Presents

Engine and Emissions Driveability Diagnostics
Part 3

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Your Instructor For This Class

"G" Jerry Truglia

- **National Trainer, ASE World Class, Master: Auto, Truck, School Bus, L1, L3, CNG and…**
- **ATTP Master Instructor, New York State, CT and New Jersey**
- **STS (Service Technician Society) 2003 President**
- **TST (Technicians Service Training) Founder and President**
- **Author / Co Author/ Technical adviser on 25 plus books including OBD II and Mode 6, and Understanding and Diagnosing Hybrid Vehicles**
- **Published articles for multiple newsletters, and magazines**
- **Picked as one of the Top Instructors in the country by EPA & SAE**
- **Numerous Radio, TV, Internet, and SAE Video appearances**
- **PTEN, MotorAge and TST Webcast Instructor**
- **Motor Magazine Top 20 award winner**
- **Provider of OBD II Training for 13 states, Ontario Canada and the US EPA**
- **Guest speaker at SAE Congress, IM Solutions and Clean Air Conference**

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Pressure Transducer Diagnostics

The newest tool to hit the market for the diagnosis of engine and driveability problems is the pressure transducer. They are sensors that translate mechanical movement (in the form of pressure) to electrical signals that can be seen as a waveform on a labscope.

All pressure transducers work the exact same, it does not matter whether you purchased them from Automotive Test Solutions, Snap-On, Pico or any other company. Here is *the* key principle of pressure transducers: they reflect mechanical movements in the engine.

A pressure transducer is no different than a pressure gauge—it merely lets us see the pressure as a waveform.

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Pressure Transducer Diagnostics

We are going to provide a good general overview of how to use pressure transducers and how to interpret them. The more you understand the exact mechanical movements of an engine, the more you will be able to anticipate what to measure and what the measurements mean.

Maybe not today and maybe not tomorrow; but when you get good at using pressure transducers, you will be able to visualize what you see in a waveform like it's an MRI of the engine.

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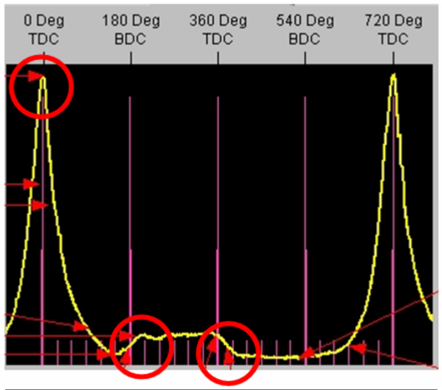
Overview of Pressure Transducer Theory



Read a pressure transducer waveform just like the following: At 0 degrees Top Dead Center the BANG or Power Stroke is occurring. The line is up high because the cylinder is at its most compressed when the spark event occurs. At 180 degrees Bottom Dead Center the exhaust valve opens as long as engine timing is correct.

The above waveform depicts the pressure in a cylinder of a 4 stroke engine through 720 degrees of rotation.

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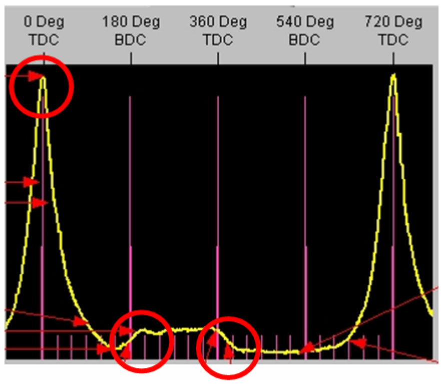
Overview of Pressure Transducer Theory



When at 360 degrees TDC the piston begins going down and the cylinder decompresses (the SUCK) begins. At 540 degrees BDC the SUCK completes, and the SQUEEZE begins. At 720 degrees TDC the process repeats.

If the waveform shifts in either direction left or right, timing may be advanced (left) or retarded (right). Other irregularities reflect that the engine is not sucking, squeezing, banging, or blowing correctly.

The above waveform depicts the pressure in a cylinder of a 4 stroke engine through 720 degrees of rotation.

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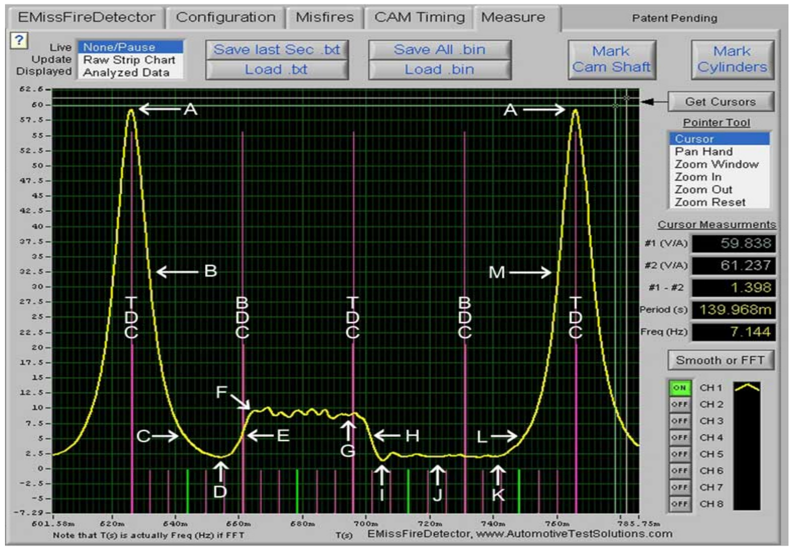
Overview of Pressure Transducer Theory

We are going to cover how to interpret a pressure transducer waveform using the adjacent figure. **Each letter represents a mechanical movement in the engine.**

This waveform was taken at idle with a transducer in the spark plug hole.



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Overview of Pressure Transducer Theory

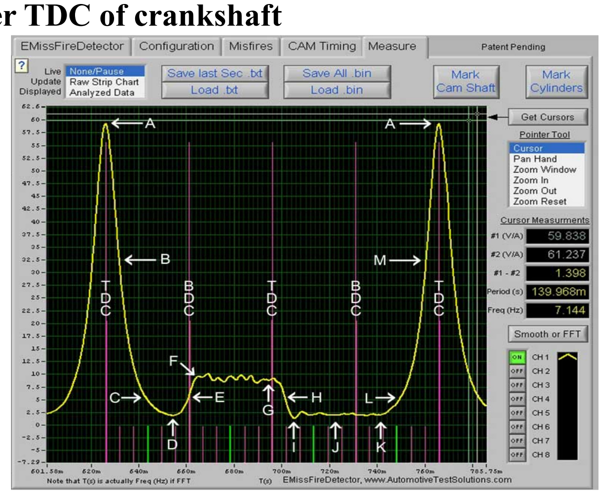
A – Top Dead Center (Piston is at closest point to cylinder head)

B – Piston should be about 30 degrees after TDC of crankshaft rotation.

C – Piston is now halfway towards BDC and begins its slowdown to that point.

D – *Exhaust valve* opens just before BDC is reached. The added exhaust increases pressure.

E – Bottom Dead Center is reached somewhere in the middle of the "exhaust ramp," which is the time it takes for cylinder pressure to equal exhaust pressure. Otherwise, timing is off.



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Overview of Pressure Transducer Theory

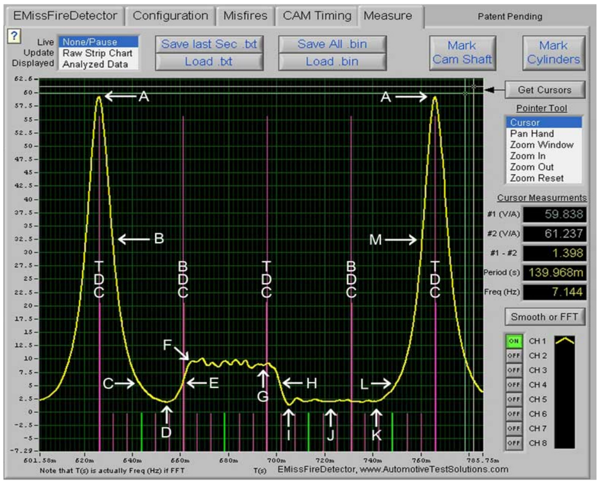
F – At this point exhaust pressure equals cylinder pressure.

G – *Intake valve* opens at Top Dead Center, seen as a pressure drop.

H – This is the center of the "intake ramp," 20 degrees from TDC.

I – *Exhaust valve* closes, seen as a
& return to the lowest possible
J pressure like on point D.

K – *Intake valve closes* causing a pressure rise as piston returns to TDC.



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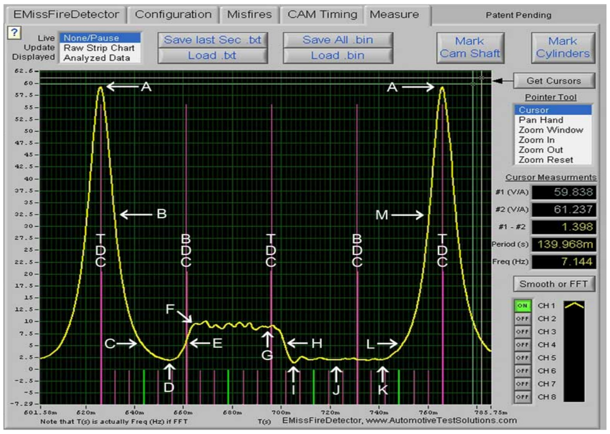
Overview of Pressure Transducer Theory

Honda VTec - Unlike the waveform to the right, the center of the "intake ramp" should be about 30 degrees from TDC. This is about ten degrees more than on regular engines (to the right).

On VVTs, intake pressure at point J should falls as low as exhaust pressure at point D.



If you are not familiar with VVT systems read the information on the Honda VTec system.

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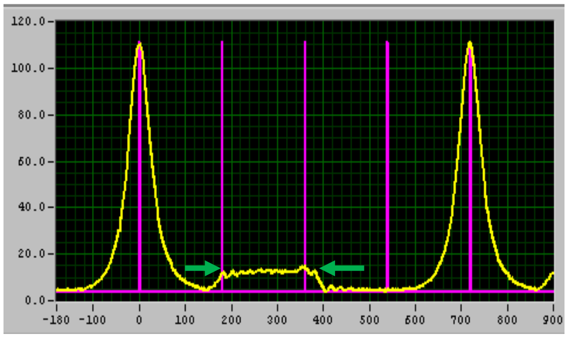
Overview of Pressure Transducer Theory



To the left is a waveform on a VVT engine. On VVTs timing issues are harder to pin point, because the vehicle is readjusting its own timing.

In working variable valve timing systems, adding power or ground to the variable valve timing solenoid/camshaft variable actuator or using a scan tools bi-directional control will force changes in timing. (Between the arrows the humps should move to the left or right by adding power or ground.)

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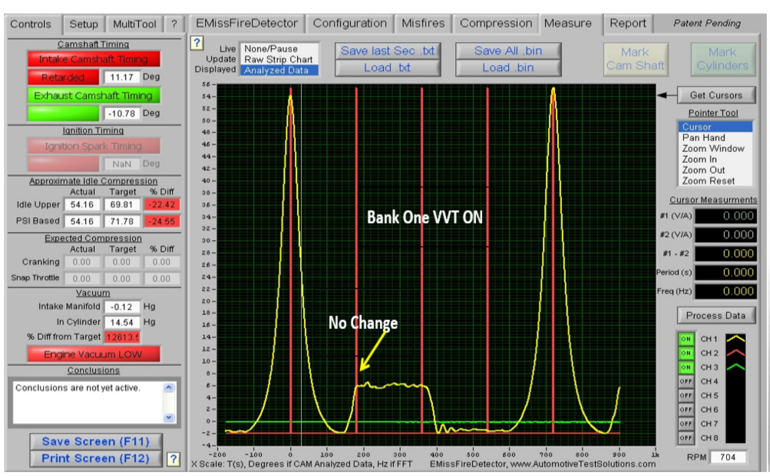
Pressure Transducer Theory in Detail



The above waveform is a bad VVT. **On this vehicle using bi-directional control with a scan tool or adding power and ground made no changes in timing.**

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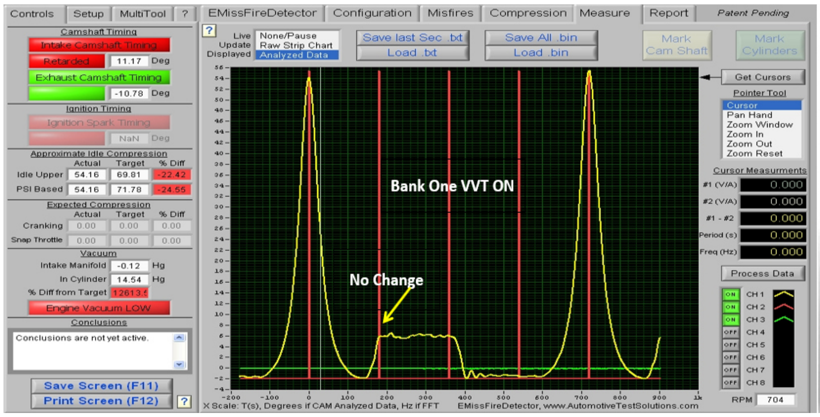
Pressure Transducer Theory in Detail



Note: Make sure to check the oil level as well as using the specified engine oil.

The exhaust ramp was borderline passable while the intake ramp occurred a bit over 11 degrees retarded. The solenoid or the Cam gear itself is the only possible parts at fault when jumping the solenoid shows no results.

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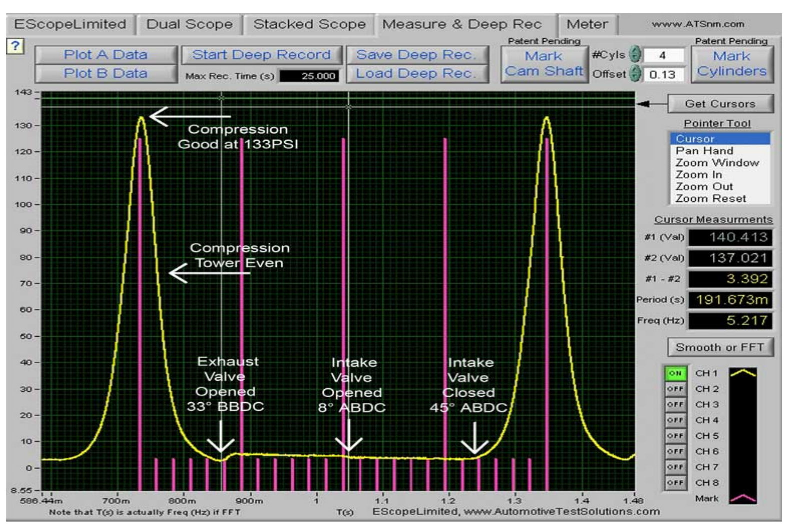
Pressure Transducer Waveform Exhaust Plateau In-Depth

The exhaust plateau is created by vacuum in the intake manifold, so it changes with intake vacuum. That's why cranking compression will have no exhaust plateau: intake vacuum is somewhere between 1 and 3 inches of mercury, barely enough to register on a waveform.



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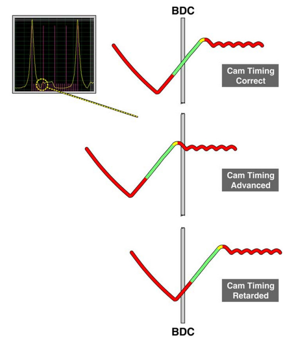
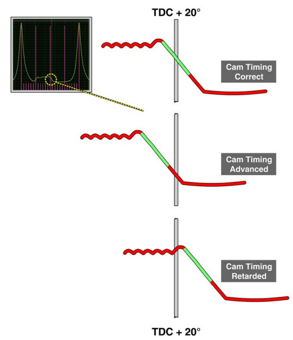
Room for Deviation on Waveforms

- The center of the **exhaust ramp can deviate -10 to +15 degrees BDC.** Any more or less means the timing is off. **Sports cars can go as far as +20 degrees and be acceptable, but the bottom of the ramp.** Anywhere in the light colored part of the line to the right is fine.



- **The intake ramp can deviate -10 to +10 degrees from TDC + 20 degrees.**

- **On VVT engines the intake ramp should be at TDC + 30 degrees, with a room for error -10 to +10 degrees.**



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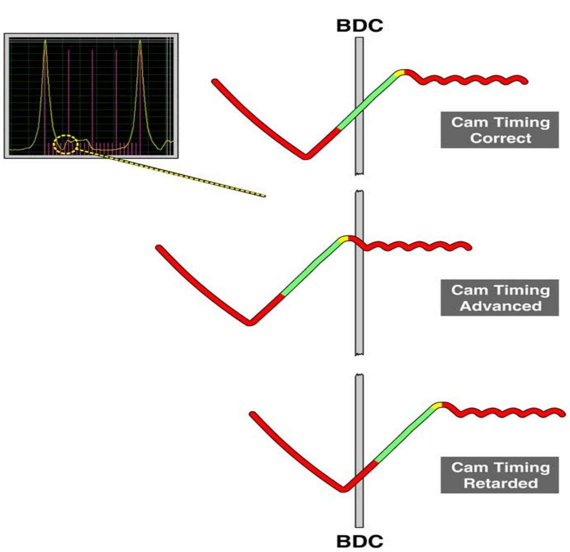
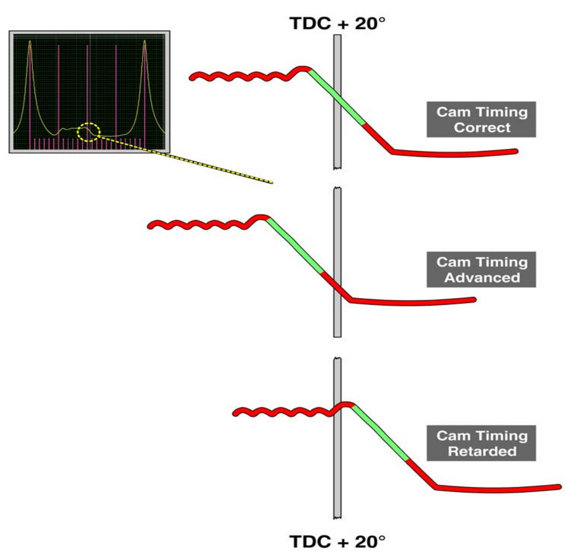
Room for Deviation on Waveforms





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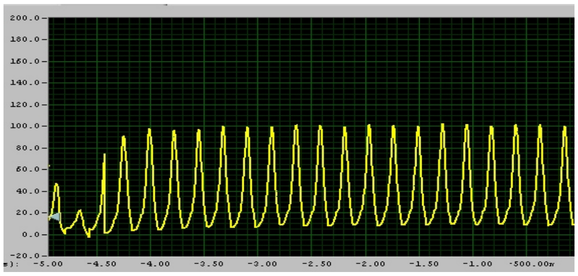
Case Study: 2004 Mazda RX 8 1.3L Drivability Issue

The following is about a 2004 RX8 that was very rough at idle. It had proper fuel delivery and spark, so the issue had to be engine mechanical. The Mazda RX8 has a rotary engine and is thereby harder to diagnose using conventional means.

Cranking compression using a Pressure Transduce was used to capture the following waveforms.



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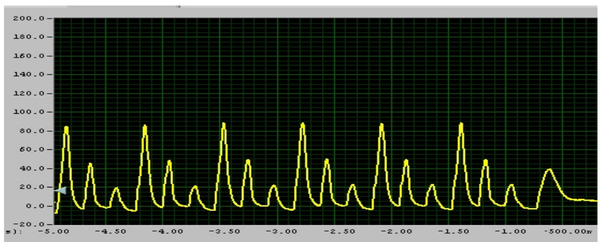
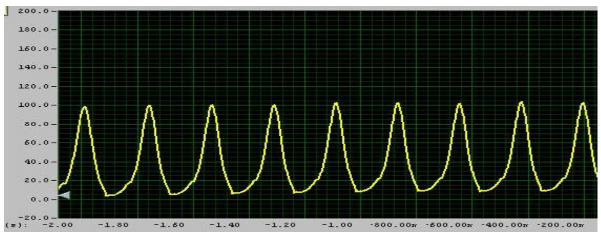
Case Study: 2004 Mazda RX 8 1.3L Drivability Issue

Rear Trailing Chamber Compression Low & Abnormal Specifications 96.8 to 120 PSI



Rear Trailing Chamber Compression Low & Abnormal Specifications 96.8 to 120 PSI



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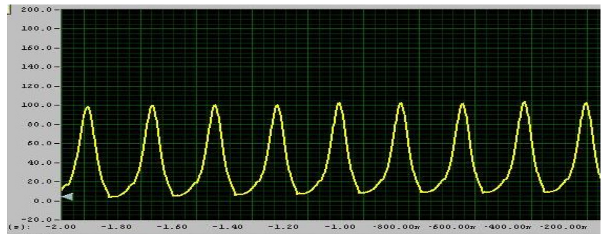
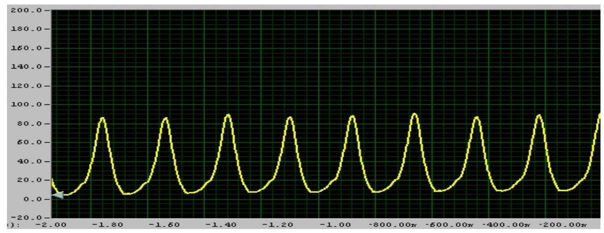
Case Study: 2004 Mazda RX 8 1.3L Drivability Issue

After a fuel system cleaning.
Front Chamber (100 PSI-Good)



Rear Trailing Chamber
(95 PSI-Marginal)



The fuel system cleaning had it running smooth again.

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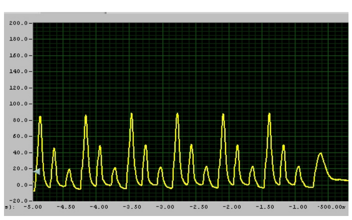
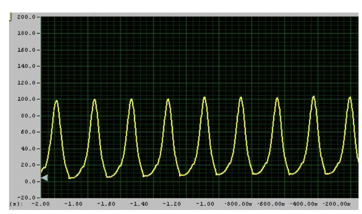
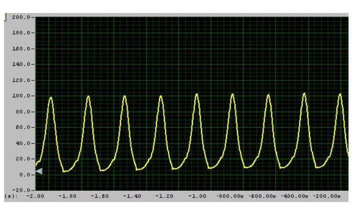
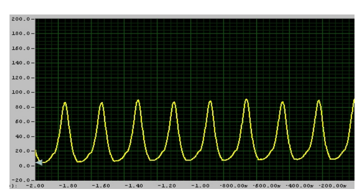
Case Study: 2004 Mazda RX 8 1.3L Drivability Issue









Note: Carbon build up in the Wankel motor is a common problem. To remove the carbon try performing a decarb service.

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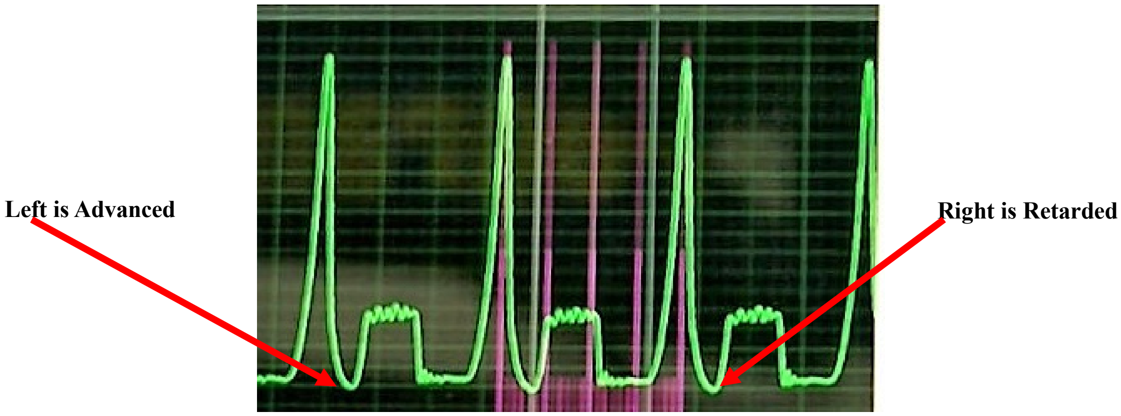
Pressure Transducer Tips



If towers lean or the exhaust pocket is lower than the intake pocket there can be a cam timing issue. **Exhaust pockets can be up to 2 psi higher than intake pockets never lower or it indicates a cam timing problem**

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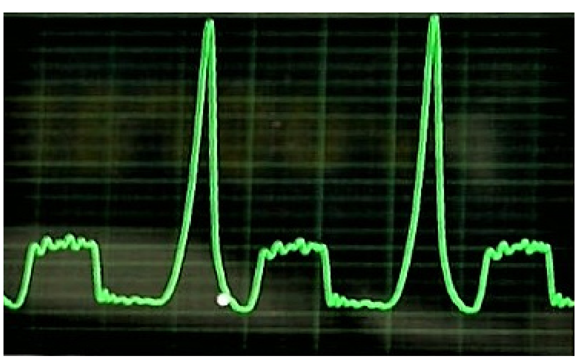
Pressure Transducer Tips



Look at the exhaust pocket edge for cuts or bumps that indicates an exhaust valve leak

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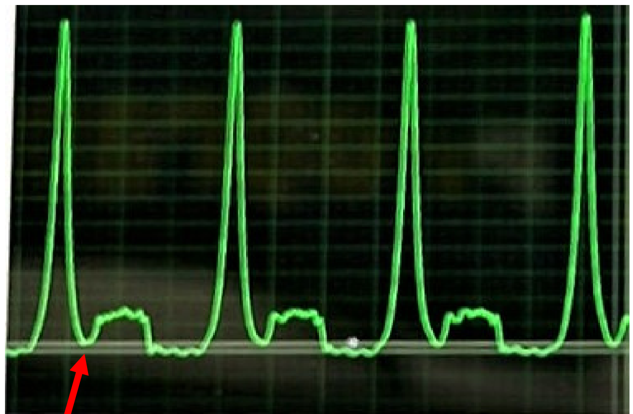
Pressure Transducer Tips



If the first exhaust pocket is lower than the second or third pocket reading there is an exhaust valve problem

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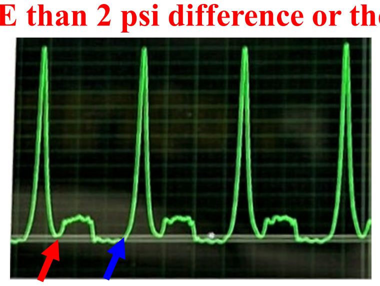
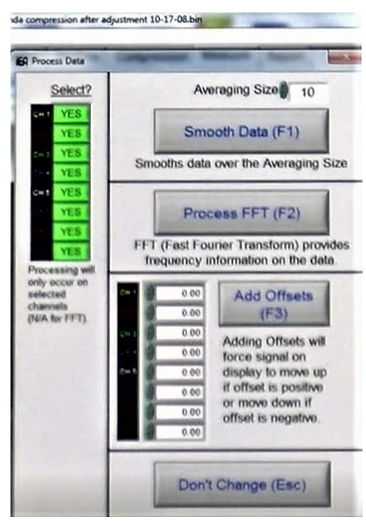
Pressure Transducer Tips

Always Smooth Data on all pressure waveforms

If you saved a waveform on another channel other than channel 1 you can change it to channel 1 when reviewing.

Measure from the bottom of the intake pocket to the exhaust pocket NO MORE than 2 psi difference or there is exhaust valve leak.





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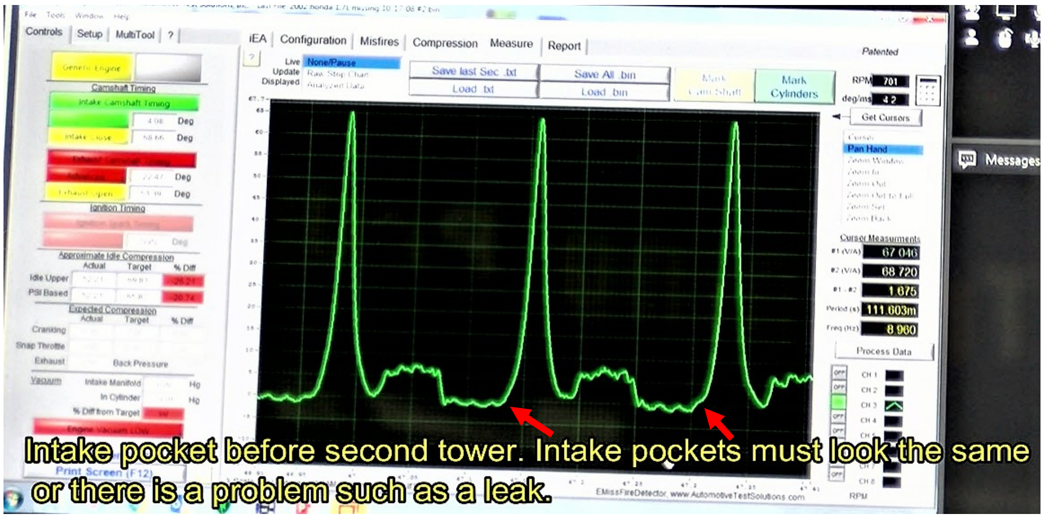
Pressure Transducer Tips



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Pressure Transducer Tips

Waveform to the Left from a Honda that had a valve pocket issue. **Waveform to the Right after valve adjustment.**

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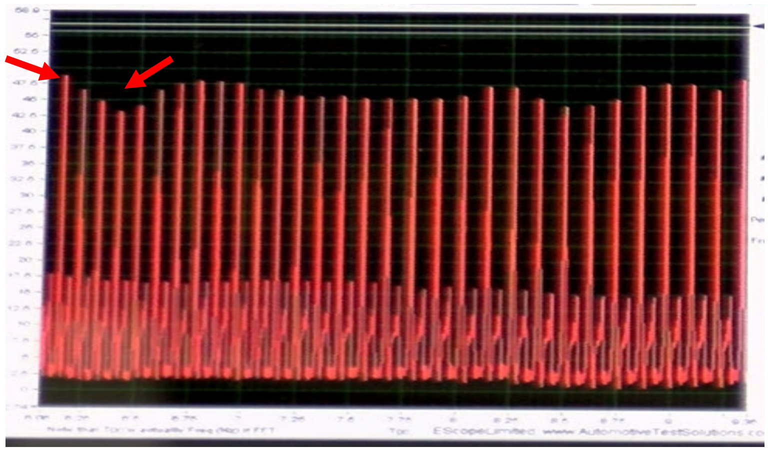
Pressure Transducer Tips



Waveform's that have High's and Low's indicate a valve problem –
Check at idle and higher rpms

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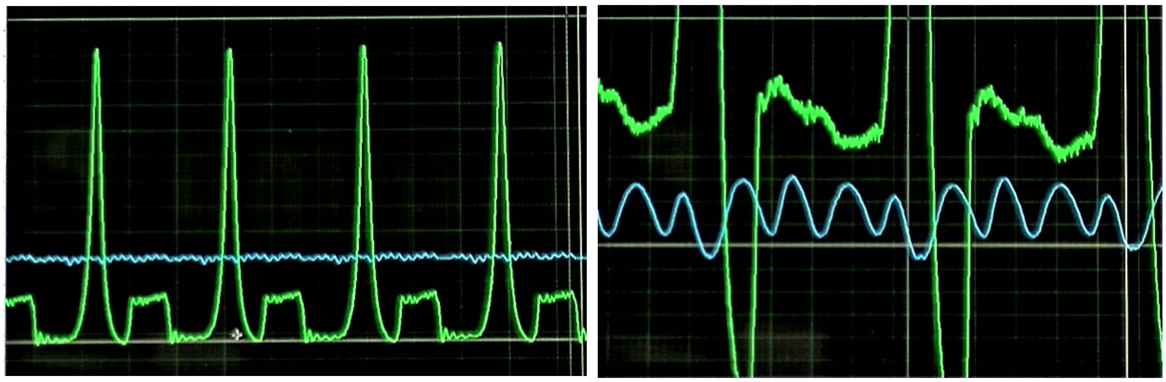
Pressure Transducer Tips



Vacuum and Pressure Waveform Normal and Blown Up
Always Use A Vacuum Waveform With A Pressure Waveform

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Using Emissions Analysis to Diagnose Vehicles

Gas	Engine Condition
CO_2	measure of combustion efficiency
CO	rich mixture, too much fuel, not enough air
O_2	lean mixture, too much air, not enough fuel
NO_x	high combustion temperatures, high engine load
HC	unburned fuel, leaking fuel or vapors

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Using Emissions Analysis to Diagnose Vehicles

Good Readings at Idle

HC < 100 PPM

CO < 0.3%

CO2 > 14.5%

O2 = < 0.5%

Lambda 0.97 to 1.03

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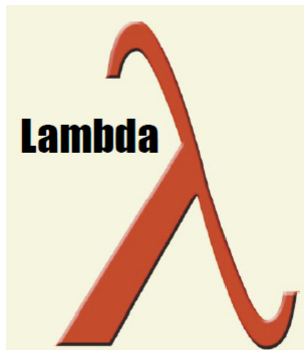
What is Lambda?

Simply said, lambda is the air-fuel measurement. Perfect lambda is 1.0, which equals 14.7 parts of air per part of fuel. Lambda below 1 indicates the engine is rich and lambda above 1 indicates the engine is lean.



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Engine Exhaust Color

Black smoke = Rich condition

Blue smoke = Oil burning

White smoke = coolant burning

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Thank You !

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