# Take Engine Diagnostics to the Next Level

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Internal combustion engines all use the same basic physics and engineering principles: intake, compression, combustion, exhaust.

1. Intake. Air and fuel enter a cylinder when intake valves open and the piston is pulled back by the crankshaft, creating a vacuum that draws the air and fuel in.
2. Compression: Air and fuel are compressed by the piston being pushed up by the crankshaft.
3. Combustion: Air and fuel ignite, and the resulting explosion pushes the piston back down.
4. Exhaust: Exhaust valves open and the burnt gas/fuel is forced out by the piston being pushed up by the crankshaft.

The combustion process and piston and valve movements cause air pressure variations in the exhaust system and in the crankcase. These pressure variations give important clues to the engine conditions and performance.

Exhaust and crankcase pressure pulse measurements, displayed as voltage readings from one of the leading sensor systems, SenX FirstLook® sensors, will be uniform and smooth in a perfect engine. However, as most of us know, non-uniformity and roughness (noise, or static) in the pressure curves increase with wear and tear on the engine.

The IC engines were not originally designed with emissions control equipment to affect the combustion process for emissions reduction. The unintended consequences of these changes (PCV valve, EGR systems, direct injection, exhaust filters, etc.) have increased the problem of carbon accumulations in the manifolds, on valves, in the oil, etc. resulting in reduced fuel economy, reduced performance, increased emissions and shorter engine life.

Advances in Automotive OBD have greatly improved the efficiency and effectiveness of engine **repair** work. There have been additional recent discoveries of new and increasingly efficient technologies that are making rapid advances in the identification of potentially catastrophic engine problems or failures.

Michigan-based Predictive Fleet Technologies, Inc. (www.EnginePolygraph.com), has developed new, next-level diagnostic strategies with their introduction of "***Engine Polygraph"™.*** The Engine Polygraph technology identifies issues *before* they become failures using some of the same engineering and scientific principles used by the OBD. An important aspect of Engine Polygraph is that it also identifies conditions that affect engine performance, but might *never* trigger an OBD code.

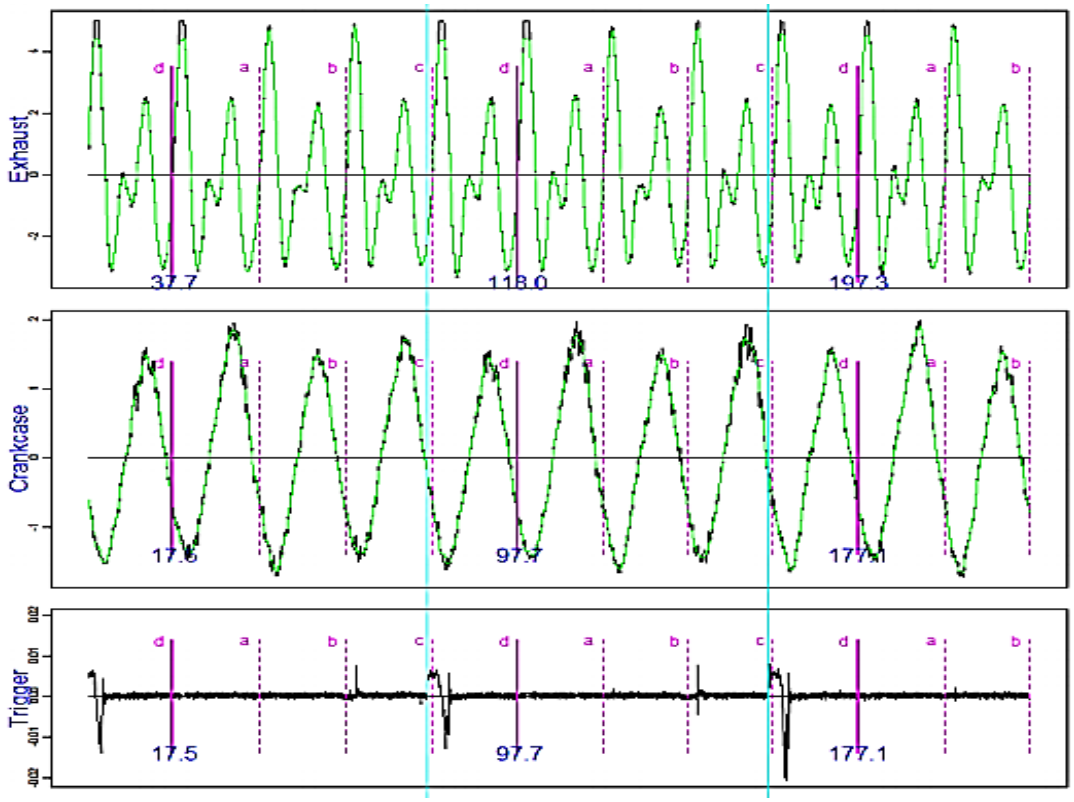
Engine Polygraph measures the pressure pulses of exhaust gas in the exhaust system and simultaneously measures the air pressure changes in the crankcase as the pistons move up and down, alternately compressing the air in the crankcase and the PCV valve pulls crankcase gas into the intake manifold. 'Listening' inside the engine while it is running is like using Instrument Flight Rules (IFR) to fly rather than the borescope Visual Flight Rules (VFR) – except that I wouldn't try using the borescope while the engine is running!

Engine Polygraph uses two, non-invasive, easy-to-install SenX FirstLook® sensors (www.SenXTech.com). One sensor is inserted into the exhaust pipe and the other into the dip stick tube; then start the engine and let it run. You will actually "see" cylinder compression and pressure variations created by carbon buildup, valve chatter, blow-by and PCV valve action.

Within 15 minutes, from pulling out the sensors to putting them away, and without even getting your hands dirty, you will have a total engine assessment.

Engine Polygraph, like the OBD, will identify failures, such as mis-fires. But unlike the OBD, Engine Polygraph provides the owner-operator, shop manager or mechanic with real-time pressure images and identifies conditions *before* those conditions are severe enough to trigger an OBD code.

The uniformity of the Exhaust and Crankcase pressure "Signatures" in the following illustration show an engine in good condition. (The bottom graph shows the spark in cylinder 1.)




Keep in mind the differences in air flow in the upper and lower engine:

> The Exhaust sample is from the tailpipe with hot gases blowing in one direction, pushed out due to the increased pressure from combustion and the pistons pushing the exhaust during each exhaust stroke. Since all cylinders are the same size, pulse variations are telling you things about the relative combustion in each cylinder, its air leakage during compression and power strokes (when valves should be closed), and other factors affecting volumetric efficiency.

Assessment of the Upper Engine integrity and the Volumetric Efficiency of the combustion process is mainly exhibited in the Exhaust Signature. The Exhaust Signature shows:

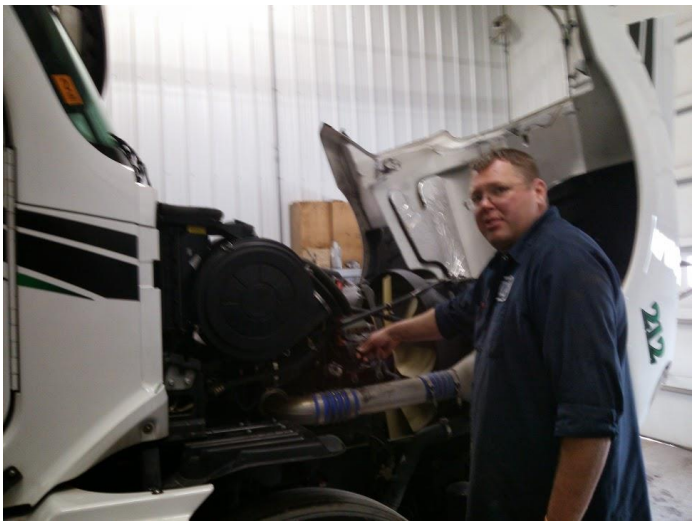
- Issues with valves, fuel supply, gaskets, ignition/combustion
- Carbon deposits causing turbulence and blockage
- Weak or broken valve springs
- Gasket failures
- Blow-by (exhaust pressure drop)

In contrast, the Crankcase is relatively closed, with the air pushed around as some pistons are moving downward while other pistons are moving upwards. (Think of a balloon that when squeezed in one place, pops out somewhere else.) However, the PCV valve action and blow-by can be detected as factors influencing the 'constant volume' approximation. Because the crankcase is physically near the engine, it can also pick up vibrations at pre-defined frequencies from different engine components.

Assessment of the Lower Engine integrity is mainly exhibited in the Crankcase Signatures, which will show:

- Blow-by (pulse into the crankcase)
- PCV valve operation
- Rough or corroded cam lobes
- Bearings
- Inadequate lubrication of the ring-cylinder wall
- Carbon deposits on the rings

Engine Polygraph is a way to identify the severity of these and other issues quickly and without getting dirty! While the engine is running, the Volumetric Efficiency and the Valve Seating scores provide clear evidence of carbon buildup issues. And evidence of effectiveness of remedial procedures can be clearly seen by re-running the test after a cleaning procedure.



Fleet owners will now be able to immediately identify engines that are not operating at optimum performance for power and fuel economy. They can monitor engine conditions and schedule repairs instead of running to failure.

Dealers can use Engine Polygraph to assess engines before purchase. There may be no stored engine codes, but Engine Polygraph will demonstrate existing wear and carbon buildup which causes performance loss and triggers eventual repairs.

One of the most powerful assets of this technology is that Repair Shops can use Engine Polygraph to create before and after records documenting the engine performance improvements from their work.

Engine assessments are presented in an easy-to-read chart rating the Upper and Lower Engine integrity, and also rating the Volumetric Efficiency and the Valve Seating. The chart is color coded and will list specific issues identified by the pressure measurements. The charts below illustrate a "good" engine and an engine that could use maintenance.

"Good" Engine Polygraph Assessment

| | |
|---|---|
| Upper Engine | 1 |
| Lower Engine | 3 |
| Volumetric Eff. Score | 1 |
| Valve Seating | 1 |
| Warnings | |
| | |
| | |
| | |

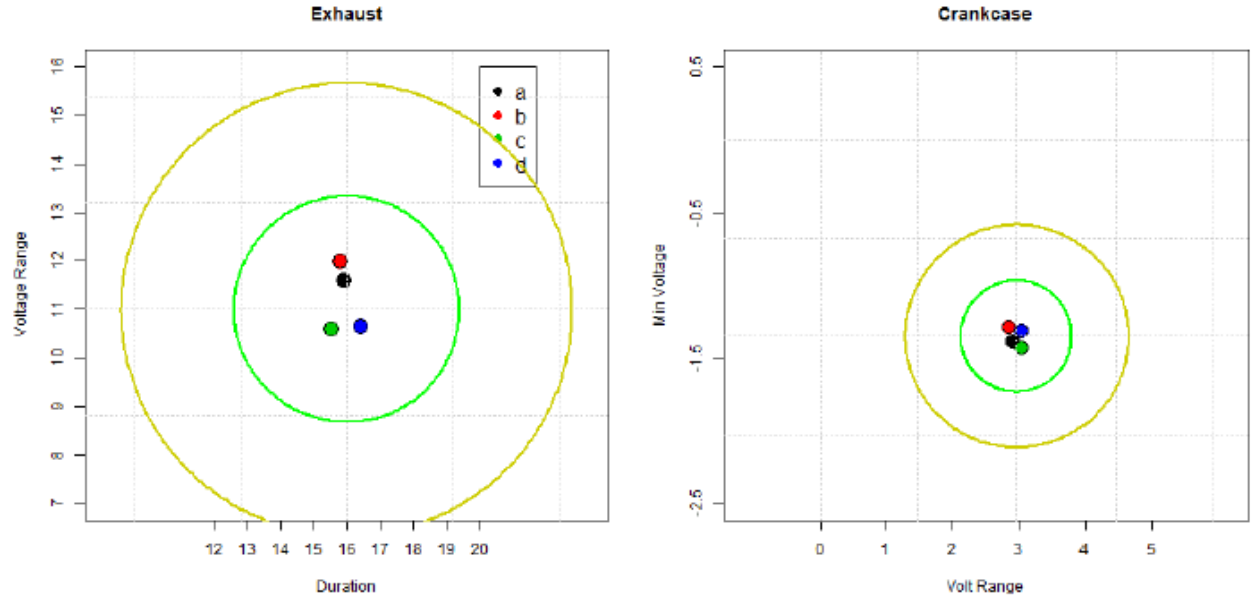
1 2 3 4 5 6 7 8 9 10

"other" Engine Polygraph Assessment

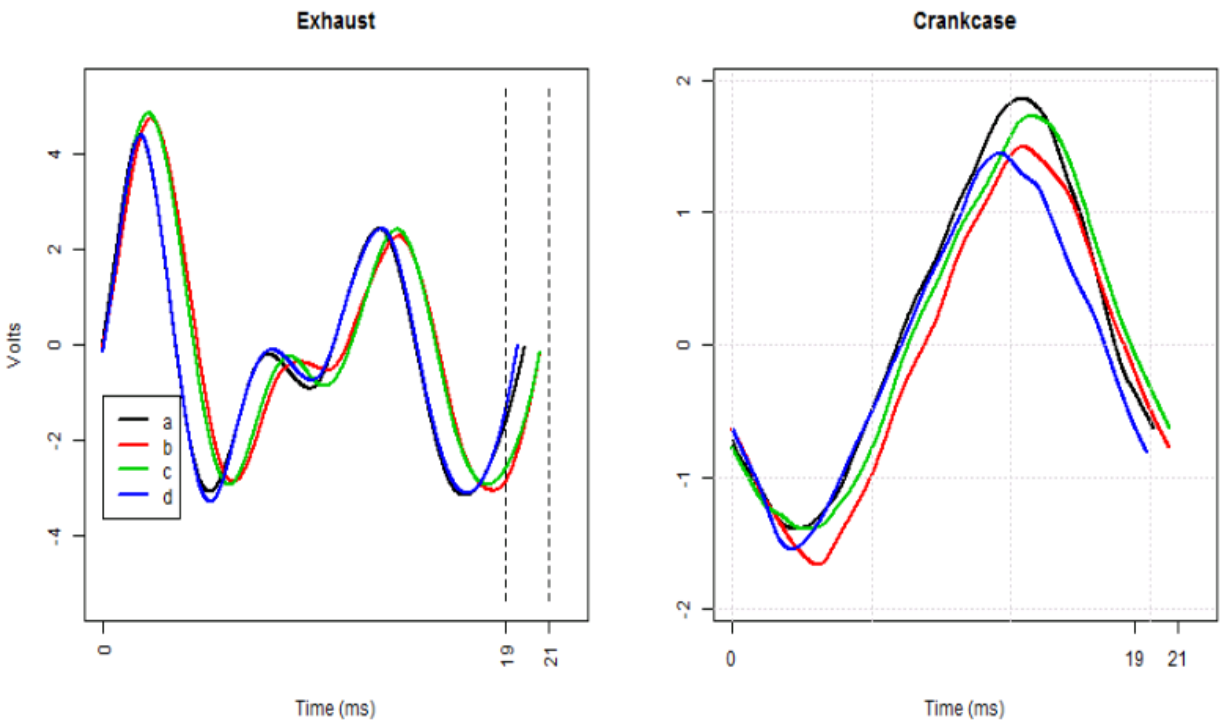
| | |
|---|---|
| Upper Engine | 6 |
| Lower Engine | 3 |
| Volumetric Eff. Score | 10 |
| Valve Seating | 10 |
| Warnings | |
| | |
| | |
| Low exhaust pressure. Check leakage | |

1 2 3 4 5 6 7 8 9 10

Engine Polygraph assessments include graphs and overlays showing the uniformity and smoothness of the mechanical motion and the exhaust and crankcase profiles of each cylinder, as shown below:




Each cylinder in firing order sequence, as shown in the legend, is plotted to show the (dis)similarity of the behavior in each cylinder. The voltage is in direct proportion to the pressure sensed and the duration is in milliseconds. Ideally, the points would be right on top of each other; if they are in the interior green circles, the cylinders are quite good.




The pressure profiles for each cylinder in the firing order shown in the legend, are shown in the above 'profile' diagrams. The time scale is again milliseconds. In these graphs, the higher frequency oscillations are removed so we see the pressure fluctuations resulting from factors primarily associated with the piston and valve movements. The crankcase graphs are aligned with the cylinder of the legend during its power stroke; the exhaust profiles are from the exhaust strokes of the indicated cylinder.

Engine Polygraph takes engine diagnostics beyond that provided by OEMs. Find engine performance issues sooner. Track and repair maintenance issues before they become failures. Show your customers how you have improved their engine performance.

Start Today. Take your diagnostics game and the service you provide to the next levels with Engine Polygraph from Predictive Fleet Technologies, Inc. at [www.EnginePolygraph.com](http://www.EnginePolygraph.com)