ATTS AUTOMOTIVE TECHNICIAN TRAINING SERVICES

Presents

Engine and Emissions Driveability Diagnostics
Part 1

© A.T.T.S. Inc. 2003 - 2020

1

Your Instructor For This Class

"G" Jerry Truglia

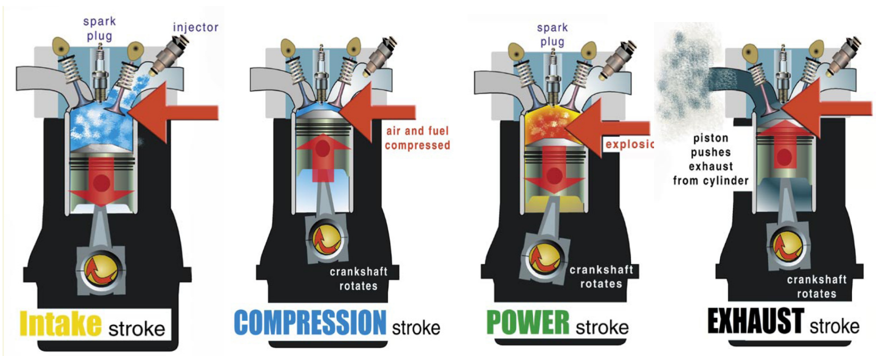
- **National Trainer, ASE World Class, Master: Auto, Truck, School Bus, L1, L3, CNG and…**
- **ATTP Master Instructor, New York State, CT and New Jersey**
- **STS (Service Technician Society) 2003 President**
- **TST (Technicians Service Training) Founder and President**
- **Author / Co Author/ Technical 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**

© A.T.T.S. Inc. 2003 - 2020

2

Engine and Emissions Need-to-Know Theory

All engines work in the same way. The intake stroke SUCKS in fuel and air, the compression stroke SQUEEZES the air/fuel (i.e. COMPRESS) and in diesel engines the compression is significant enough to actually ignite the fuel. Spark plugs offer the "BANG," the ignition necessary to explode the gasoline.

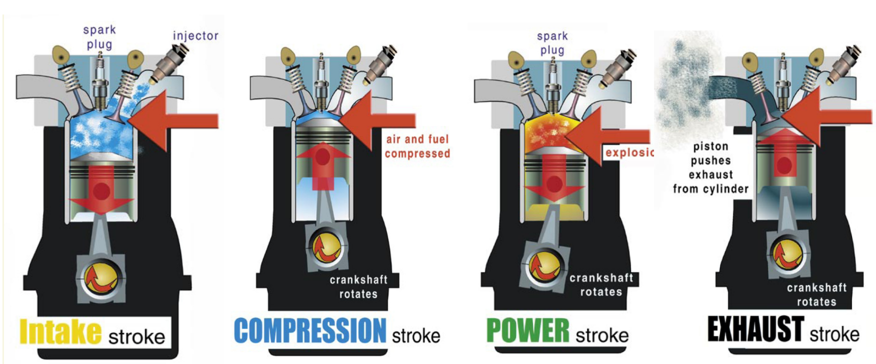


© A.T.T.S. Inc. 2003 - 2020

3

Engine and Emissions Need-to-Know Theory

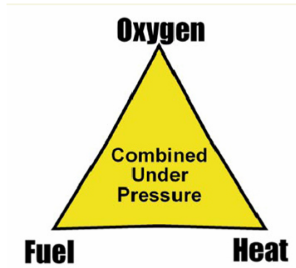
This is what powers the engine and allows the process to repeat. Subsequently, the explosion byproduct is BLOWN out of the cylinder and the force of the BANG starts up the SUCK process again. More in depth information will be covered in a bit.



© A.T.T.S. Inc. 2003 - 2020

4

Combustion Theory



- Fuel - The fuel used in most spark ignition engines is gasoline.
- Oxygen - To burn one gallon of gasoline, you'll need about 9,000 gallons of air. (Now you know why air filters get dirty so quickly!)
- Heat - The heat required to start the combustion process comes from a spark plug that ignites an atomized (sprayed in a fine mist), pressurized mixture of air and fuel. The ignition system must be capable of producing and delivering reliable sparks of 30, 40, or even 100 KV — that's 100,000 volts!

© A.T.T.S. Inc. 2003 - 2020

5

Oxygen

The oxygen needed for combustion comes from the air that surrounds us. An engine essentially is an air pump. A lot of air must be drawn into the engine to provide the oxygen for combustion.

- Most of the air, about 78% of it, consists of nitrogen, whose chemical symbol is N, or sometimes, N2.
- About 20 to 21% of the atmosphere is oxygen. The chemical symbol for oxygen is O2.
- The remaining tiny fraction of atmospheric gases is a mixture of other elements.

© A.T.T.S. Inc. 2003 - 2020

6

Fuel

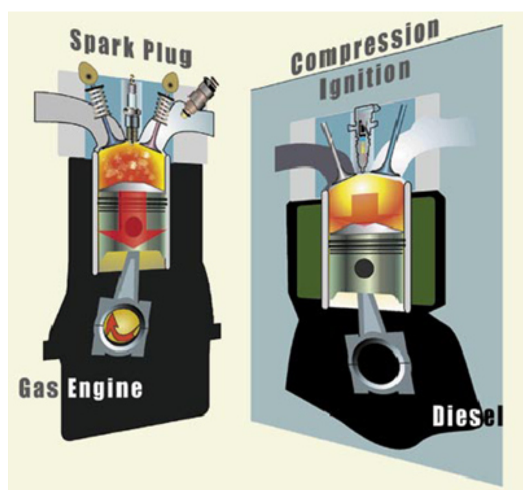
Fuel is a complicated chemical "soup" made of thousands of chemical compounds known as Hydrocarbons. Each has its own specific chemical formula. To keep things simple, we'll refer to them in a group that we'll label HC.

© A.T.T.S. Inc. 2003 - 2020

7

Heat

The final ingredient of our ignition triangle is heat. In gas engines air and fuel are compressed inside the engine's cylinders, and then ignited by a spark from an ignition system. The ignition system commonly includes an ignition coil that is connected to a spark plug at each cylinder.



© A.T.T.S. Inc. 2003 - 2020

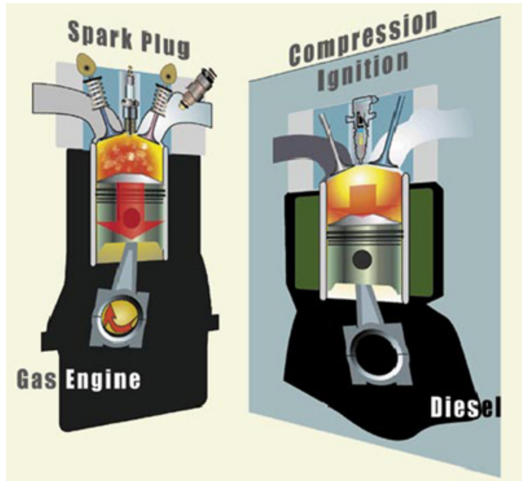
8

Heat

There are two critical parts to spark ignition:

• Spark energy (the amount of electrical energy available for the spark)

• Spark timing (when the spark occurs during the combustion cycle)



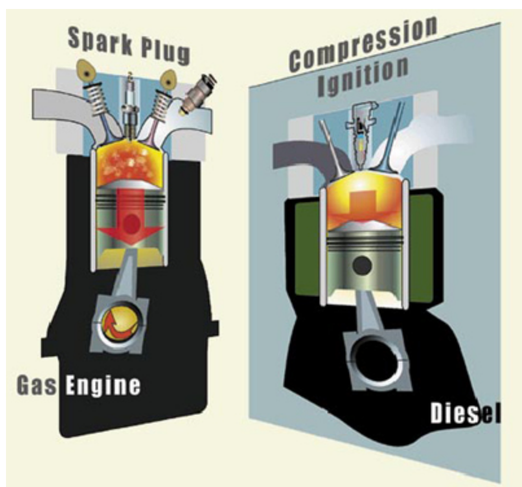
© A.T.T.S. Inc. 2003 - 2020

9

Heat

On the flip side of the coin, diesels do not have spark plugs. So, they ignite their fuel by compressing the air/fuel mixture inside each cylinder well beyond the compression ratios of spark ignition gasoline engines.

Increasing cylinder pressure increases cylinder heat until the mixture gets hot enough to burn.



© A.T.T.S. Inc. 2003 - 2020

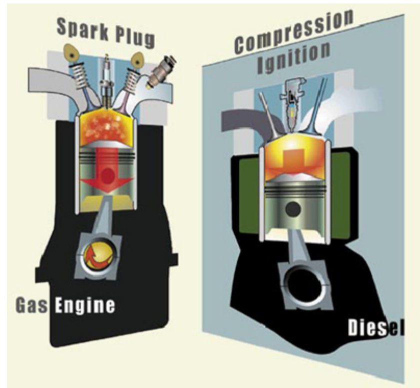
10

Compression

Because compression increases the temperature of fuel, it is a *condition* required for combustion. Low compression resulting from an engine mechanical failure reduces combustion efficiency and may prevent combustion altogether.

Both diesel and spark ignition engines need compression to run.

It's just that the diesel needs about twice as much compression to squeeze the air and fuel to the point of ignition.

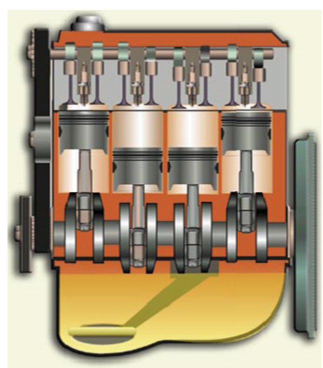


© A.T.T.S. Inc. 2003 - 2020

11

The Inner Workings of an Engine

Engines have changed over the years, but they still fundamentally are the same. Early engines used carburetors and magnetos or breaker point ignitions to fuel and fire combustion. In a modern vehicle, the Powertrain Control Module (PCM) directs the electronic fuel injection and ignition systems to keep fuel and fire synchronized with the movements of the engine's pistons.



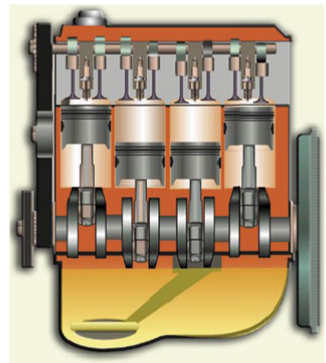
© A.T.T.S. Inc. 2003 - 2020

12

The Inner Workings of an Engine

• Pistons move down inside the cylinder, sucking in air.

• During this the fuel injectors fire at the right time. The mixture of air and fuel is squeezed and ignited — BANG. The resulting explosion pushes against the head of a piston, forcing it toward the crankshaft. A rod connecting the piston and crankshaft rotates the shaft, and it turns thereby giving the power of movement to the vehicle.



• After ignition the exhaust is blown from the cylinder into the exhaust system, so the process can repeat itself.

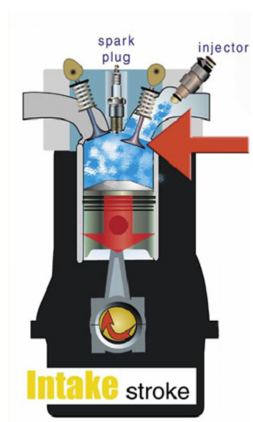
© A.T.T.S. Inc. 2003 - 2020

13

Intake Stroke - SUCK

The first step in combustion is to fill a cylinder with an explosive charge of air and atomized fuel. (If you've ever blown up a tin can with a cherry bomb or M80, you understand the effects of an explosion in a closed container.)

1. A cylinder is filled with air when its piston moves toward the crankshaft (downward in most engines), creating a low pressure inside its cylindrical bore. As the piston moves, the cylinder's intake valve opens, allowing atmospheric pressure to push air into the cylinder.



Intake valve opens - exhaust valve closes

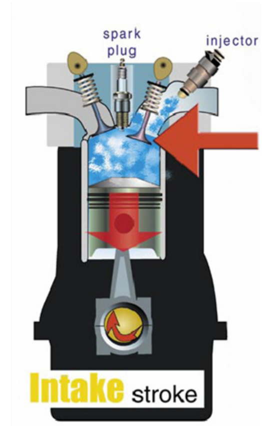
© A.T.T.S. Inc. 2003 - 2020

14

Intake Stroke - SUCK

2. The computer briefly operates a fuel injector to spray atomized fuel into the incoming air. The injector stays open for a very short time, so short in fact, that its open time, or ON-time, is measured in *milliseconds* (thousandths of a second).

So far, so good. We now have a combustible volume of air and atomized fuel inside the cylinder.



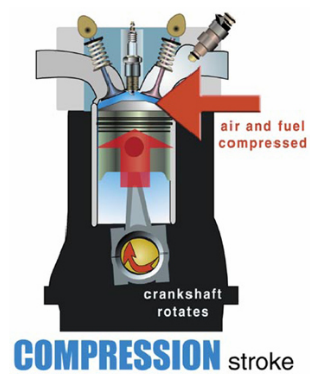
© A.T.T.S. Inc. 2003 - 2020

15

Compression Stroke – SQUEEZE

Now it's time to put the squeeze on the gassy mixture in the cylinder.

1. The intake valve that opened to let the air and fuel enter the cylinder during the intake stroke now closes. With both the intake and exhaust valves closed, the cylinder is sealed.



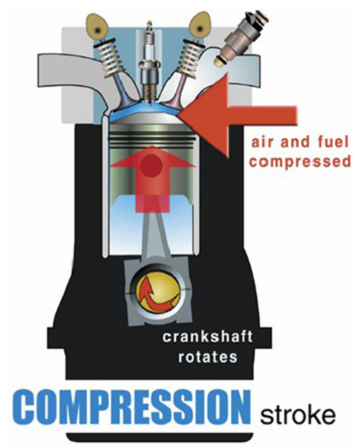
© A.T.T.S. Inc. 2003 - 2020

16

Compression Stroke – SQUEEZE

2. The piston reaches the bottom of the cylinder bore and reverses direction. As it moves upward, it begins to squeeze the air and fuel trapped inside the cylinder. Compression creates heat. The greater the compression, the hotter the gases get.

Both intake and exhaust valves are closed



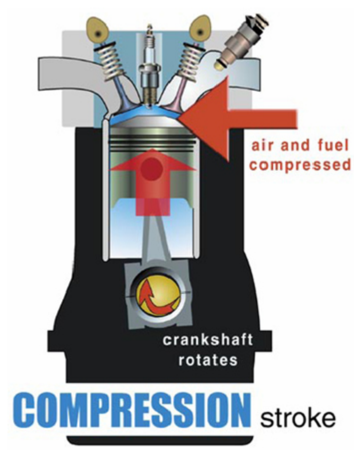
© A.T.T.S. Inc. 2003 - 2020

17

Compression Stroke – SQUEEZE

3. In diesel engines with extremely high compression, the mixture actually gets hot enough to self-ignite.

In spark ignition engines, the big bang of the power stroke is started by a small bolt of lightning across a spark plug gap inside the cylinder.

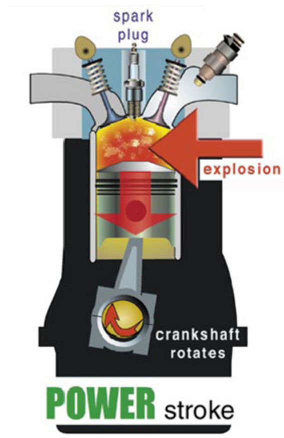


© A.T.T.S. Inc. 2003 - 2020

18

Power Stroke - BANG

At the right moment, an arc of electrical energy jumps across the spark plug gap, igniting the compressed mixture. The force of the resulting explosion inside the cylinder depends on several factors, among them the ratio of oxygen to fuel, the degree of compression, the quality and octane of the fuel, and the timing of the spark event that starts the mixture burning.



© A.T.T.S. Inc. 2003 - 2020

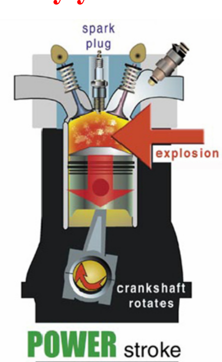
19

Power Stroke - BANG

When ignited, the gas charge expands rapidly as it burns, exerting great force against the only thing in the cylinder that can move, the head of the piston, driving it forcefully downward. It is similar to the force applied to a bicycle pedal by your foot: pushing down on the pedal *rotates* the chain sprocket.

Both intake and exhaust valves are still closed

Incomplete combustion, also known as a misfire may occur during this stage is something is off. Common misfire causes include a weak incorrect spark timing, improper air/fuel ratio, poor fuel quality, and low compression.



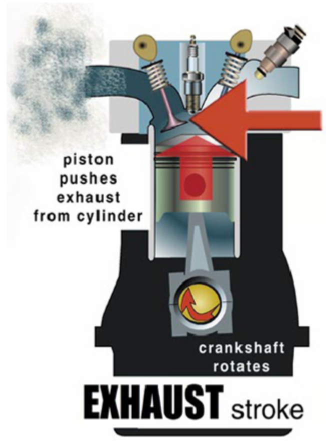
© A.T.T.S. Inc. 2003 - 2020

20

Exhaust Stroke - BLOW

As the piston moves downward, the explosion burns out and its force weakens. Burned remains of the combustible charge are similar to the soot and ash left over after a wood fire goes out.

Any left over pressure and waste gas material must be exhausted from the cylinder before a new charge of fresh air and fuel enters on the next intake stroke.



© A.T.T.S. Inc. 2003 - 2020

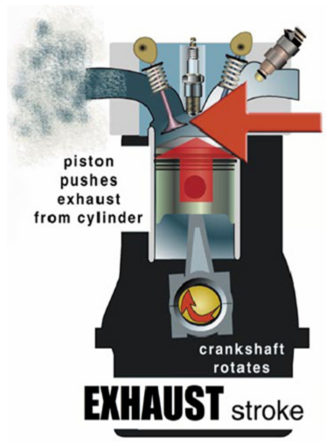
21

Exhaust Stroke - BLOW

Intake valve closes - exhaust valve opens

During the exhaust stroke, the exhaust valve opens and the next upward motion of the piston blows the waste gas out of the cylinder to the exhaust system.

This completes one entire four stroke combustion cycle. The process continues to repeat itself as long as the elements needed for combustion continue to show up in the cylinders in the right proportions at the right times.



© A.T.T.S. Inc. 2003 - 2020

22

Engine Mechanical Diagnostics Check List

Start with your most important tools:

1. **Brain**
2. **Eyes**
3. **Ears**
4. **Nose**
5. **Hands**

Followed by:

- **TSBs**
- **DTC check**
- **Exhaust tail pipe paper check**
- **Fuel Analysis**
- **Vacuum checks**
- **Relative Compression**
- **Compression Dry**
- **Compression Wet**
- **Cylinder Leak Down**
- **Back Pressure**
- **Pressure Transducer**

© A.T.T.S. Inc. 2003 - 2020

23

Check The Simple Stuff: Engine Cranking The Right Way

© A.T.T.S. Inc. 2003 - 2020

24

Preliminary Diagnostics

It is always best to begin with the tools God gave you: the brain, eyes, ears, nose, and hands. Always check DTCs and TSBs before doing anything.

Do not forget to check the basics. Here we are making sure that the engine is turning the right way by observing that the exhaust is blowing instead of sucking. Some starters may spin the wrong way and cause major confusion in your shop. The tail pipe will be sucking rather than blowing. Always check the rotation of the engine.

© A.T.T.S. Inc. 2003 - 2020

25

Preliminary Diagnostics

If the engine is making a sound, this might tell you a lot about what is wrong with the vehicle.

Engine noises :

Top End Problems

- **Clacking or knocking = camshaft endplay**
- **Slapping or thumping, front of the engine = timing belt, chain**
- **Clacking = lifter or valve spring**
- **Valve clatter = possible oil problems, valve guides and rocker problems**

© A.T.T.S. Inc. 2003 - 2020

26

Preliminary Diagnostics

Engine noises :

Bottom End Problems

- **Knock at idle with or without load = crankshaft endplay**
- **Clattering knock at throttle close = connecting rod bearing**
- **Metallic clatter when cold = piston slip**
- **Knocking at idle = wrist pin**

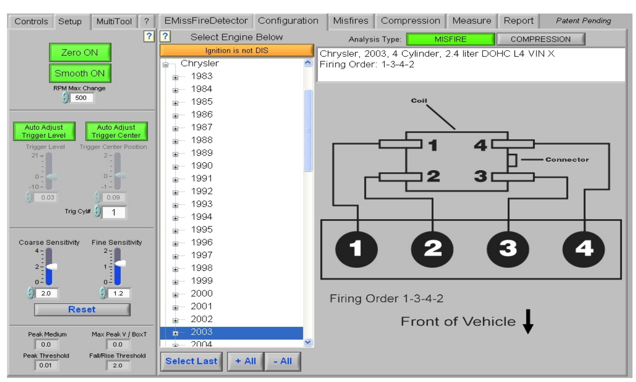
© A.T.T.S. Inc. 2003 - 2020

27

Using Engine Theory To Diagnose Cars

We are not going to belabor the point regarding firing order. However, though it may be obvious that cylinders fire in a different order, it might be less so that it helps us understand how to use a labscope using pressure transducers in the exhaust pipe.

These days, we do not have to swap spark plugs and coils, awaiting a cylinder misfire DTC to isolate whether we have an engine ignition or mechanical issue causing a problem in a given cylinder.



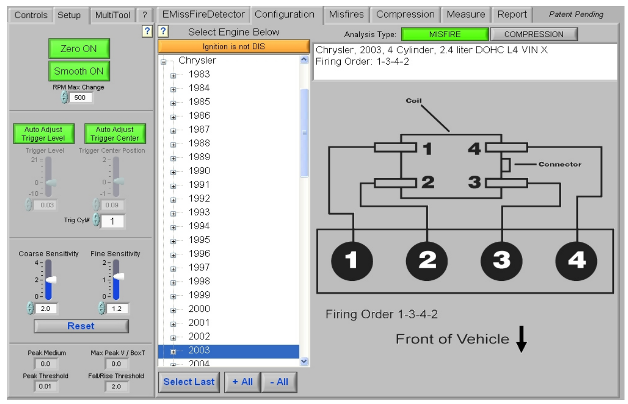
© A.T.T.S. Inc. 2003 - 2020

28

Using Engine Theory To Diagnose Cars

There are misfire software and pressure transducers that tell us exactly which cylinder(s) is/are misfiring and when. Simply said, without choosing the correct firing order, they do not work.

Quick Note: The Camshaft Position Sensor controls fuel and the Crankshaft Position Sensor controls spark. Sensor related and mechanical problems can throw fuel and spark off.



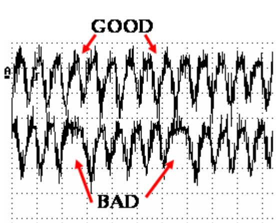
© A.T.T.S. Inc. 2003 - 2020

29

Relative Compression

Important Note: Only do this test after making sure the basics are good, such as battery voltage and the starter. (DO NOT USE A BATTERYCHARGER OR MAINTAINER)

The following tests and equipment are necessary to diagnose driveability issues caused by engine, ignition, fuel issues and emission issues as well.

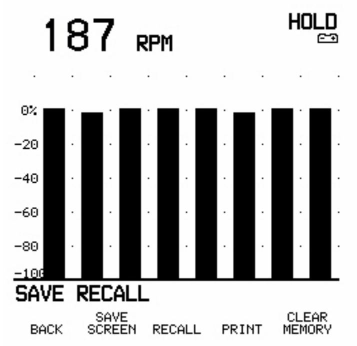


© A.T.T.S. Inc. 2003 - 2020

30

Relative Compression

1. Disable fuel.
2. Install the scope leads scope (+) & (-) leads on (+) and (-) of the battery post / terminals while cranking the engine.
3. Crank the engine over until you get a waveform. If your scope has a movie mode use it.
4. If you want to identify the correct cylinder, place an RPM clamp on cylinder #1 spark plug wire (or back probe a primary ignition wire) to trigger the test and get the correct firing order.



How do we know which cylinder is which?

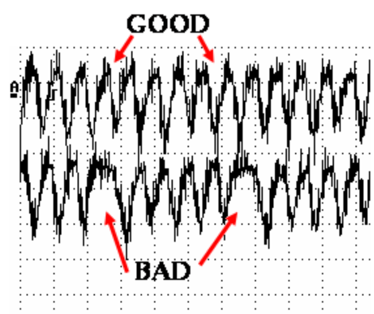
© A.T.T.S. Inc. 2003 - 2020

31

Relative Compression

When a voltage spike is 15 percent less than the others, the cylinder in that firing order has low compression. This way, we know there is definitely an issue with that cylinder.

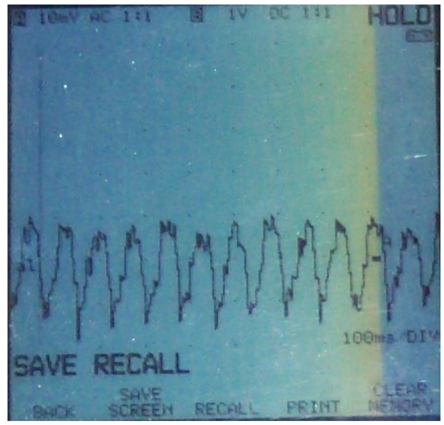
The Fluke 98 is one of three (Intero, Vetronix 5100/5200 are no longer sold) labscopes that does a relative compression test using easy to read bars, as we see to the top right. However, any other labscope (Fluke 192 shown to the right) can do the test, reflected as a waveform like the one we see to the right. Pictured are a GOOD top and a BAD bottom relative compression waveform. All we have to do is count out the cylinders as per the firing order, and by eyeballing the waveform, we can tell which cylinder has relatively less compression than the others.



© A.T.T.S. Inc. 2003 - 2020

32

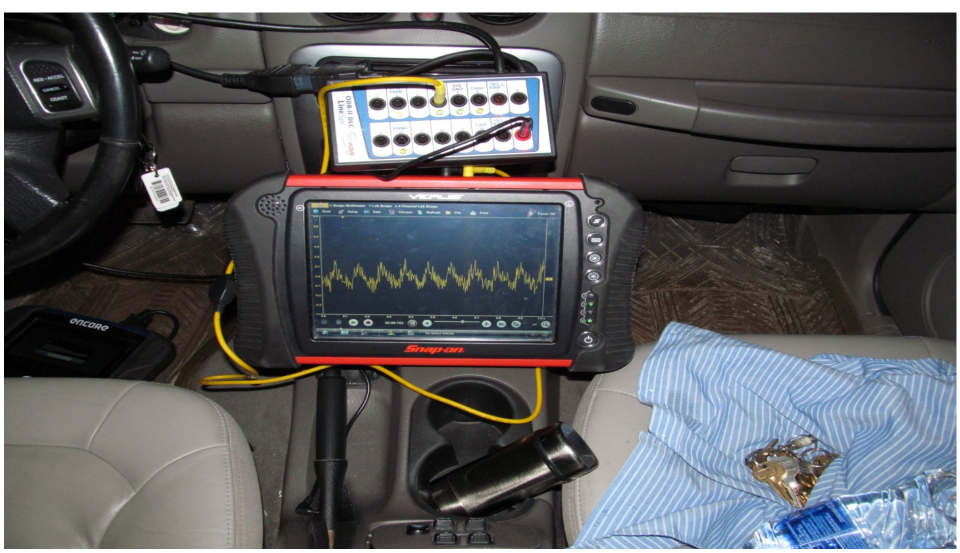
After The Basic Tests Check Relative Compression



© A.T.T.S. Inc. 2003 - 2020

33

Labscope Relative Compression From The Drivers Seat

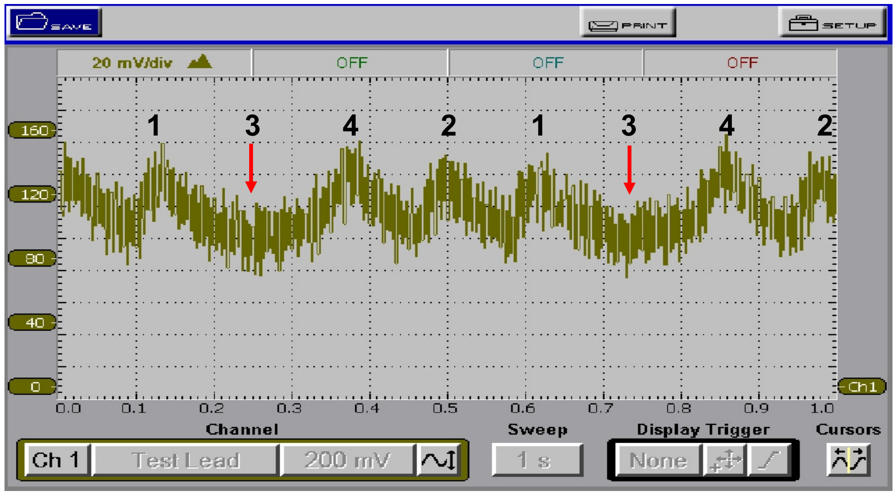


© A.T.T.S. Inc. 2003 - 2020

34

Relative Compression On Snap On Labscope

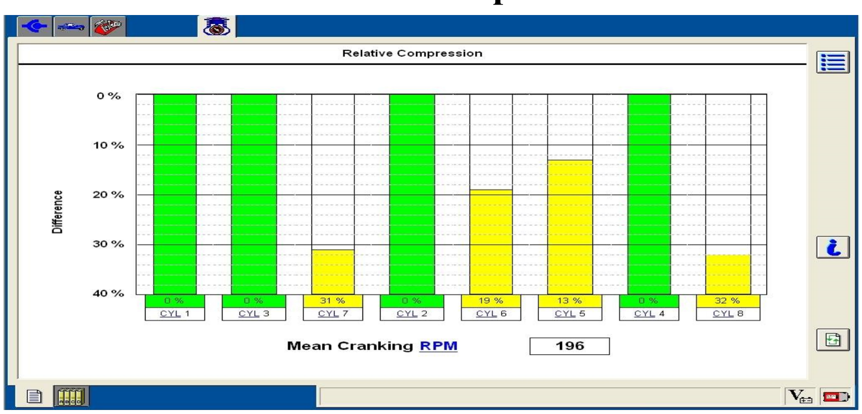
The screen shot is displaying a problem on number 3 cylinder. If you need to know the firing order, trigger off another channel while connected to number 1 ignition wire or coil.



© A.T.T.S. Inc. 2003 - 2020

35

Relative Compression



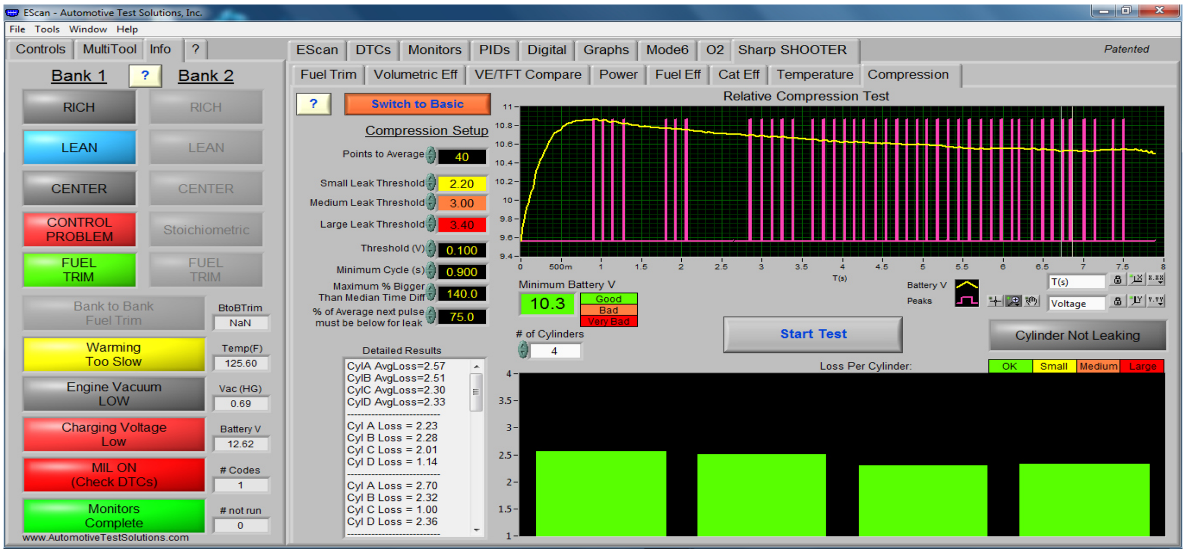
When one of the voltage peaks is 15 percent less than the others, that cylinder has low compression. If you need to know the firing order (using a labscope not the above scan tool), hook up a probe to number 1 ignition wire or coil.

Do you see anything wrong with the relative compression?

© A.T.T.S. Inc. 2003 - 2020

36

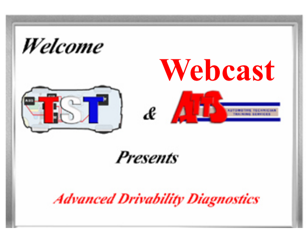
Relative Compression On ATS EScan

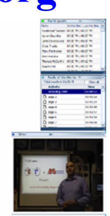


© A.T.T.S. Inc. 2003 - 2020

37

TSTseminars.org





Check out our YouTube channel…type in tstseminars in the search box

© A.T.T.S. Inc. 2003 - 2020

38

Thank You !

Interested In More Training?

p. 845 628-1062
f. 845 628-9109
e. gt@attstraining.com
w. ATTStraining.com

© A.T.T.S. Inc. 2003 - 2020

39