt clear without kinking or damaging it.
23. Once the cam belt is removed, do not turn the crank or you may damage the valves.
24. This next stage is my own method of ensuring that the cam timing can be restored, before removing the cam pulley. By using Kevin Gross's tip as indicated at stage (10) above, it should be possible to eliminate the need for making any alignment marks in order to restore the cam timing on reassembly. The factory method requires dial gauges to properly set up the cam but I don't have the factory settings so instead I very carefully marked the cam and pulley positions before removing the cam pulley. White paint won't do for this, since you need to be much more precise than paint marks will allow. I used a scriber and scribed marks on the exhaust cam and the adjacent front bridge piece which clamps the front end of both cams onto the head. The marks must line up exactly. Next, I scribed a line across the top face of the cam tooth that has the timing mark on its edge. In effect, my scribe mark was a continuation of the pulley timing mark. I used a 6 inch steel rule to keep the scribed line straight. Next, I placed the 6 inch rule, end on across two cam teeth such that the edge of the rule aligned with my scribed mark and the rule was also in contact with the rear metal pulley cover. This enabled me to also

scribe a line on the lip of the pulley cover. It was necessary to make these two marks because the existing timing marks on the pulley and cover were not aligned exactly. Very close, but not perfectly aligned. In any case, removing the belt can move the pulley slightly. I can't emphasis enough how accurate you need to be in scribing these marks, especially on the cam and housing, since the diameter of the cam is much less than the pulley and hence even a 0.5mm misalignment is about 2 degrees of cam rotation. These marks will enable you to align the cam and pulley on reassembly. Next, using a pin spanner in the slotted holes of the pulley to prevent the pulley rotating, undo the pulley bolt using a 10mm spline drive bit (12 point bit). It is fairly tight. Mine needed 75ft/lbs to crack it loose. Remove the pulley bolt and its hexagonal washer. Before I removed the pulley, I also scribed lines on the end of the pulley and camshaft, after first lining up the two sets of lines I had already scribed. This was because the rear metal cover behind the pulley, onto which I had scribed a static mark for lining up the pulley, may not install back in exactly the same position if there is any clearance in its attaching holes and bolts. By scribing marks on the end of the pulley and cam, it allows the alignment of the pulley cover itself to be checked on reassembly before relying on the scribed marks.

25. Pull the pulley off the cam. A puller should not be necessary to do this. If using Kevin Gross's tip as shown at (10) above, you will also pull off the metal shield and the three-armed "propeller" trigger for the hall effect sensor, with the pulley. If not, these need to be removed individually. I did not remove the woodruff key in the cam but take care that it doesn't fall out and get lost.
26. Remove the three bolts and the rear metal pulley cover.
27. Remove the four bolts and the front bridge piece which clamps the ends of both cams to the head.
28. Remove the exhaust cam end seal and the inlet cam end sealing bung.
29. Before removing the chain tensioner and cams, offer up the new cam chain along side the old one. To the left of each chain sprocket on the cams, there should be a cast-in triangular pointer which should be pointing pretty much straight up, with the cams at the crank TDC position. The cam chain should have two copper colored links in it. There are five plain colored links in between the copper ones. These links should align with the tooth on each sprocket which lines up with the triangular pointer on the cam. This is on the top run of the chain as you look at the installed chain and cams. It is this alignment of the chain and sprockets which governs the timing of the inlet cam to the exhaust cam and so it is critical to ensure that this is set up properly when you subsequently fit the new chain and refit the cams.
30. Remove the metal pipe from the chain tensioner and head by unscrewing both banjo bolts. Make sure you also remove the sealing washers, 2 per banjo fitting. In my case, the pipe had broken away. I have heard of pipes cracking, so it's probably good insurance to replace the pipe anyway.

31. Prior to removing the tensioner, it is necessary to depress the upper rubbing block against the tensioner spring pressure and to temporarily lock it in position. I did this by first inserting a thin strip of metal between the chain and the plastic, and then inserting two nails into the holes in the metal body of the tensioner, alongside the plastic rubbing block. The use of the metal strip was to reduce the risk of the nails damaging the plastic, since the spring pressure is quite strong. If you intend to replace the tensioner anyway, then this would not be necessary.
32. With the tensioner compressed as above, remove the two bolts which attach the tensioner to the head and remove the tensioner itself.
33. Carefully remove the cam retaining cap bolts using an 8mm spline drive bit (12 point bit). It is very important to ease each bolt out very gradually and evenly, approximately a quarter or half turn each at a time. This is due to some valves being open and their springs putting uneven pressure on the cam. Each cap is numbered 1-8 and there are numbers stamped on the head next to each cap to ensure they go back on in the correct position. Not only should each cap go back on in the same position but its orientation should also be the same, so note the orientation before removing the caps. Take great care not to damage the caps since they are not replaceable and are line bored with the head during manufacture.
34. Carefully lift out both cams together, complete with chain. Take care not to damage the cam bearing surfaces or the cam followers.
35. With the cams removed, chain replacement is simple. Just ensure that the copper links go over the sprocket teeth which align with the triangular pointers on each cam as described above. I compared the free length of old and new chains and couldn't really see much difference at all. However, chains are cheap and so again, it's good insurance.
36. Refitting the cams is the reverse of removal. Make sure the cams are fitted with their triangular pointers in the same place they were prior to removal, and that the chain is correctly fitted with the copper links lined up, before you refit the cam retaining caps. Lube all bearing surfaces before refitting. Make sure the caps go back in exactly the same positions and orientations they were before, and tighten the bolts very carefully and progressively. If you feel any undue resistance with any bolts, then adjust other bolts to even up the orientation of the cam before proceeding. Finally torque the bolts to 15 ft/lbs.
37. Refit the cam end seal (exhaust) and bung (inlet).
38. Refit the bridge over the end of both cams. I used a thin smear of Hylomar sealing compound on the mating surfaces.
39. Refit the cam pulley rear metal cover.
40. Slide the pulley onto the cam. At this stage, don't bother with the "propeller" and metal shield. Check the alignment of the scribed marks made previously. The cam can be rotated slightly if necessary by using the pin spanner on the cam pulley. Once the scribed marks on the cam and adjacent front bridge are aligned perfectly, next ensure the marks on the end of the pulley and the end of the cam are aligned. Then, check that the marks on the pulley tooth and the pulley rear

cover are aligned. You may have to loosen the rear cover bolts and move the cover slightly to get the marks lined up. Once all marks align perfectly, you can tighten the pulley rear cover bolts. If you followed Kevin Gross's tip above, then instead of aligning all these marks, you should just need to refit the pulley/metal shield/"propeller" assembly, held together with the three ignition rotor screws. The key way in the "propeller" should ensure that the pulley goes back on in the same position as it was before. However, using this method, you should be careful not to try to rotate the cam by turning the pulley, since I suspect the three small rotor screws may not prevent the pulley from rotating in the elongated slots where the three screws fit. If the pulley does rotate in relation to the "propeller" then, unless you have made "back up" scribed marks, you will need to use the factory timing procedure using dial gauges.

41. Remove the pulley and refit the "propeller" and the thin metal shield, then refit the pulley. Before torquing the pulley bolt (48-52 ft/lbs), make sure all scribed marks align perfectly. Hold the pulley with the pin spanner while tightening the pulley bolt. I had to do this several times because each time I tightened the pulley bolt, the pulley would move slightly. Once the bolt is torqued (I also used Loctite on the bolt), then recheck all scribed marks to make sure everything is back as it was before you pulled it apart. I cannot over stress the importance of getting the cam timing alignment right. If it's not right, then as a minimum, the engine will probably not have optimum torque across the rev range, and worst case is valves and pistons coming together and all the resultant damage.
42. From there on, reassembly is pretty much the reverse of removal.
43. When you install the cam cover bolts, be sure that you don't overtighten them. They should only be torqued to 7 ft-lbs.

44. Cam and balance belts should be replaced if they show any signs of wear or damage, and in any event, if they are approaching 45,000 miles. Tensioner and idler rollers should be inspected and if the bearings are worn or rough, they should be replaced. I chose not to replace the water pump but there are plenty of opinions that this should be done if the pump is approaching or past 100k miles. I also replaced both balance shaft front seals, and the "top hat" bushings that slide onto the ends of the shafts. The oil seals seal onto these bushings and in my case, both bushings had wear ridges from the old oil seals. The Haynes manual is quite good in detailing the balance shaft seal replacement procedure.
45. The cam chain tensioner should be inspected very carefully if the original is to be refitted. In my case, the plastic wear block was cracked and there were very noticeable wear grooves so I bit the bullet and changed it. The consensus seems to be that, although there is no change interval specified by Porsche, the tensioner should be changed at about 60k miles.
46. Don't forget to remove the rags used to block of the oil return galleries inside the head!
47. The belts should be refitted with the crank at TDC (the crank should not have been disturbed throughout the procedure!) and the cam sprocket mark aligned with the static mark on the sprocket rear cover. The notches on the balance shafts should be aligned with the static marks on the plastic cover. If the old belts are to be reused, they should be refitted to run in the same direction as they were before removal.
48. Belt tensioning is best performed with the special tool. I did not have access to this and had to rely on the automatic tensioner for the cam belt, and "feel" for the balance belt.
49. After completing the belt installation and adjustment but before starting the engine, it is advisable to turn the engine over slowly through several revolutions by hand with the spark plugs removed. Any hard fouling of pistons and valves should be detected this way and serious damage avoided.
