Essential Scope Techniques

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Performing a traditional compression test can be time consuming, and costly to the customer. Using techniques like this one can, at a minimum, identify weak performing cylinders and justify the need for more labor intensive testing.

Be sure to disable the fuel system to prevent fuel from washing down the cylinder walls.

Pattern notes:

- Look for peaks that are lower than the others. Most modern scopes can detect as little as a 10% loss between cylinders.
- Triggering off of an ignition source (primary or secondary) allows you to do two things. One, you can use firing order to determine which cylinder any low peaks are associate with and two, you can check timing by looking for the firing line to pass near the center of its associated peak.
- If valve timing is off, the pattern will look normal but the amplitude of the individual peaks will be less. Valve timing lowers compression equally across all cylinders that share the out of time cam. Keep that in mind when dealing with multiple cam engines!
Engine Mechanical: Relative compression (known bad)
Engine Mechanical: Relative compression at exhaust

Remember the “dollar bill” trick for testing an engine with a suspect exhaust valve? The dollar bill would be sucked into the tailpipe every time that cylinder hit its exhaust stroke. The FirstLook pressure sensor allows the user to “see” those pressure pulses as they happen.

Pattern notes:

- The number of cylinders and exhaust layout will affect the actual shape of this pattern. Don’t focus on the minor variations. Instead look for the “odd man out”. Focus on the forest, not the trees!
- Identification of the weak cylinder can still be done with the ignition trigger, but you have to adjust for the timing. Remember, you’re looking at the exhaust stroke, not the compression stroke, on this waveform.
Additional notes:
Checking crankcase pressure to isolate compression loss

One great advantage of using a pressure sensor instead of traditional testing is the speed at which you can quickly isolate the cause of the problem. If your starter current test or tailpipe test indicates a weak cylinder, move the sensor to the oil dipstick tube and run the test again.

Pattern notes:

- This test measures crankcase pressure fluctuation. As the pistons move up and down, they create changes in pressure. If a piston’s rings are not sealing, it will show up here. A stable pattern indicates the loss of compression has to be coming from the top end!
Engine mechanical: Intake manifold vacuum with a pressure transducer

Both pressure sensors and pressure transducers can be used to test intake manifold vacuum. Transducers measure the actual pressure relative to zero, while sensors react to pressure change only.

Look at the fluctuations by cylinder and remember what stroke you’re on! This one, using an injector as a reference, can make determining the cylinder you’re looking for a little more challenging.

Next, imagine what a traditional manifold vacuum gauge would be doing as these pressure changes were occurring. (I’ve included a reference for your use in this handout).

Is this a good pattern? Why or why not?

What does the pressure reading equate to? Why?
Gauge needle steady, reading normal

This is a normal reading for most engines. Some engine designs may read slightly lower. A quick snap to wide open with the throttle plate should cause vacuum to drop to approx. 5”/Hg with a rapid rebound above normal before returning to normal readings.

Gauge needle steady, reading lower than normal

This reading can indicate late ignition timing or a cam that is out of time. It can also indicate an engine that is low on compression on all cylinders or a vacuum leak.
Gauge needle vibrates excessively at all rpm. **Reading lower than normal.**

Look for signs of a leaking head gasket. The needle will bounce each time pressure is lost through the leak.

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Gauge needle fluctuates or drops 1” to 2”, average reading normal

Suspect a possible cylinder misfire with this reading. Test ignition system first. **If gauge swing is more prevalent (3” to 4”/Hg), sticking or burnt intake valves are a possibility.**
Gauge needle intermittently fluctuates, drops 1” to 2”, average reading normal

An intermittent misfire or sticking valve can cause this type of reading.

Gauge needle normal at idle, but fluctuates at higher rpm

Sticking valves or weak valve springs could be the culprit here.
Gauge needle vibrates excessively at idle, smooths out at higher rpm.

Worn valve guides are a likely suspect with this reading.
Which is correct? (Trigger on #2 injector, firing order 1-5-3-6-2-4)
Additional notes:
Engine mechanical: In-cylinder cranking compression

The use of an in-cylinder pressure transducer has lots of uses. It takes just as much time as the use of a traditional, mechanical compression gauge but it allows you to see so much more. Instead of simply reading a peak pressure, you can observe the pressure changes in the engine over the entire 720° of the four-stroke cycle.

Pattern notes:

- Cranking compression pressures less than 90 psi is insufficient to support combustion.
- For most engines, a line drawn through the peak will split the pattern into symmetrical halves. If not, and the pattern is accompanied by a deeper than normal exhaust pocket, there is a leak.

There are software applications that can make rotational degree highlighting quick and easy. If you don't have one, you can use Window's “Paint” program to mark them off yourself.

Simply paste the screen capture into “Paint” and place your marking cursor at the top of one peak, and then the other. At the bottom of the “Paint” window, you'll see a pixel coordinate like 100, 210. The first number is the horizontal element and the second is the vertical element. Note the first number, and then move your cursor to the second peak. Subtract the first from the second and you’ll get a total pixel spread for your capture. Divide by four to divide the space into 180° segments, by eight for 90°, and so on.
Using Windows “Paint” notes:

Known bad example
Additional notes:
Engine Mechanical: In-cylinder running pressure test

The running in-cylinder pressure test is a valuable diagnostic tool. Not only can you identify cylinder sealing issues and causes, you can use this method to test the operation of variable valve timing, verify cam and ignition timing, and catch intermittently sealing valves in the act.

Pattern notes:
(Use this section to write down what caught your attention about this dynamic testing method)

To learn more, read the series on In-Cylinder Pressure Testing authored by the man who developed the technique, Bernie Thompson. You can access all of Bernie's articles on Motor Age at:

https://www.searchautoparts.com/motorage/author/bernie-thompson
In-cylinder running pressure pattern elements

A: TDC of the compression stroke
   TDC line typically splits peak into symmetrical halves.

B: BDC of the power stroke
   Exhaust valve opens just before BDC. Look for BDC to intersect ramp in area marked by “G”.

C: TDC of the exhaust stroke
   The plateau between “B” and “C” is pressure in the exhaust manifold.

H: The intake valve opens while the exhaust is still open (overlap). Pressure drop is result of exhaust closing and cylinder exposed to intake manifold absolute pressure. Look for ramp to intersect in area marked by “H”.

D: BDC of the intake stroke.
   This pressure should be near identical to that in the exhaust pocket. Note line “F”.

E: Back to beginning of pattern at TDC compression.
Additional notes on in-cylinder running pressure pattern:
Additional notes:
Comparing known good synch relationships to the ones captured on a problem car is another way to check cam timing. Finding the known good patterns is easier than ever, with resources available from sites like iATN, Wavehook.com, Autonerdz, and others.

But that isn't the only value in these captures. Tie in injector and/or ignition events to see if there are any problems with ECM control of timing. Use the zoom features to check the circuits for voltage drop just as you would use your voltmeter.

Pattern notes:
Known bad

Created
Fuel system testing

Many pressure transducers allow you to monitor fluid pressures as well as air pressure. This opens up all new doors for troubleshooting systems like fuel delivery.

The use of fuel pump current patterns as a troubleshooting tool is an example of how inventive techs create diagnostic strategies and then share them with others. Now it is considered a standard drivability troubleshooting technique. Let's make sure you can take full advantage of them both.

Pattern notes:

- Current patterns can tell a tech a lot about the electrical and mechanical health of the fuel pump. Each peak is the current reading of one set of commutators, one winding in the pump motor, as it passes through the brushes. Low, deformed peaks indicate brush and commutator wear.
- Current can also tell us the speed of the pump. This knowledge, when backed by current draw, can point a tech in the direction of restricted fuel flow (clogged filters) or even empty gas tanks!
- Pressure sensors can allow a tech to perform an injector drop test in minutes, without the need for a scan tool, manual injector driver, or traditional fuel pressure gauge.
- Pressure transducers can do the same, but with the added advantage of providing an accurate pressure measurement and monitoring of that pressure over any time base our scope is capable of.
Fuel system testing: Fuel pump current

Fuel pump current pattern can tell you about the electrical and mechanical health of the fuel pump, and the ability of fuel to move through the system.

High pump speed and low current draw can indicate:

Low pump speed and high current draw can indicate:

Normal pump speed and low current draw can indicate:
Additional notes:
Fuel system testing: Fuel pressure with transducer

Using a pressure transducer in place of a traditional pressure gauge will not only allow you to measure pressure, but see the pressure drop across the injectors.
Fuel system testing: Fuel pressure using a pressure sensor

The FirstLook sensor used here is just like its tailpipe cousin. It reacts to pressure change, but does not measure actual pressure in the system.
Additional notes:
Fuel system testing: Fuel injector voltage and current

Injector patterns can help locate sticking injectors, or nail down intermittent issues.

**CAUTION:** Be sure to know the input voltage limits of your scope. Injector kickback can exceed the capacity of most scopes, requiring some form of attenuation.

Mark where the injector pintle opens in this capture.

Mark where the injector pintle closes in this capture.

Where would you measure commanded on time? Actual open time?
What is wrong with this capture?

This looks kind of messed up!

What about this one?
How could you catch an intermittent problem using injector current?

Is the calculation of resistance accurate?

What other system(s) do you think you can apply this to?
Ignition system: Secondary ignition patterns

Is this a normal pattern?

Firing voltage is affected by:

Spark voltage is affected by:

Why does the second current ramp not start at “0” amps?
Spark duration is affected by:

High spark kV with an upward sloping burn line can indicate:

Low spark kV with a downward sloping burn line can indicate:

A burn line that displays peaks and valleys may indicate:

Master ignition waveform analysis with the help of Jim Morton’s video!

https://youtu.be/yChGNQEMdE
Additional notes:
Ignition system: Primary ignition pattern

Modern ignition systems can make capturing a secondary ignition event difficult. The primary ignition pattern may be the alternative you need to capture the waveform.

*CAUTION: Primary voltage can exceed the maximum input voltage capability of most scopes. Capturing this pattern may require the use of some form of attenuation.*

What is the same about this pattern when compared to the secondary?

What is different?

Can this pattern be captured on all vehicles?
Current cut off

78,130 samples per second (one every 12.8 microseconds) allow you to zoom in with detail. Vertical resolution makes current slopes more accurate.
Battery-starting-charging system testing

How would you like to be able to perform a complete system test in less than 5 minutes?

Known bad
Battery-starting-charging system: Battery voltage

Open circuit voltage is:

In-rush voltage is:

Loaded voltage is:

Charging voltage is:
Battery-starting-charging system: Starter current

How is this trigger set?

What is the peak voltage? Why is it so high?

Can you identify on the pattern where the engine started running on its own?

What do the two peaks that occur after the initial spike mean?

What is considered an acceptable current reading after the vehicle has been running for 3-5 minutes? What does a higher than normal reading indicate?
Additional notes:
Back to the bad pattern

This is caused by:

Known good:
Resources:

AES
http://www.AESWave.com

Automotive Test Solutions
http://www.AutomotiveTestSolutions.com

Autonerdz
http://www.Autonerdz.com

International Automotive Technicians Network (iATN)
http://www.iATN.net

Pico (UK)
http://www.PicoAuto.com

Diagnostic Network
http://www.diag.net/