**CAUTION:** The magnetic timing wheels (1) must not come in contact with magnets (pickup tools, trays, etc.) or any other strong magnetic field. This will destroy the timing wheels ability to correctly relay camshaft position to the camshaft position sensor.

1. Inspect all sprockets and chain guides. Replace if damaged.

2. If removed, install the right side cam chain guide (1) and tensioner arm (6). Tighten bolts (2) to the proper (Torque Specifications).

3. If removed, install the right side cam chain tensioner (3). Tighten bolts (4) to the proper (Torque Specifications).

4. Reset the right side cam chain tensioner (3) by pushing back the tensioner piston and installing Tensioner Pin 8514 (5).
5. If removed, install the left side cam chain guide (2) and tensioner arm (1). Tighten bolts (4) to the proper (Torque Specifications).

6. If removed, install the left side cam chain tensioner (5). Tighten bolts (6) to the proper (Torque Specifications).

7. Reset the left side cam chain tensioner (5) by lifting the pawl (3), pushing back the piston and installing Tensioner Pin 8514 (7) (Refer to 09 - Engine/Valve Timing - Standard Procedure).

8. Verify that the key (3) is installed in the crankshaft. **CAUTION:** Do not rotate the crankshaft more than a few degrees independently of the camshafts. Piston to valve contact could occur resulting in possible valve damage. If the crankshaft needs to be rotated more than a few degrees, first remove the camshafts.

9. Verify that the number one cylinder piston is positioned at top-dead-center by aligning the dimple (2) on the crankshaft with the block/bearing cap junction (1). **CAUTION:** Do not rotate the camshafts more than a few degrees independently of the crankshaft. Valve to piston contact could occur resulting in possible valve damage. If the camshafts need to be rotated more than a few degrees, first move the pistons away from the cylinder heads by rotating the crankshaft counterclockwise to a position 30° before-top-dead-center. Once the camshafts are returned to their top-dead-center position, rotate the crankshaft clockwise to return the crankshaft to top-dead-center.

10. Verify that the camshafts are set at top-dead-center by positioning the alignment holes (1) vertically.
CAUTION: Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.

11. Place the primary chain onto the crankshaft sprocket (3) so that the arrow (2) is aligned with the plated link (1) on the timing chain.

12. While maintaining this alignment, invert the crankshaft sprocket and timing chain and place the idler sprocket (4) into the timing chain so that the dimple (2) is aligned with the plated link (1) on the timing chain.

13. While maintaining this alignment, lubricate the idler sprocket bushing with clean engine oil and install the sprockets and timing chain on the engine. To verify that the timing is still correct, the timing chain plated link (6) should be located at 12:00 (1) when the dimple (5) on the crankshaft is aligned with the block/bearing cap junction (4).

14. Install the idler sprocket retaining bolt (2) and washer (3). Tighten bolt (2) to the proper (Torque Specifications).
15. Install the primary chain guide (2). Tighten bolt (1) to the proper (Torque Specifications).

16. Reset the primary chain tensioner (5) by pushing back the tensioner piston and installing Tensioner Pin 8514 (3).

17. Install the primary chain tensioner (5). Tighten bolts (4) to the proper (Torque Specifications) and remove the Tensioner Pin 8514 (3).

18. Press the left side intake cam phaser onto the intake camshaft. Install and hand tighten the oil control valve (6).

NOTE: The left side and right side cam chains are identical.

CAUTION: Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.

19. Drape the left side cam chain over the left side intake cam phaser and onto the idler sprocket (1) so that the arrow (3) is aligned with the plated link (2) on the cam chain.
20. While maintaining this alignment, route the cam chain around the exhaust and intake cam phasers so that the plated links are aligned with the phaser timing marks (1). Position the left side cam phasers so that the arrows (3) point toward each other and are parallel to the cylinder head cover mounting surface (5). Press the exhaust cam phaser onto the exhaust cam, install and hand tighten the oil control valve (2).

**NOTE:** Minor rotation of a camshaft (a few degrees) may be required to install the camshaft phaser or phaser lock.

21. Install the Lock, Camshaft/Phaser, Left Side 10202-2 (4) with the tool number facing up.

22. Tighten the oil control valves (2) and (6) to the proper (Torque Specifications).

23. Remove the Camshaft Phaser Lock (4).

24. Press the right side exhaust cam phaser onto the exhaust camshaft. Install and hand tighten the oil control valve (7).

**CAUTION:** Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.

25. Drape the right side cam chain over the right side exhaust cam phaser and onto the idler sprocket (1) so that the dimple (2) is aligned with the plated link (3) on the cam chain.
26. While maintaining this alignment, route the cam chain around the exhaust and intake cam phasers so that the plated links are aligned with the phaser timing marks (1). Position the right side cam phasers so that the arrows (3) point away from each other and the scribe lines (4) are parallel to the cylinder head cover mounting surface (6). Press the intake cam phaser onto the intake cam, install and hand tighten the oil control valve (2).

NOTE: Minor rotation of a camshaft (a few degrees) may be required to install the camshaft phaser or phaser lock.

27. Install the Lock, Camshaft/Phaser, Right Side 10202-1 (5) with the tool number facing up.

28. Tighten the oil control valves (2) and (7) to the proper (Torque Specifications).

29. Remove the Camshaft Phaser Lock (5).

NOTE: There are no timing marks on the oil pump gear or chain.

CAUTION: Always reinstall timing chains so that they maintain the same direction of rotation. Inverting a previously run chain on a previously run sprocket will result in excessive wear to both the chain and sprocket.

30. Place the oil pump sprocket (5) into the oil pump chain (6). Place the oil pump chain onto the crankshaft sprocket while aligning the oil pump sprocket with the oil pump shaft. Install the bolt (4) and tighten to the proper (Torque Specifications).

31. Install the oil pump chain tensioner (1). Make sure that the spring (3) is positioned above the dowel pin (2).
32. Remove the Tensioner Pins 8514 (1) and (6) from the right side and left side cam chain tensioners.

33. Rotate the crankshaft clockwise (as viewed from the front) two complete revolutions stopping when the dimple (4) on the crankshaft is aligned with the block/bearing cap junction (5).

34. While maintaining this alignment, verify that the ARROWS (2) on the left side cam phasers point toward each other and are parallel to the cylinder head cover mounting surface (3) and that the right side cam phaser ARROWS (7) point away from each other and the SCRIBE LINES (9) are parallel to the cylinder head cover mounting surface (8).

35. There should be 12 chain pins (2) BETWEEN the exhaust cam phaser triangle marking (1) and the intake cam phaser circle marking (3) as viewed from either the front or rear of the cam phasers.

36. If the engine timing is not correct, repeat this procedure.

37. Install the engine timing cover (Refer to 09 - Engine/Valve Timing/COVER(S), Engine Timing - Installation).

38. Install the spark plugs (Refer to 08 - Electrical/8I - Ignition Control/SPARK PLUG - Installation).

39. Install the cylinder head covers (Refer to 09 - Engine/Cylinder Head/COVER(S), Cylinder Head - Installation).

40. Install the air cleaner body (Refer to 09 - Engine/Air Intake System/BODY, Air Cleaner/Installation).

41. Fill the engine crankcase with the proper oil to the correct level (Refer to 09 - Engine/Lubrication/OIL - Standard Procedure).

42. Connect the negative battery cable and tighten nut to the proper (Torque Specifications).

43. Fill the cooling system (Refer to 07 - Cooling - Standard Procedure).
44. Operate the engine until it reaches normal operating temperature. Check cooling system for correct fluid level (Refer to 07 - Cooling - Standard Procedure).

**NOTE:** The Cam/Crank Variation Relearn procedure must be performed using the scan tool anytime there has been a repair/replacement made to a powertrain system, for example: flywheel, valvetrain, camshaft and/or crankshaft sensors or components.