TECHELP
The Automotive & Smog Training Center

Tech Tip

2006 Cadillac STS

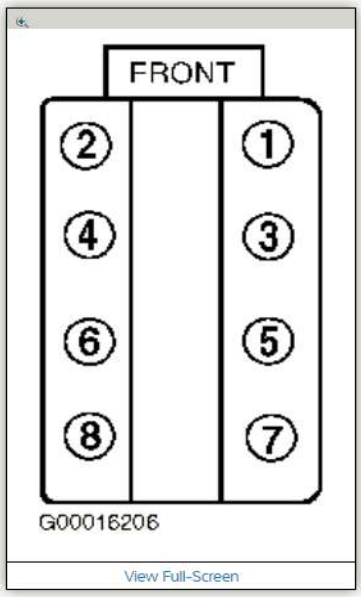
4.6 Liter DOHC V8

Variable Camshaft Timing on all Four Camshafts

The above mentioned vehicle, a 2006 Cadillac STS, came to the Training Center from another shop. The engine was running rough and needed to be diagnosed.

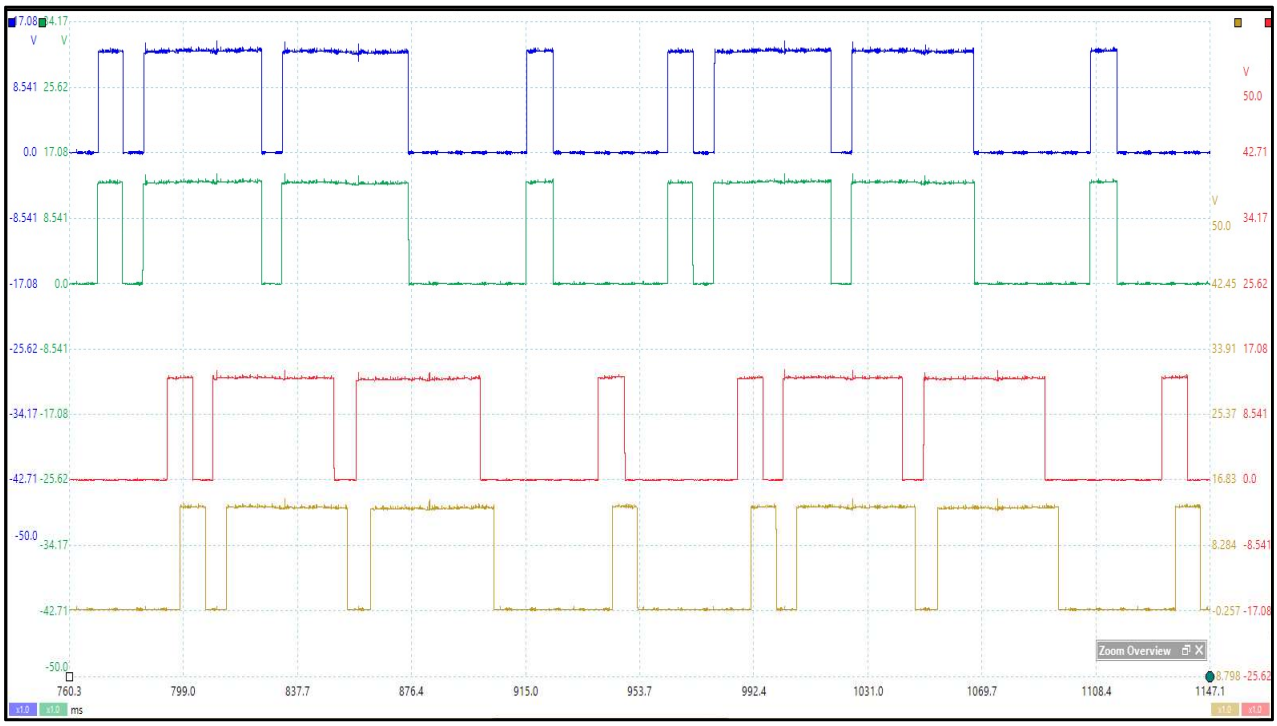
There were Diagnostic Trouble Codes stored in the ECM for the Variable Camshaft Timing on Bank 2

4.0L, 4.4L & 4.6L V8 Engines

Engine Configuration	Firing Order	
4.0L, 4.4L, 4.6L	1-2-7-3-4-5-6-8	
4.6 Liter V8, 4 Cam Variable Camshaft Timing	Codes in the ECM for Crankshaft – Camshaft Correlation, Bank 2.	

The 4.6 Liter V8 engine is equipped with Variable Camshaft Timing on all Four Overhead Camshafts. The system utilizes Four Camshaft Sensors, Four Oil Control Solenoids along with a Crankshaft Sensor.

Searching all available resources along with an internet search,
No Known Good Crankshaft / Camshaft Waveform were available.

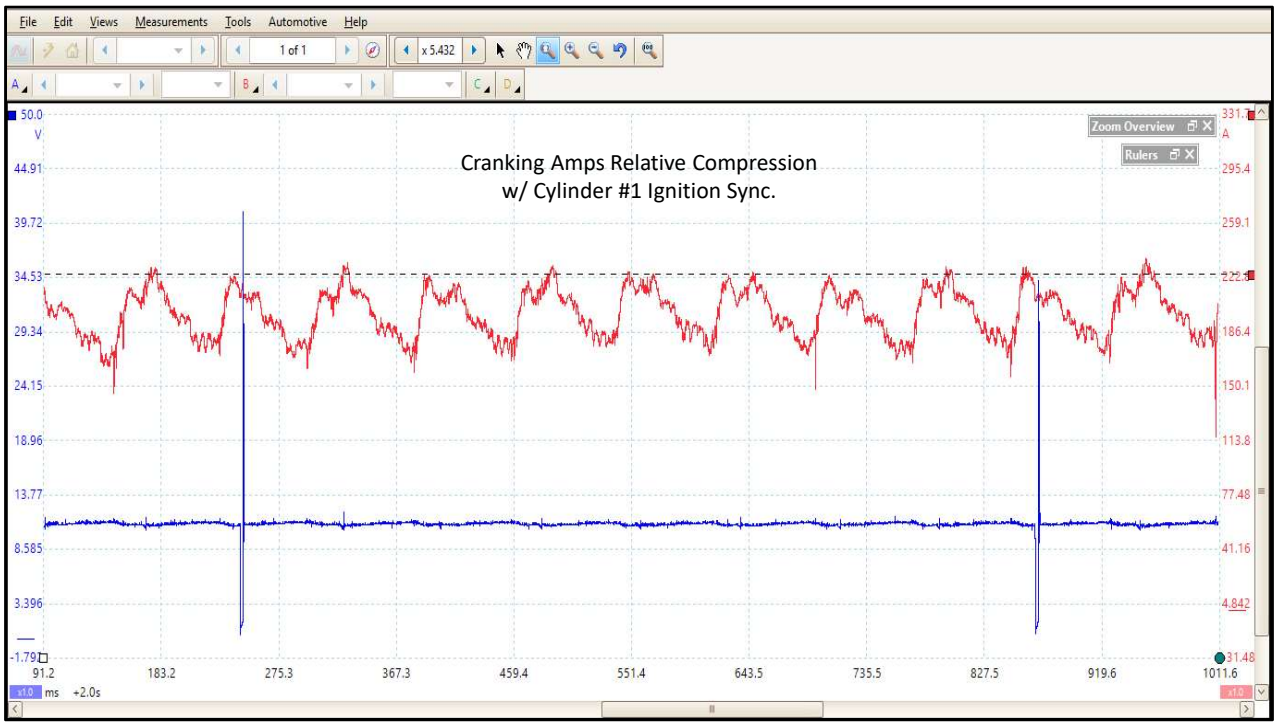


For reference purposes the above waveform was captured. The waveform is of Bank 1's Camshaft Sensors (the two upper traces) and Bank 2's Camshaft Sensors (the two lower traces).

Examining the relationships between the two upper traces from Bank 1,the two traces mirror one another. Comparing the two lower traces from Bank 2 you can see the Bank 2 traces do not line up (they do not mirror one another). There is a noticeable offset.

Is this enough diagnostic information to warrant "Engine Tear Down"

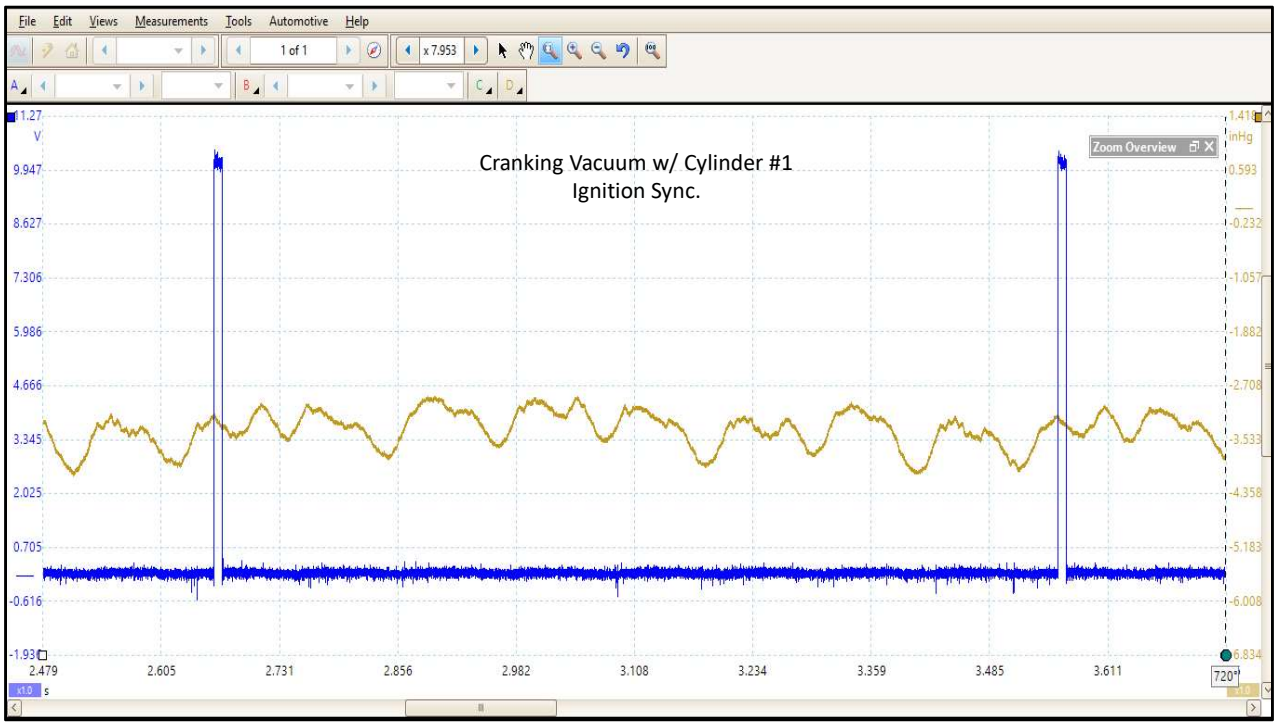
To remove the possibility of a Leaky Oil Control Solenoid, the Two Exhaust Camshaft Oil Control Solenoids were swapped between Banks 1 & 2 with no change to our waveform.



One of the tests recently talked about in past Technical Tips is the Cranking Amps Relative Compression Test. This test compares Current Demand drawn by the Engine's Starter Motor, as each Cylinder comes up on Top Dead Center Compression, during an "Extended Crank". This test is performed to evaluate the engines ability to create "Equal Compression" in each cylinder. The Blue Trace is the "Sync Signal" which in this case identifies Cylinder #1.

Evaluating the waveform above the Current Demand for each cylinder of the 4.6 Liter V8 is equal and thus Compression is Relatively Equal in all Cylinders.

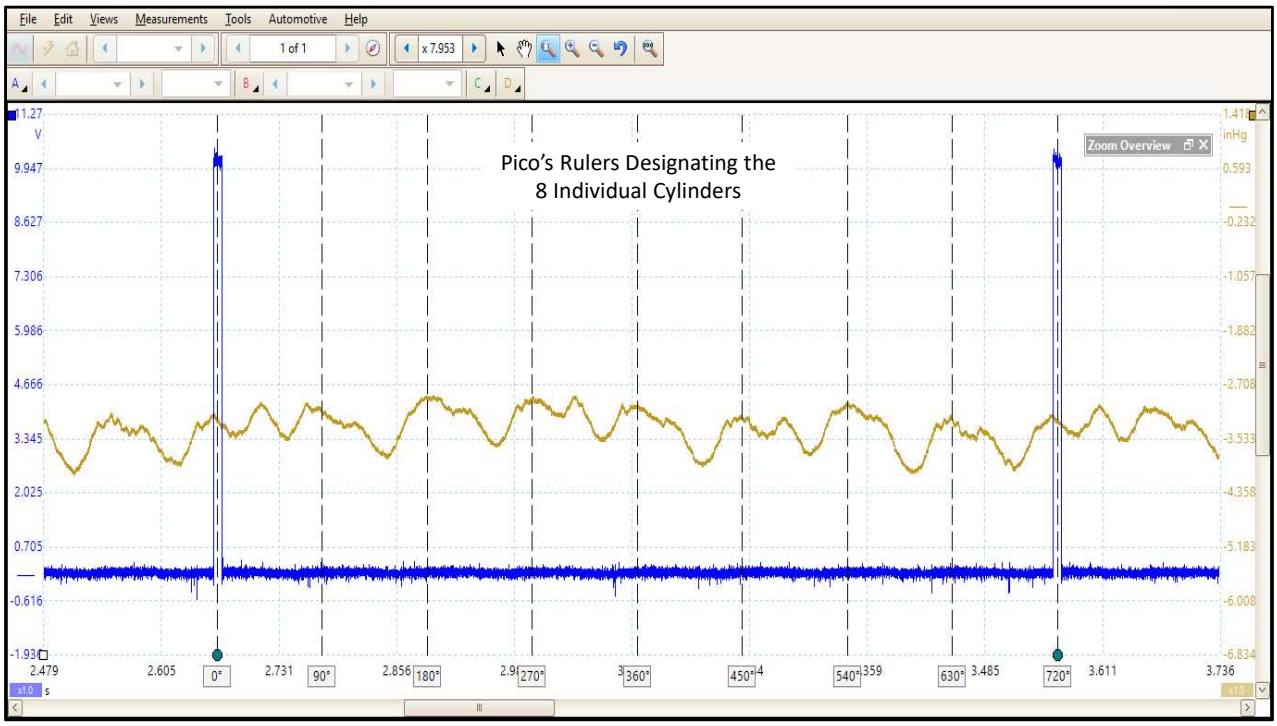
Does this test Confirm or Contradict the previous one shown?



The above waveform is a Cranking Vacuum Test using Pico's WPS 500 Transducer attached to the vacuum port for the Purge Solenoid.

What we are learning is because Variable Camshaft Timing is now being utilized on both the Exhaust and Intake Camshafts on Dual Overhead Camshaft Engines, we can have Perfect Compression (Intake Camshaft Timing is Good) but Diminished / Weak Vacuum Pulls (Exhaust Camshaft Timing, is Not Good).

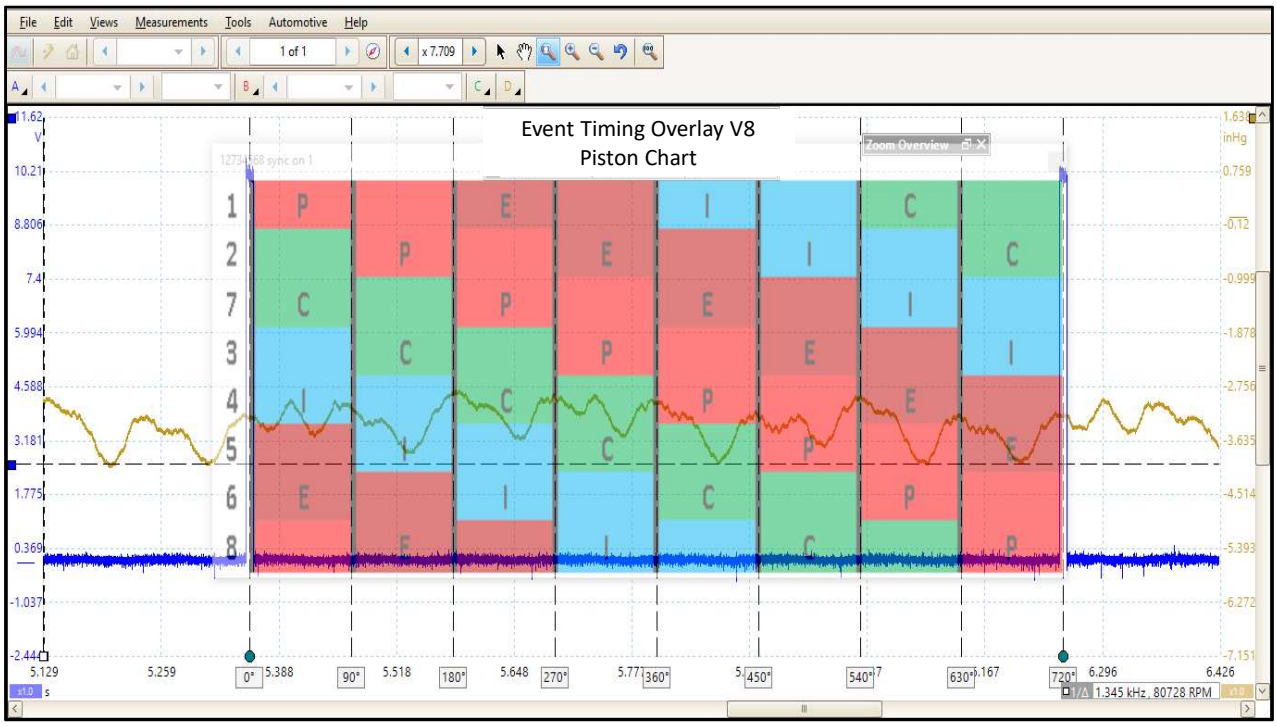
Remember in order to create "Pressure" the piston has to have something to "Push Against", the Intake & Exhaust Valves Sealed.
In order to create "Vacuum" the piston has to have something to "Pull Against", Intake Valve Open, Exhaust Valve Sealed, Throttle Plate Closed.



Using Pico's Rulers the Vacuum Pulls from each cylinder can be segmented from one another. This technique along with the "Sync Signal" in Blue (Cylinder #1's ignition) allows for cylinder identification according to the Engine's Firing Order

Continuing from page 5: if during the Intake Stroke the Exhaust Valve doesn't "Seal Properly", vacuum will be diminished / weaker because the piston doesn't have something to "Pull Against".

With the Exhaust Valve still "Open" during the Intake Stroke the piston isn't pulling against the Throttle Plate creating Vacuum. The piston is actually pulling exhaust fumes into the combustion chamber which is represented above as "Diminished / Weaker Vacuum Pulls".

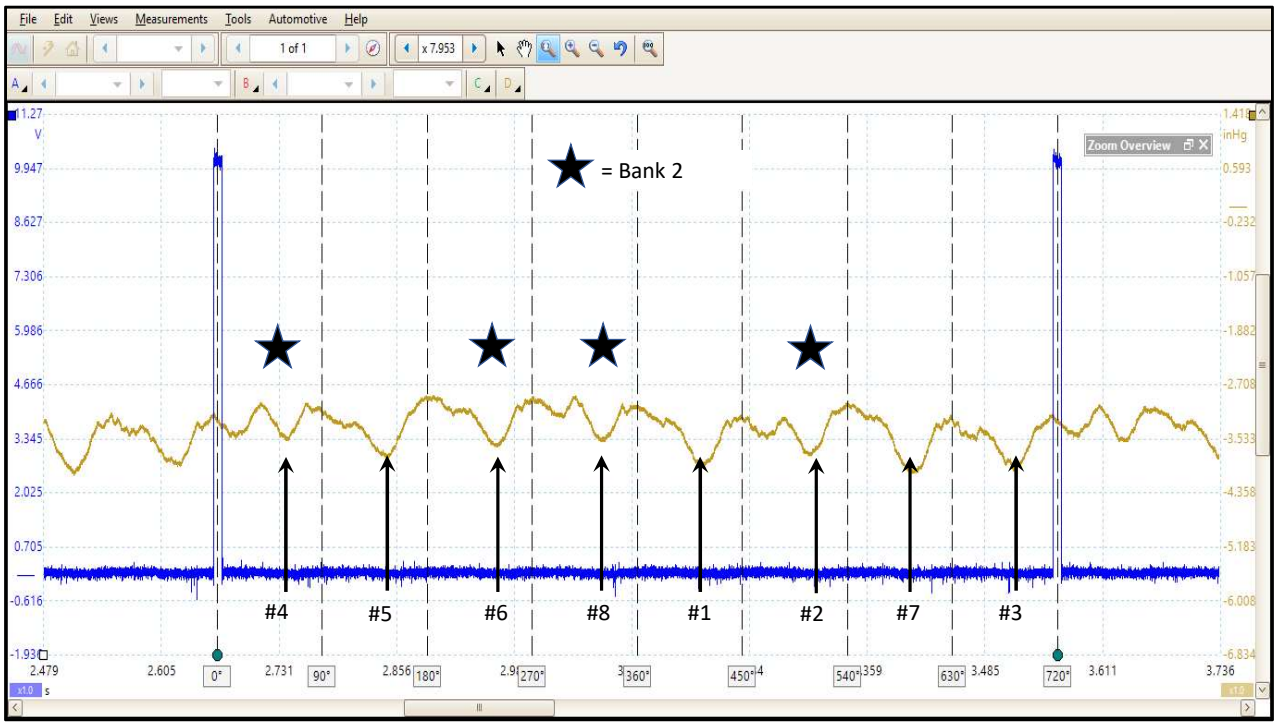


In this example a Piston Chart has been overlaid atop the Cranking Vacuum Waveform. Piston Charts show the position / stroke of each cylinder's piston in relationship to the others.

Using the Sync Signal as a starting point Cylinder #1 starts it Power Stroke, at the same time Cylinder #4 starts its Intake Stroke. Next Cylinder #2 starts it Power Stroke and Cylinder #5 starts its Intake Stroke and so on

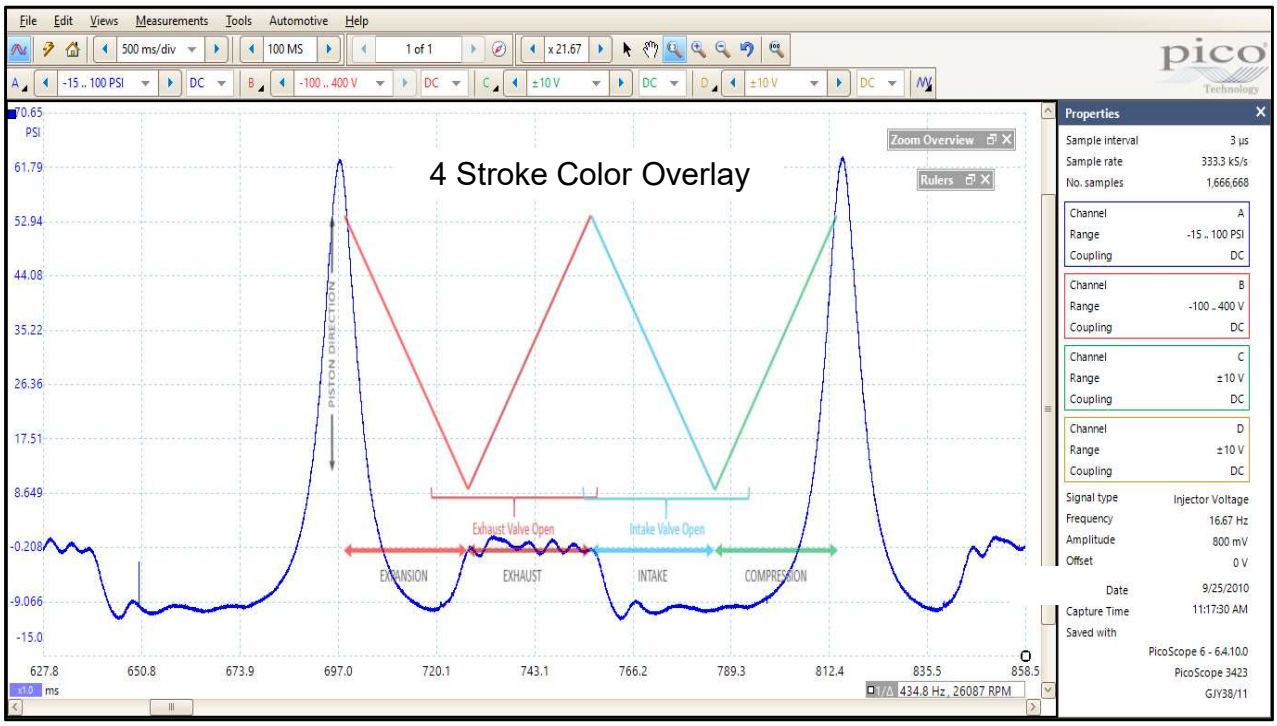
Using this Piston Chart clearly shows Cylinders 4, 6, 8 and 2 all have diminished / weaker vacuum pulls as compared to Cylinders 5, 1, 7 & 3.

Going back to page #2 the image shows all even numbered cylinders are on Bank 2 while all odd numbered cylinders are on Bank 1



The piston chart has been removed and the cylinders have been labeled. Stars have been put atop the cylinders with diminished / weaker vacuum pulls.

Now do we have enough ammunition to recommend engine tear down? This issue on Bank 2 is either caused by a frozen variable camshaft phaser or a jumped timing chain.

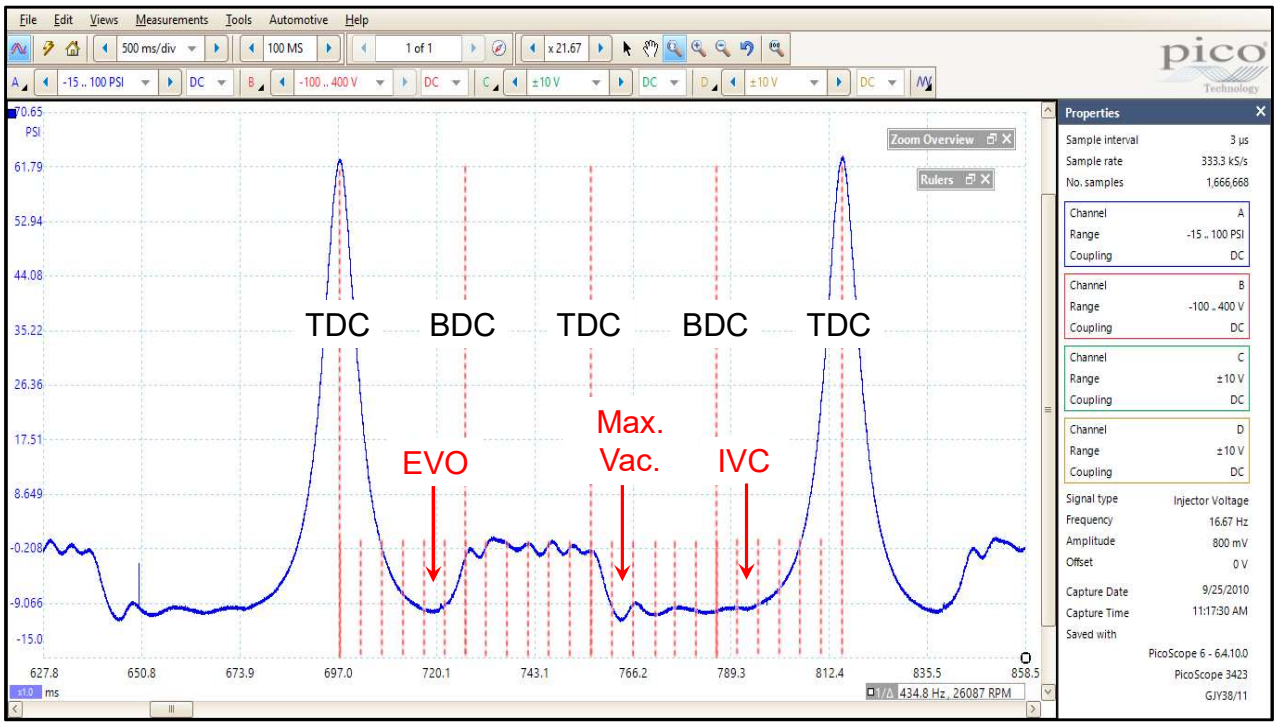


Before we get into the diagnosis of the Cadillac let's review In-Cylinder Pressure Transducer Testing. Using a in-cylinder pressure transducer and a lab scope a digital image is traced over time which represents the "Volume of Air" moving inside a particular cylinder's combustion chamber. In the image above an overlay has been added to help illustrate what the In-Cylinder Pressure Trace is displaying. The "Peak" on the left side of the screen shot above represents Top Dead Center Compression. The "Peak" on the right side of the screen shot again represents Top Dead Center Compression (720 degrees of Crankshaft Rotation later).

Moving from left to right the In Cylinder Pressure Trace shows the changes in pressure as the cylinder goes through:

The Expansion Stroke
The Exhaust Stroke
The Intake Stroke
The Compression Stroke

Each piston stroke is 180 degrees of crankshaft rotation in duration. 4 strokes of 180 degrees each equals 720 degrees total.
(4 x 180 = 720 degrees total)



Another popular overlay is the 30 Degree Overlay, this overlay breaks up each 180 degree area into 30 degree smaller increments. It is used to accurately measure Valve Opening and Closing Points in relationship to Crankshaft / Piston Position.

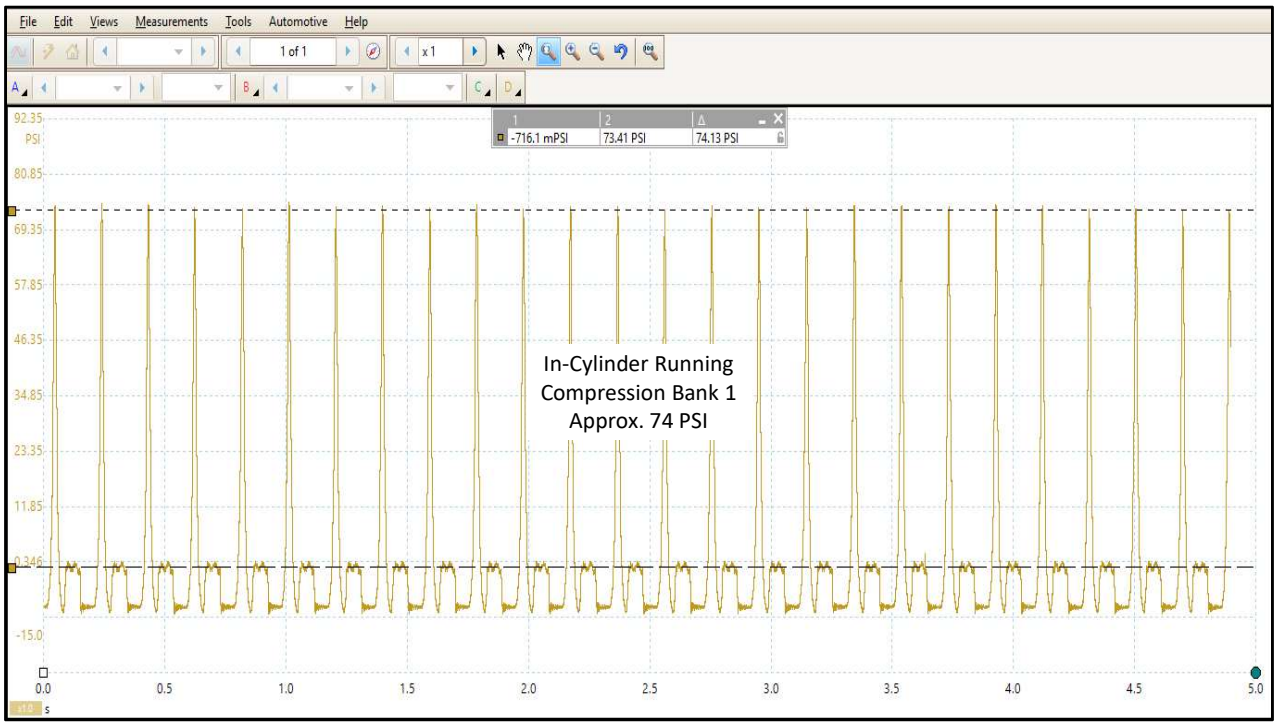
In the image above:

The Exhaust Valve Opens at approx. 45 Crankshaft Degrees Before Bottom Dead Center (EVO)

Maximum Vacuum happens at approx. 45 Crankshaft Degrees After Top Dead Center (Max Vac.)

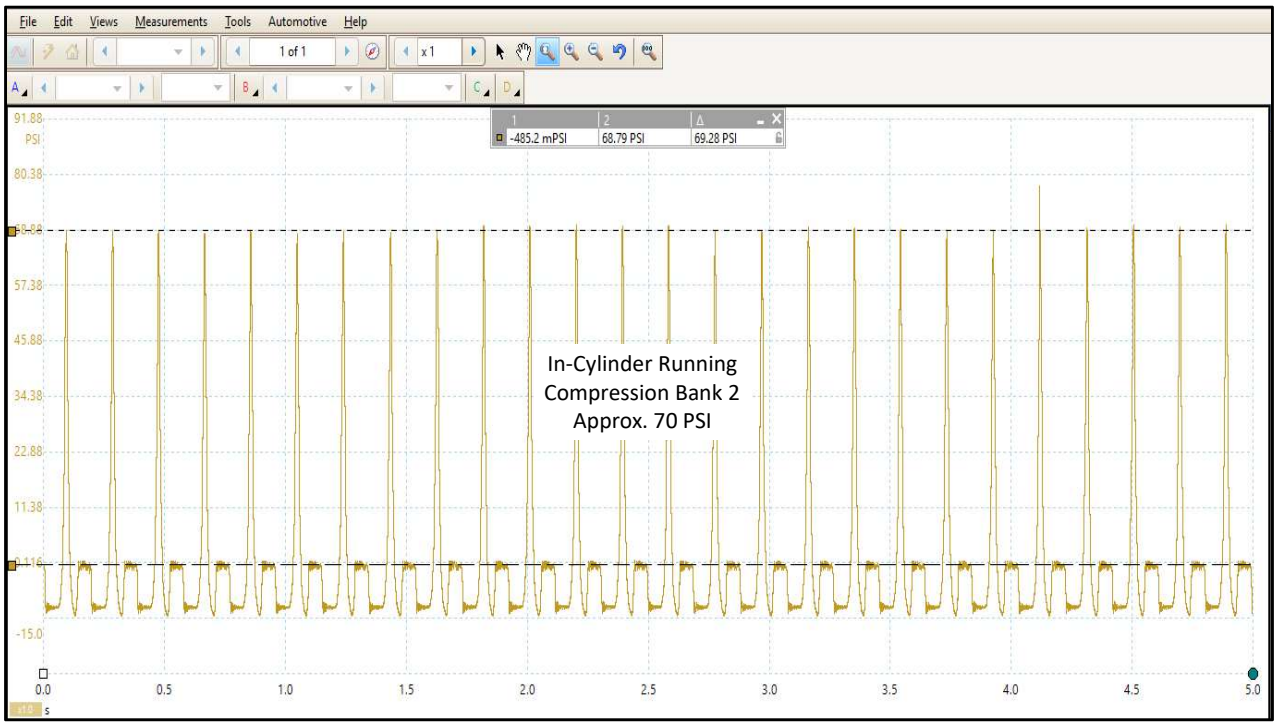
The Intake Valve Closes at approx. 45 Crankshaft Degrees After Bottom Dead Center (IVC)

Understanding this “Known Good Waveform” will help you better understand the waveforms on the following pages.

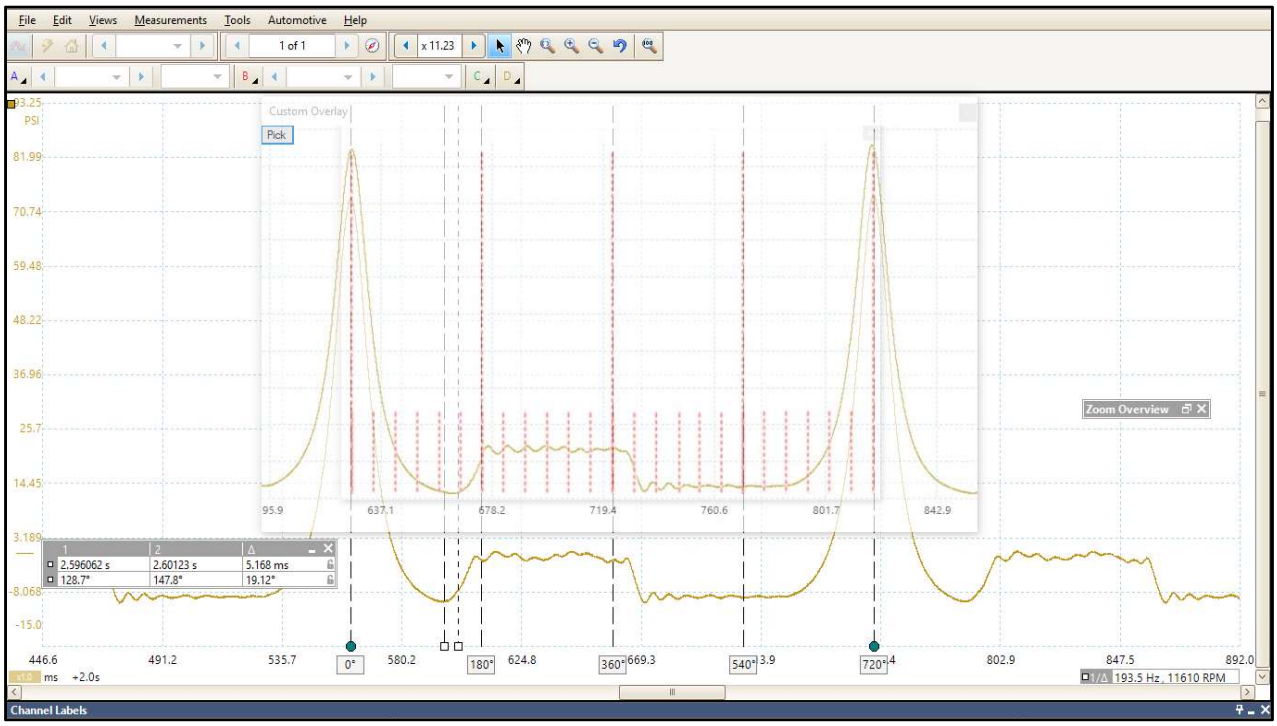


In-Cylinder Pressure Transducer Testing was performed on both Bank 1 & Bank 2. Above is the waveform from Bank 1, running compression at idle was approx. 74 psi.

Testing Cylinder #1, all of the “Compression Peaks” are even this shows Cylinder #1’s ability to create the same compression with every compression stroke.



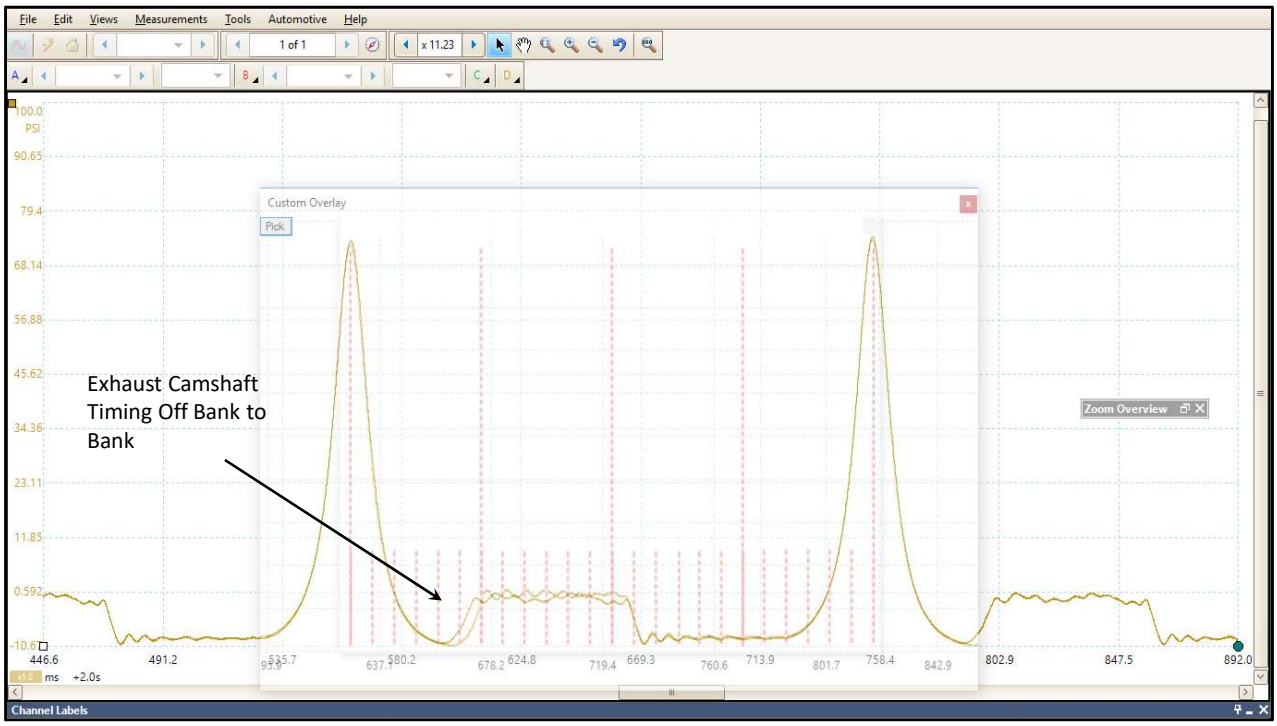
Performing In-Cylinder Pressure Transducer Testing on Bank 2, Cylinder 2 shows approx. 70 psi of running compression at idle. Although the compression is slightly lower than Bank 1 if there were no drivability issues with this vehicle this slight difference could of got overlooked.



The final waveforms are “Zoomed In” pictures of Bank 2 overlaid atop Bank 1. Focusing on the “Exhaust Turn” on the left side of the two traces there is a measurable difference confirming the Bank 2 Camshaft Timing is “Out of Time” as compared to Bank 1.

The total diagnosis on this vehicle took approx. one hour, with an additional 1/2 hour of research time.

The ability to diagnose drivability problems like this using these techniques is going to become more common as time goes by. Variable Camshaft Timing is being widely used by today’s world automakers.



Thank you for taking the time to read this article,

T = Together
E = Everyone
A = Achieves
M = More

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