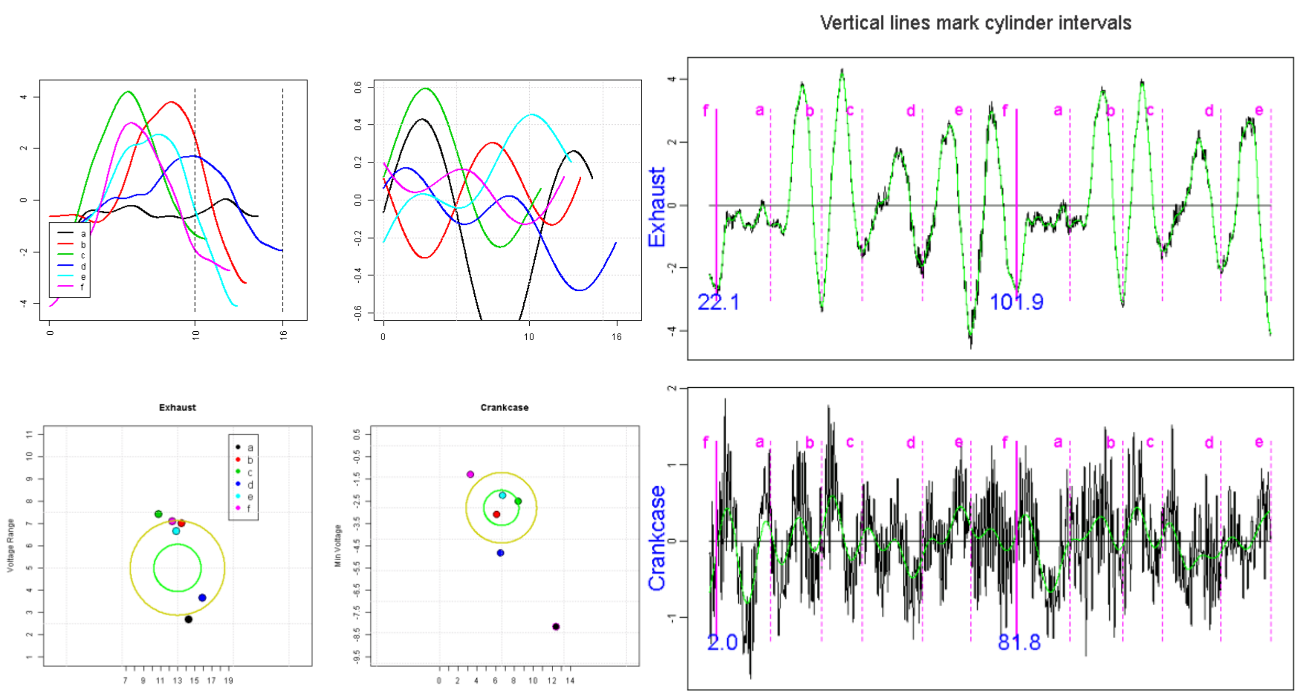
Engine Polygraph® (enginepolygraph.com)

Assessment Report v6.50

Upper Engine	6
Volumetric Eff. Score	1
Valve Seating	3
Lower Engine	8
Rumble	8
Scrape	8

1	2	3	4	5	6	7	8	9	10



info@PredictiveFleetTechnologies.com Phone: 1-833-ENGANGL (364-2645) Assessment Report, ver 6.50

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Contents

A newer version of this document might be available on our website: www.EnginePolygraph.com .

Introduction

The Engine Polygraph® (www.EnginePolygraph.com) is an application 'in the cloud' to store the FirstLook® sensor output (signatures) from an engine for future reference and to, optionally, request an engine analysis report. A SenX signature (Fig. 1) is a record of voltage from one or more piezoelectric sensors recording pressure changes (pulses) from an exhaust sensor and a crankcase sensor and optionally additional parts of an internal combustion engine. The value to these signatures is that internal combustion engines repeat firing in the cylinders of the engine in a regular fashion. If everything is working well in the engine the pulses repeat in very regular waveforms; however, engine problems usually present variations that repeat every engine cycle (two revolutions for 4-stroke engines).

The user may request an analysis of the data in view of the engine model identified and parameters of the test conditions. Currently the report choices are Assessment, Diagnostic report, or none. The Engine Polygraph® reports automate many of the steps that a user would perform manually in interpreting a 'signature': a pair of SenX waveforms from an internal combustion engine, one from the exhaust stream and the second from the oil dipstick tube.

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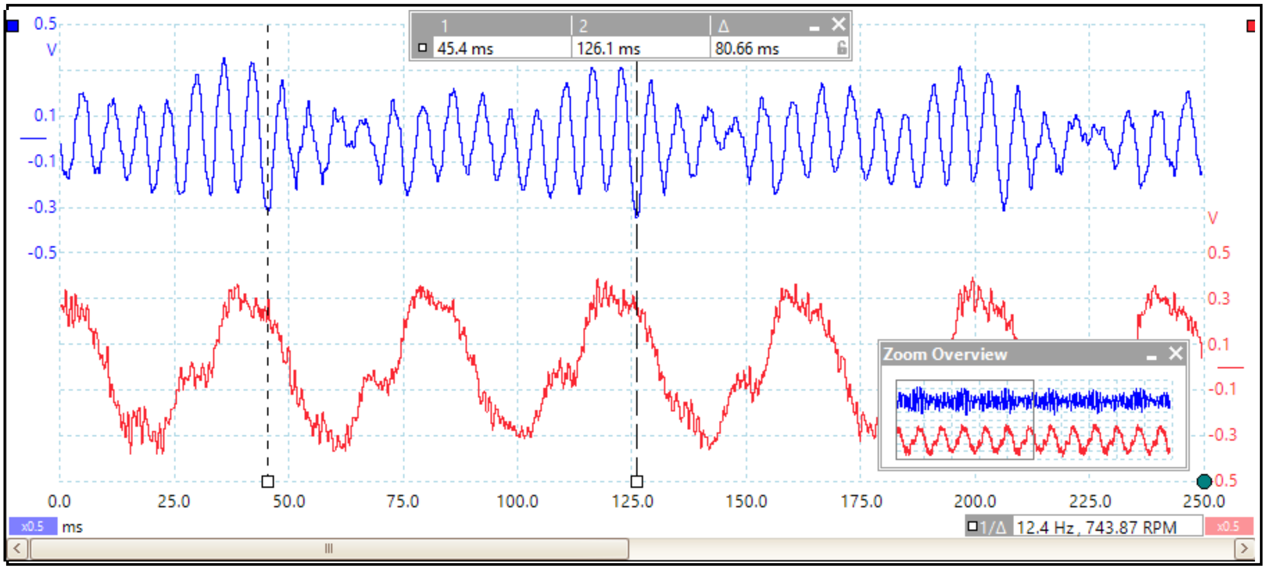

Figure 1: A SenX Signature using a PicoScope PC Oscilloscope

The above signature is from the exhaust (red) and a 'trigger file' from a spark plug induction clamp (blue) from a 6 year old, V6 engine. The vertical dashed bars mark the boundaries of a 720° full 2 rotations of the crankshaft which took 80.66 ms, indicating that the engine was running at idle of 1487.7 rpm. (You might notice that the oscilloscope indicates the rpm as 743.87 in the lower right corner. But we know that we have a 4-stroke engine requiring 2 rotations for all cylinders to fire once and this is a V6, so the rpm is twice the frequency of the 4-stroke frequency.) The cylinders are very regular.

Why are the signatures important?

In a 4-stroke engine, each cylinder of a well-running engine fires once during two rotations of the crankshaft (every 720°); in a 2-stroke engine, every cylinder fires once during one rotation of the crankshaft (360°).

In an engine with a problem of 'physical integrity', one or more (usually one) cylinders output an abnormal pressure, resulting in an irregular pulse that is quite obvious. We use the term, 'physical integrity' to refer to the head gasket, valves, pistons, rings, cylinders, fuel delivery, or ignition. Depending on where the signature is taken and the nature of the abnormality, the problem can often be identified. In this way, an engine with a mechanical problem can be diagnosed. [If the engine has tripped an OBD code AND the engine shows physical component compromise, the problem might not be correctly identified by the code. Most codes assume that the engine has no mechanical problems (no loss of physical integrity) but might have sensor problems, or ancillary control system problems. If the engine **has** mechanical problems, the code may well be erroneous.]

Over time, wear and tear on the engine will cause less-than-failure variation from cylinder to cylinder. Most engines are not 'broken', but many are dirty (carbon buildup) or parts wearing out. The cylinder that is changing the most is typically the one that will fail first. That is why it is important to 'look back' at the signatures of an engine over time to identify if one (or a few) cylinders are degrading and might need attention. By looking at the rate of degradation, one can estimate the future time of failure. In this way, the sensor data can be used for 'predictive failure' to give you the option of preventative maintenance/repair or retirement. You may want to watch the videos on the SenX Technology website: www.senxtech.com.

Engine Polygraph Reports

Engine reports are produced from analysis of certain signatures. There are currently two reports available for selection. The Engine Polygraph® reports automate many of the steps that a user would perform manually in interpreting a 'signature': a pair of SenX waveforms from an internal combustion engine, one from the exhaust stream and the second from the oil dipstick tube.

The **Assessment** report is an analysis of a 'Load' condition signature with simultaneous 'exhaust' and 'oil tube' pressure sensitive sensor recordings that calculates 'scores' with values from 1 (very good) to 9 (very poor) ranking 6 quality 'measures'. The scores are generated from a mathematical model 'trained' with examples of data from engines with assignments made by experts. The report is available as a PDF, and if the Owner is a subscriber to Engine Angel, the results are stored in the database to show time-series graphics of the scores over time.

The scores are: an overall engine score and scores for the upper engine (valves, injectors, head gasket, ignition), engine volumetric efficiency score, and a score for valve seating leakage; the lower engine (rings, pistons, cylinder walls), rumble (humming), and scraping (high frequency screeching). The overall score is indicating the current state of the engine and a measure of risk that one of the monitored components will fail soon – it is NOT a measure of the remaining life of the vehicle although that is related.

The **Diagnostic** report is an analysis of the data from a 'Signature' file of data, data about the engine model being tested, and some test conditions data. The report evaluates the 'physical integrity' of the engine AND an Expert System evaluates 'Abnormal Observations' detected to produce a list of possible causes of the Abnormal Observations along with a confidence that the indicated cause is correct and suggestions that might remedy the problem. The Diagnostic report contents are described in a separate document, EP Diagnostic Report, available for download from www.EnginePolygraph.com.

Currently, the system will produce reports for signatures with ***exhaust*** and ***oil tube*** sensors in the ***Load*** condition (running at about 1500 rpm). Optionally, a channel can be assigned to the ***trigger*** sensor (usually a clamp inductor to detect current in a spark-plug firing or an injector signal for a specific cylinder). A fourth channel can be assigned to another sensor (e.g., an intake manifold or vacuum line); however, these additional waveforms will only be displayed on the reports. They will not (currently) be included in the engine analysis for either report.

Both reports display some information about the engine model that is being analyzed. This includes the method of ignition (diesel or spark), firing order, cylinder adjacency and bank assignment. In addition, distinctive engine technologies and common problems are listed as they become known. (The Diagnostic report contains additional data.)

Search and Retrieval of Reports

Previously processed reports can be displayed from the Assessments tab, as shown in Fig. 2, below:

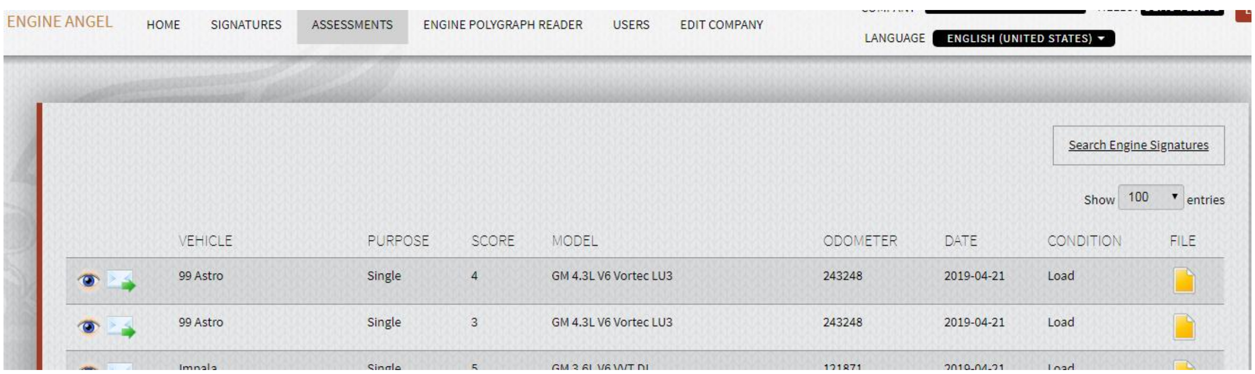

Figure 2:Engine Polygraph Assessments screen

A report can be in a 'processing' state, indicating that the report request has been sent to, but not yet processed by the system. Once the assessment has been received (usually in less than 2 minutes), the signature is shown with the **View** and **Email** options. The View button will start a 'download' process to your workstation for local storage and viewing. The email option allows easy email capability to send the PDF report as an attachment to a provided email address.

If the submitted signature does not have data that can generate a meaningful report, the system will produce a PDF 'Exception' report describing the issue and suggesting corrective action. You will not be charged for a request that results in this circumstance. The most common reason for inadequate data in the signature file for a meaningful report is that the PC oscilloscope settings might not be appropriate for the engine you are working with. Please review the Appendix: ***PicoScope Startup Settings*** if you want more information.

The Engine Angel Assessment Report

The Assessment Report output from the system is a PDF report that provides an Assessment of the engine's 'health' or physical integrity. It has several sections.

Description of Vehicle and Test conditions

Engine Polygraph Report

http://www.EnginePolygraph.com

Vehicle ID : EBC1471

Owner	Jimmy
Engine	3.6L V6 LGX GM
Serial Number	
Engine Condition	Load
Purpose	Single
Odometer	11997
Date	2019-05-18 06:32:18 PM

Assessment 3

RPM	1000 (939)
Engine Temperature	165 F
Engine Polygraph name	e5ebcf0e-a6cf-4251-8737-8f72b5a87b18.zip
User's file name	2ef0c4b6-7463-4fc4-88f0-588fcda6be6a.zip
Engine Polygraph Report	Assessment
Source	pft01Carbon
User's comments	Test ver 6.0

Warnings

Abnormal Observations	possibly caused by..	suggestions...
High differences between cycles	Engine might have experienced a transition between operating phases.	You might want to rerun the Signature to get a more consistent result.
Low exhaust pressure. Check leakage	Exhaust sensor might not be well placed; Sensor hose might be accidentally squeezed shut by the clamp or cramped shut. Also possible that there is a leak in the exhaust system.	Check Exhaust sensor position and clamp location; Wrap wet cloth around any exhaust leakage in the exhaust system.
		You might want to rerun the Signature to get a more consistent result.

Figure 3: First page of the Diagnostic Report showing vehicle, engine, engine status and test conditions data.

The first page of the Assessment report shows the user inputs for the Signature that was analyzed for this report along with the overall assessment score. The RPM value may contain two numbers: the user input estimate when provided, and an RPM contained within parentheses calculated from the signature. (See Fig. 3.)

The analysis program might detect some warnings about the data collected and if so, these are reported as shown above.

Engine scores for the six categories

The scores for the components are presented: the Upper Engine (valves, gaskets, injectors, and ignition) with Volumetric Efficiency and Valve Seating; the Lower Engine (rings, pistons, and cylinder walls) with 'Rumble' (relatively low frequency vibrations from the crankcase) and Scrape (high frequency vibrations often associated with metal-on-metal with inadequate lubrication). The Upper Engine score, the Volumetric Efficiency score, and the Valve Seating are obtained from the exhaust sensor; the Lower Engine scores are derived from the oil tube sensor.

In Fig. 4, we list the scores along with a description of what the score suggests relative to the condition of the engine. Below that is a table of descriptions of what the scores refer to.

The two major categories are: Upper Engine score and Lower Engine score. These scores show how the model evaluates the data obtained for the engine relative to the associated components' physical condition: wear or failure. The vibration frequency measures in each category relate more to carbon buildup or adjustments (e.g. valve lash adjustment affecting volumetric efficiency.

Engine Polygraph Assessment

Version 6.0

Upper Engine	1	Excellent upper engine mechanical condition
Volumetric Eff. Score	1	Valve lash very good; no sign of carbon buildup
Valve Seating	1	Valves seated very tight - no sign of carbon causing leakage
Lower Engine	3	Good lower engine mechanical condition
Rumble	3	Not much hum or 'rumble' detected in the crankcase
Scrape	6	Very noticeable sign of lubrication problems in the crankcase

1	2	3	4	5	6	7	8	9	10

Upper Engine	Upper engine mechanical condition (injectors, valves, head gasket, etc.)
Volumetric Eff. Score	Parts affecting the rate of air exchange through the engine
Valve Seating	Parts affecting tightness of the exhaust valves closure
Lower Engine	Lower engine mechanical condition (pistons, rings, cyl walls, PCV valve, etc.)
Rumble	Hum in the crankcase
Scrape	Screeching in the crankcase indicating poor lubrication

Figure 4: The Assessment scores with descriptions of conclusions and below, a table of definitions of the scores.

The color-coding scale is shown on the page to allow for variation in the display and printing tones.

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Engine Integrity Diagram

The Engine Integrity Diagram shows the values of key parameters for each cylinder. The cylinders are named alphabetically (a, b, c, etc.) in firing order sequence with unknown starting cylinder location. We call this the *Engine Integrity diagram* because if the points are close together, the engine has high integrity since all cylinders have similar operating parameters. (We are making the assumption that an engine would not have all cylinders in equally **bad** condition.) The center of each graph is the median value over all the cylinders. The green radius is would contain the points for most engines with score of 3 or better; the yellow circle would contain the points for most engines with scores 5 or better. The voltage is directly proportional to the pressure. (See Fig. 5.)

In the Exhaust graphic, the cylinder Duration is the number of milliseconds the exhaust from the cylinder takes to pass the exhaust sensor, when the engine cycle is normalized to 1500 rpm. (The Profile chart below might allow easier interpretation of the number of ms.) If the difference between the fastest and slowest cylinders exceeds 4 ms, the engine is running ‘rough’. The vertical axis of the Exhaust chart shows the maximum voltage (pressure) observed by the sensor during the exhaust stroke for each cylinder. As you might expect, a cylinder with high exhaust output had a very successful power stroke and so the exhaust cycle should be fast due to the acceleration of the power stroke. (So it will show in the upper left of the cluster.) Similarly, low voltage implies low cylinder output and so a slower exhaust cycle; such a cylinder would present in the lower right of the cluster.)

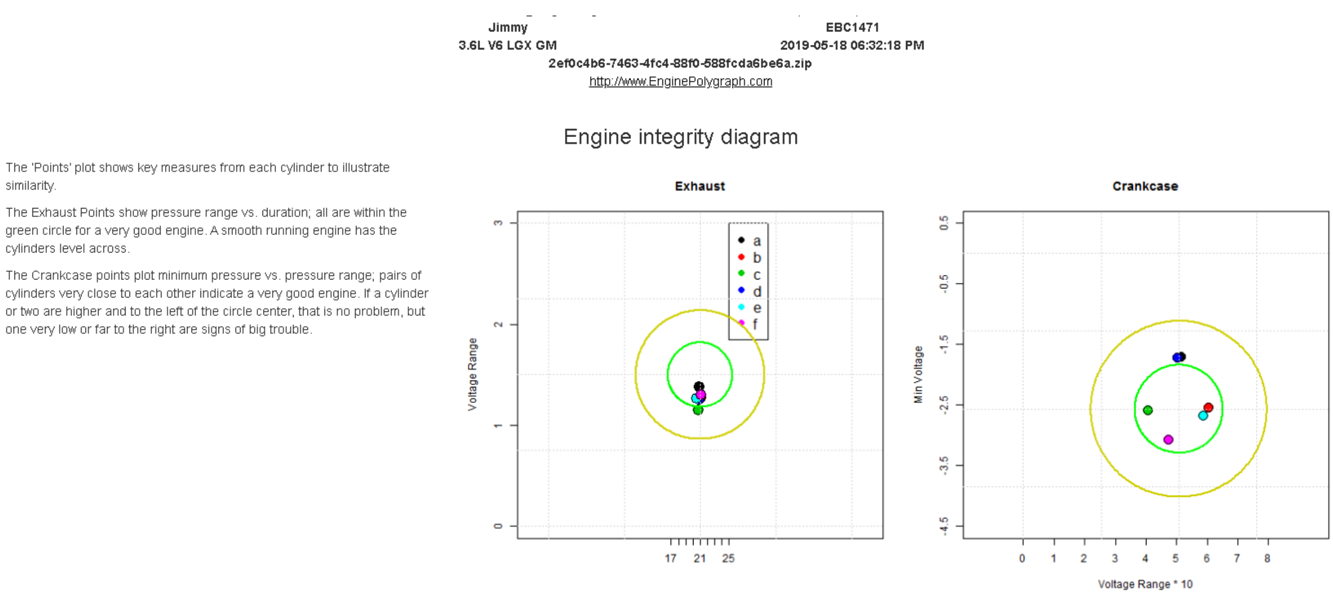


Figure 5: Engine Integrity diagram showing the (dis)similarity of the value of parameters for each cylinder derived from the Signature data.

In the Crankcase chart, the x-axis is the voltage range for each cylinder (maximum minus minimum) whereas the vertical axis is the minimum voltage. Severe blow-by exhibits as a very large dip in the minimum voltage associated with the cylinder vacuum of the intake stroke.

Each cylinder in firing order is assigned a unique color that can be used to ‘see’ the same cylinder on the various graphics.

Cylinder Profiles

The cylinder profiles plot the pressure (voltage) from the sensors on the y-axis for each of the cylinders during the interval (720°/number of cylinders) of its major contribution of the cycle. The x-axis is the time in milliseconds from the start of the stroke as determined from our analysis. So each cylinder profile begins at 0 and goes to the right until the next cylinder takes over back at the origin. (See Fig. 6.)

The Exhaust Profiles show each cylinder's exhaust ‘smoothed’ voltages (pressure) for its section of the cycle. The cylinders are identified in firing order with colors; the legend shows the cylinder letter identifier with the assigned color. In a good engine, the exhaust profile lines are very similar. The starting point for each exhaust profile curve is mainly driven by the opening of the exhaust valve for the cylinder.

The Crankcase Profiles show the crankcase pressure from all cylinder actions during each cylinder's section of the cycle. These lines are usually arranged in pairs since the crankcase patterns repeat every 360° so each cylinder in the first 360° should have a match in the second 360°. Cylinders with differing blow-by will not be aligned together, or an intake manifold that has significant carbon buildup can cause the pairing to be ruined as the PCV valve can allow the vacuum variation to affect the crankcase pressure.

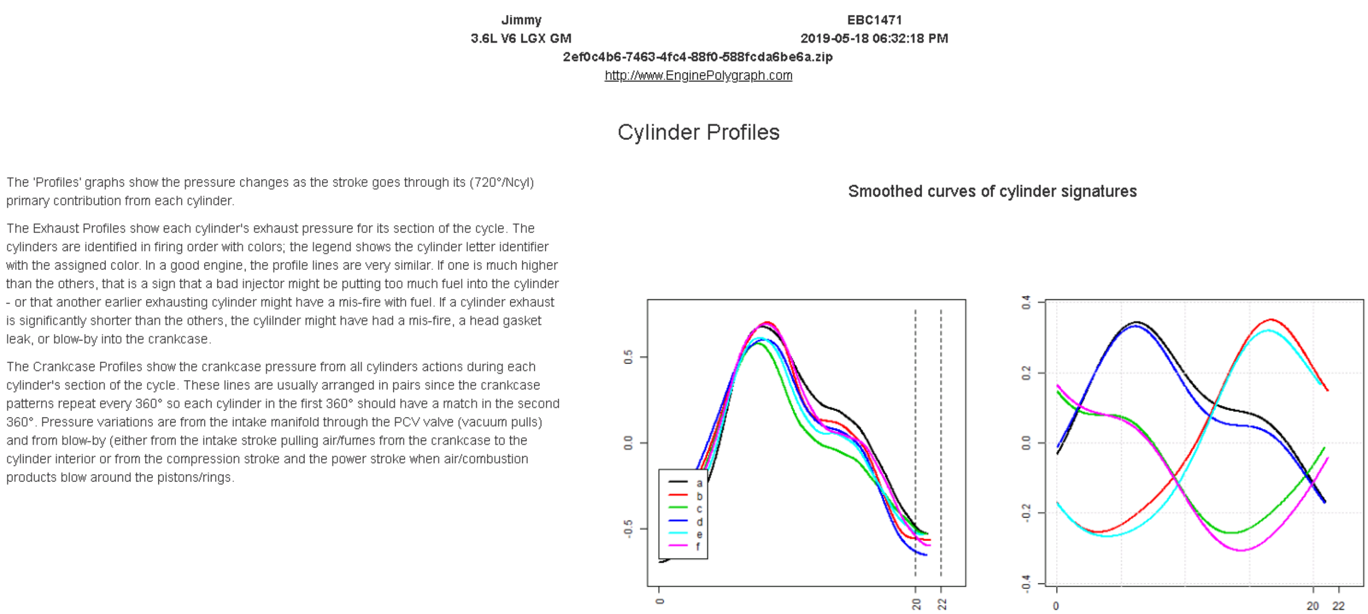


Figure 6: The Profiles graphics for the exhaust and crankcase for each cylinder.

Using a different engine's report, we illustrate the use of the colors for matching specific cylinders across the graphics:

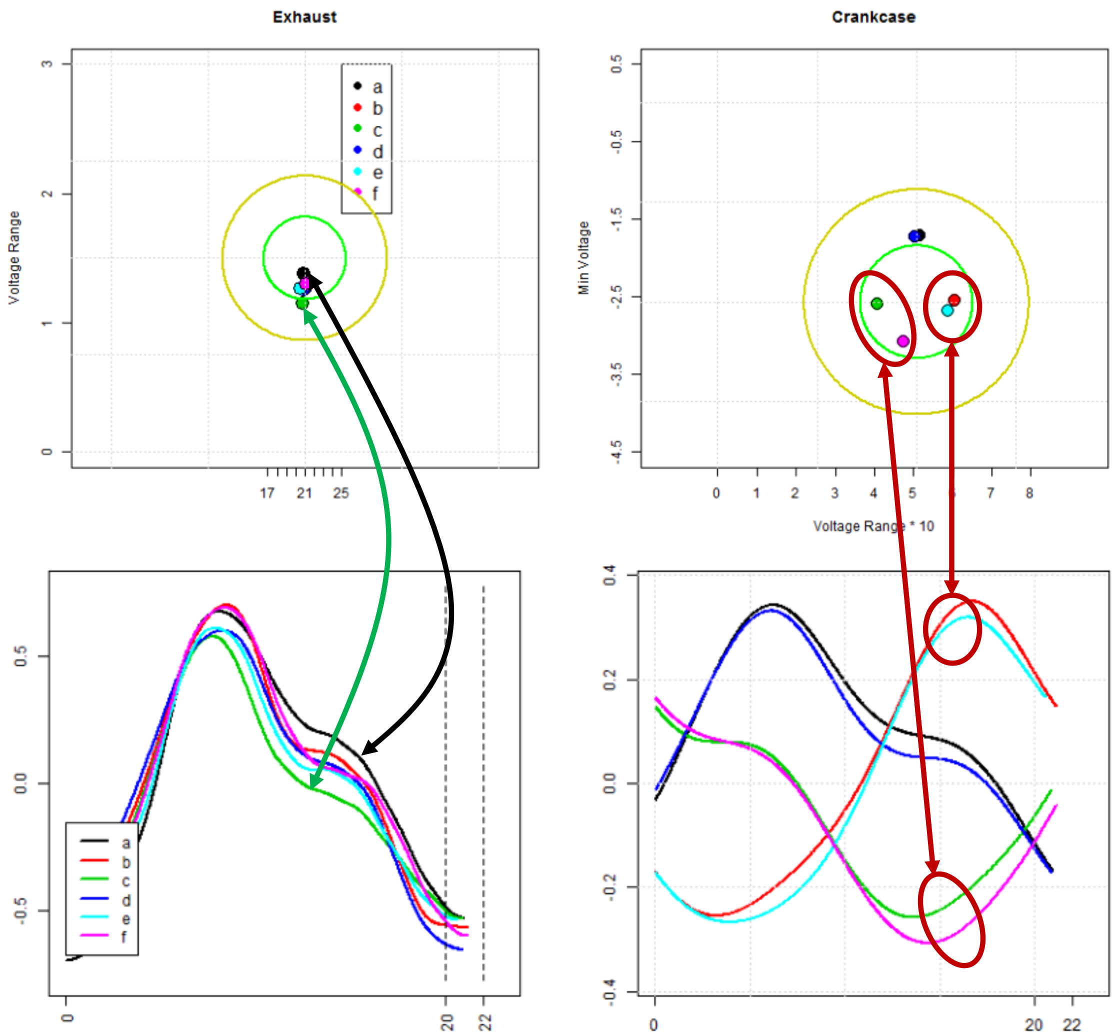


Figure 7: Illustration of using colors to relate data from differing graphics by cylinder.

Polygraph Model

The models are the oscilloscope outputs (black lines) for the exhaust and crankcase (oil tube) sensors. (Additional sensors might have been collected that will be displayed below the Exhaust and Crankcase charts). The green lines are the pressure curves with the high frequencies removed. The cylinder assignments are made from the 'smoothed' curves in the exhaust signature and from that, the durations are obtained. High frequencies in the exhaust are used to provide the Volumetric Efficiency score and Valve Seating scores.

The time axis of the exhaust data is shifted by 180° (for a hot engine) to the left and the cylinder boundaries and durations are obtained from the exhaust. This is because the major blow-by in a hot engine occurs when a cylinder is in its power stroke. Shifting the exhaust curve to the left aligns the cylinder section in the exhaust diagram to be directly above the crankcase section for the same cylinder when the cylinder was in its power stroke. The blue numbers below the signatures are the times in milliseconds for each of the 'cylinder a' strokes for each cycle. (See Fig. 8.)

Jimmy **EBC1471**
3.6L V6 LGX GM **2019-05-18 06:32:18 PM**
2ef0c4b6-7463-4fc4-88f0-588fcda6be6a.zip
http://www.EnginePolygraph.com

Polygraph Model

We 'model' the engine from the data of the signature and parameters from our Engine Model database. We generate the pressure curves (green) for both the Exhaust and Crankcase. The pressure is plotted (black) over the 'raw' data from the sensors. The solid vertical lines mark the start and end of engine cycles: 720° for a 4-stroke engine and 360° for a 2-stroke engine.

In the Exhaust model, we mark cylinder boundaries with vertical dashed lines by analyzing properties of the curve. (A cylinder mis-fire might cause that calculation to be in error.) The average cylinder duration is the (cycle-time in ms)/ divided by the number of cylinders (Ncyl). In a very good engine each cylinder should have at least one 'peak and valley'. If the engine is running properly, each cylinder's section should be the same. The cylinders are identified in the Exhaust Model by lower-case letter in firing-order. The numbers at the bottom of the graph show the relative time in ms since the start of the signature at each cycle.

The Crankcase model is displayed simultaneous with the Exhaust model but the time shown is 180° earlier, representing when the cylinder in an exhaust stroke was in its power stroke.

Trigger on a 4-stroke engine: If a trigger sensor is available to identify the timing of ignition of cylinder 1 (or any other known cylinder as per the manufacturer's design), we know that the power stroke will immediately follow in that cylinder (for the next 180°). For our example engine, let's assume that we have a trigger signal on cylinder 1.

Any other Sensor position (intake, Vacuum line, ..) can be assigned a channel number (limited by the number of channels available on your PicoScope). The data from all sensor positions will be displayed on the same time scale

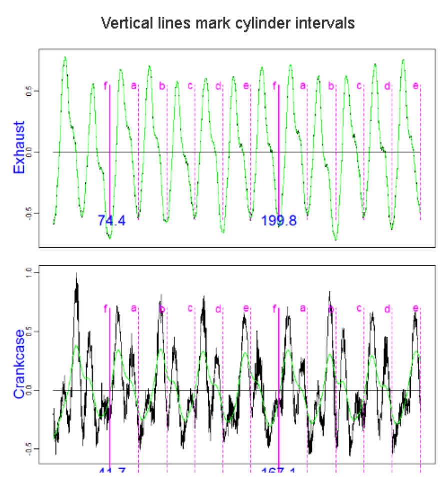


Figure 8: The Polygraph Model of the Pressure vs. vibration in the EP Signature for the subject engine.

Assessment Report with Trigger Sensor

One can optionally use a channel to record a 'trigger' sensor to detect when a specific cylinder is beginning its power stroke (an induction clamp on a spark-plug wire, an injector control, a COT (coil-on-top) spark-plug, etc.). The channel assigned must be identified on the Add Signature screen from the pull-down as 'trigger'. In this case, the signal trace is included and offset 180° to the right of the **original** exhaust (for a hot engine). The trigger event is presented on the page as a line that extends across all three channel waveforms. The physical cylinder is then identified as the cylinder that is about to exhibit exhaust immediately to the right of the trigger line. In this way, the firing sequence of the engine model can be used to map each cylinder of firing sequence to physical cylinder. An example of a V8 diesel DuraMax with trigger for cylinder 6 is shown. Following the trigger bar to the right on the exhaust waveform shows that cylinder 6 is cylinder a in the diagrams. (See Fig. 9.)

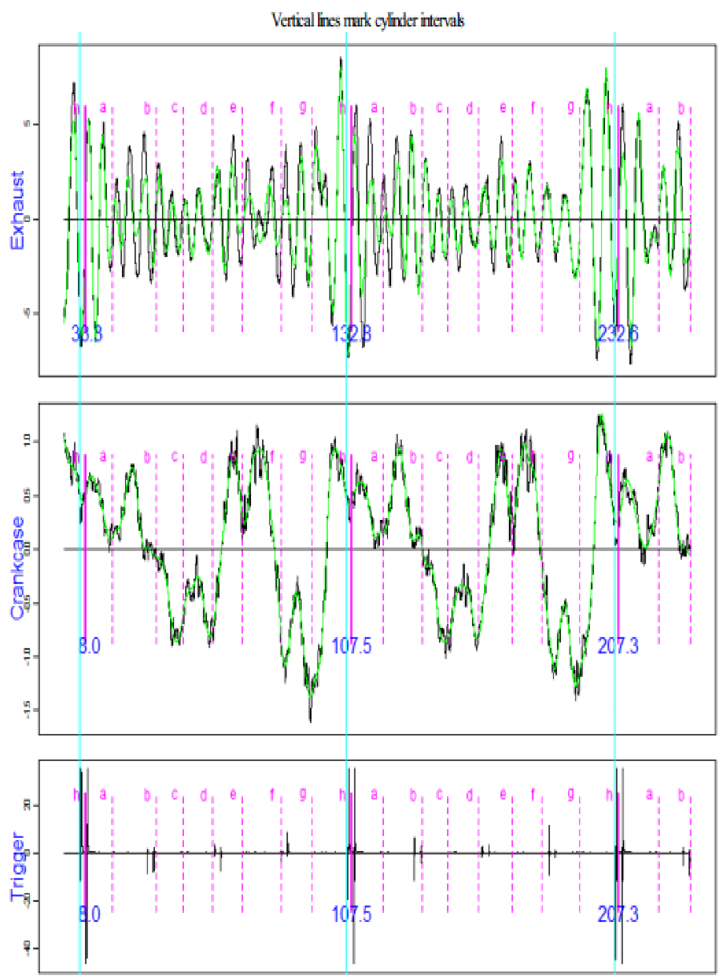


Figure 9: A Polygraph Model with an optional Trigger sensor.

1-pg **Assessment** Report

The one-page Assessment report is an abbreviated version of the Assessment report to present the conclusions on one page. We remove the textual explanation of various sections under the assumption that the readers will be quite familiar with the contents of the full Assessment report.

The page is split into 4 section:

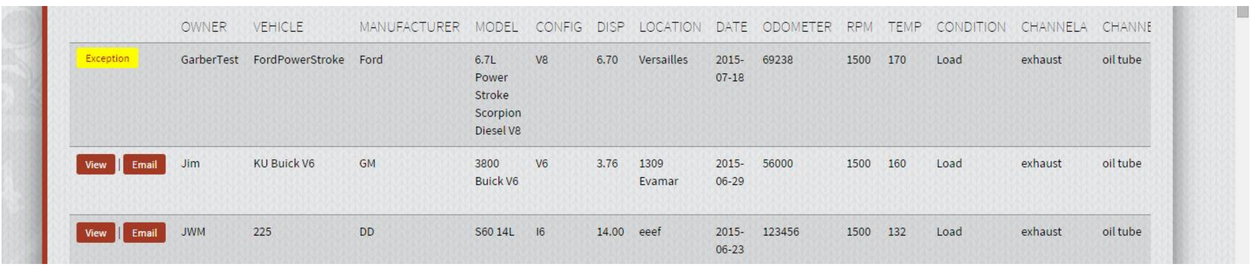
1. The information about the vehicle and engine being tested is displayed with the report headers, the owner, and date and location of the testing.
2. The second section contains the table of Assessment Scores. A sentence summarizes the findings for each of the 3 **upper-engine scores** with the ‘pressure’ scores first, and with 2 vibrational analysis scores following. Likewise, the 3 scores for the **lower engine** are displayed with a sentence describing possible interpretations of the observations.
3. Three graphics display the data and some analysis:
   The first P**oints** set illustrates the similarities and differences in the performance between the cylinders. If the points are within the green circles of the Exhaust Points graph, the engine is running very smoothly. In the Crankcase points graphic, the cylinder points should be matched pair-wise or there is an ‘imbalance’ from one engine rotation to the next (in a 4-cycle engine).
   The P**rofiles** graphs plot the pressure waveforms for each cylinder during one engine cycle. The Exhaust pressure profile (left side) shows variation in the pressure over time (the height is directly proportional to the pressure) and the variation in duration is a good measure of the temperature of the exhaust out of that cylinder – a ‘hot’ cylinder typically has very good combustion whereas a ‘cold’ cylinder (longer duration) had poor combustion.
   The Crankcase cylinder profiles should arrange in pairs if the engine is running well since the pattern should be equivalent between the two rotations of the crankshaft.
   The **Model** graphic (on the right side) plots the sensor values over time for at least one engine cycle. The upper graph shows the lower frequency ‘pressure’ waveform in green and the raw data with vibrations in black. Cylinders with small variations indicate cylinders with misfires; A cylinder or two with very high variation indicate that the misfire was ‘with fuel’.
4. The bottom section of the report lists up to 3 warnings that suggest testing conditions that may give non-representative data and hence, misleading conclusions.

The engine that produced this report was in very bad shape. The exhaust shows a misfire with fuel and the crankcase shows major problems in the ‘lower engine’. Each stroke takes an average of 144° of rotation. Each cylinder has all valves closed for 360° (during the compression and power strokes). If a piston has a detonation hole in it or is cracked, it will push all the air in the cylinder through the hole to the crankcase during its compression stroke and during the power stroke, will let the crankcase pressure flow back into the cylinder allowing the crankcase pressure to return to ‘normal’. Its exhaust will be very flat since the compression had ‘no’ pressure and the power stroke had no combustion.

Exception Reports

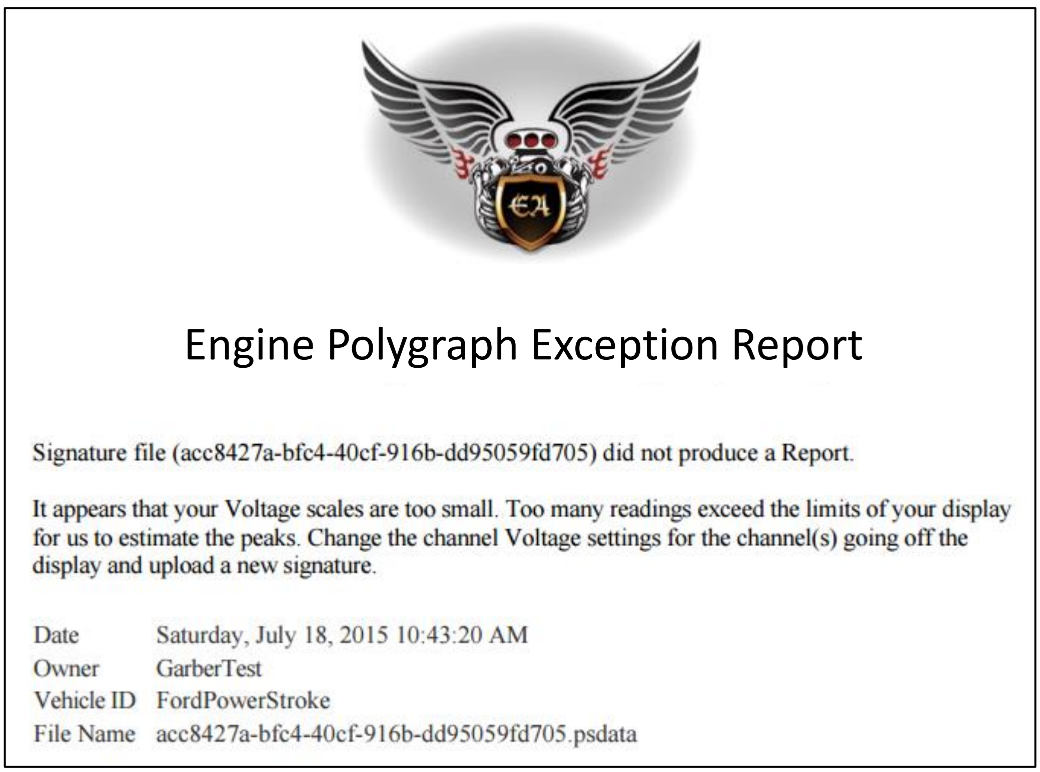
As mentioned earlier, if the analysis program is unable to reliably provide a useful report from the submitted data, you will receive an Exception report on the Assessments screen. The Exception reports are highlighted as a yellow box. The PDF report is downloaded when you click on the yellow button.

The nature of the problem and corrective action you might be able to take is provided in the report. See Fig. 10 for an example Exception report as it presents on the Assessments page. Fig. 11 has the Exception report for the situation of Fig. 10.



	OWNER	VEHICLE	MANUFACTURER	MODEL	CONFIG	DISP	LOCATION	DATE	ODOMETER	RPM	TEMP	CONDITION	CHANNELA	CHANNE
Exception	GarberTest	FordPowerStroke	Ford	6.7L Power Stroke Scorpion Diesel V8	V8	6.70	Versailles	2015-07-18	69238	1500	170	Load	exhaust	oil tube
View | Email	Jim	KU Buick V6	GM	3800 Buick V6	V6	3.76	1309 Evamar	2015-06-29	56000	1500	160	Load	exhaust	oil tube
View | Email	JWM	225	DD	S60 14L	I6	14.00	eeef	2015-06-23	123456	1500	132	Load	exhaust	oil tube

Figure 5: Assessments page showing a signature that could not be interpreted enough to generate a useful Assessment report.



Engine Polygraph Exception Report

Signature file (acc8427a-bfc4-40cf-916b-dd95059fd705) did not produce a Report.

It appears that your Voltage scales are too small. Too many readings exceed the limits of your display for us to estimate the peaks. Change the channel Voltage settings for the channel(s) going off the display and upload a new signature.

Date	Saturday, July 18, 2015 10:43:20 AM
Owner	GarberTest
Vehicle ID	FordPowerStroke
File Name	acc8427a-bfc4-40cf-916b-dd95059fd705.psdata

Figure 6: Example message presented on the Assessments page when the software is unable to process a submitted signature for analysis.

Warranty and Disclaimers

Predictive Fleet Technologies, Inc. (PFT) warrants the software will work as described. The warranty does not cover any problems with the Internet connection or your common-browser (Internet Explorer, Chrome, or FireFox) compliant workstation (desktop, laptop, or tablet). We will store your signatures, up to 10 meg (typical values are under 200 KB), and maintain them in a searchable and retrievable manner as described in the accompanying document. We use standard security, data and application backup & restore methods to protect your data investments from most natural and criminal events. If data are deleted or changed by people whom you have authorized, we cannot guarantee recovery.

The Engine Polygraph® Assessment report automates many of the steps that a user would perform manually in interpreting a SenX waveform from an internal combustion engine. It requires a waveform of adequate strength and sample frequency generated by the customer's oscilloscope such that meaningful information can be detected from the signal. Meaningful results can be expected only if the testing procedure is correctly followed; e.g., the connections of the cables are reliable, the equipment (oscilloscope, cables, sensors, etc.) work satisfactorily, and the oscilloscope parameters are set to reasonable values of duration (at least 4 rotations of the engine crankcase), sampling at about 40k Hz per channel).

It is also required that certain inputs to the EnginePolygraph Assessment request be accurate: the engine manufacturer and model must at least have the correct engine configuration & strokes per cycle and the approximate RPM input to the EnginePolygraph application is assumed to be within +/- 10% of the actual value.

The Engine Angel Assessment is NOT designed to measure misfires due to conditions such as poor fuel or irregular ignition. The Engine Angel software looks for defects that are measurable with each engine engines of either cycle (2- or 4-stroke).

The Assessment report uses advanced mathematical methods to classify the cylinder features extracted from the signatures: one from the exhaust and the other from the crankcase, usually via the oil dipstick tube. It is required that the oscilloscope channels are assigned correctly, in alignment with the connections and placement of the FirstLook® sensors. If the exhaust system has holes allowing exhaust to prematurely escape before reaching the sensor, or if particulate filters reduce or 'average' the pressure at the sensor to a very distorted level, meaningful results will not be achieved. Upon receiving a meaningful signature file, the Assessment report will display the results of a 'supervised learning' software to classify the condition of the engine's 'upper' and 'lower' components based on observation of many other engines. The measures of volumetric efficiency and valve seating condition are based on other methods. These classifications will likely improve over time and newer versions (as displayed on the report) will provide those improved results when available to you, the customer.

It is up to you to decide what action you should take based on the Assessment report. The recommendations we make are based on feedback from others' experiences. PFT is not liable for damages resulting from the implementations of such recommendations; we provide them to you for your judgment in decisions on what to do.

THERE IS NO WARRANTY OF MERCHANTABILITY. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION HEREIN. THERE ARE NO WARRANTIES EXPRESSED OR IMPLIED OR ANY AFFIRMATION OF FACT OR REPRESENTATION EXCEPT AS SET FORTH HEREIN.

REMEDY

If you suspect that there has been an error in the storage, indexing, assessment or retrieval of your data, please contact us immediately at support@PredictiveFleetTechnologies.com and/or contact us by phone: 1-833-364-2645. We will work with you to understand what happened and what recovery plan we can put in place.

In no event shall PFT be liable for damages of any nature, including incidental or consequential damages, including but not limited to any damages resulting from non-conformity, defect in design or workmanship.

Neither PFT nor its affiliates shall be liable to the subscriber of this product or third parties for damages, losses, costs, or expenses incurred by the subscriber or third parties as a result of: accident, misuse, or abuse of this product or unauthorized modifications, repairs, or alterations to this product, or failure to strictly comply with PFT's operating and maintenance instructions.

Contact Us

Learn more about us at www.EnginePolygraph.com, www.engineangel.com, and www.senxtech.com.

For specific questions about the Engine Polygraph® functionality, please email us at support@PredictiveFleetTechnologies.com or call us at 1-833-364-2645.

[1] SenX is a trademark of SenX Technology, Inc., Midland. MI
[2] PFT, Engine Angel, Engine Polygraph and EnginePolygraph are trademarks of Predictive Fleet Technologies, Inc., Inc., Midland, MI

Appendix 1: Glossary

Engine Polygraph® Glossary

Administrator	An administrator is an employee of a company (customer of EnginePolygraph) who has authority to pay for EnginePolygraph subscriptions, add new users of EnginePolygraph for the company, and to change the authorizations of the users of EnginePolygraph.
Predictive Fleet Technologies	Predictive Fleet Technologies is the name of the company that developed, supports, and operates the Engine Polygraph® software .
Assessment report	Assessment is the analysis of a 'Load' condition signature with simultaneous 'exhaust' and 'oil tube' sensor recordings that calculates 'scores' with values from 1 (very good) to 9 (very poor). The information is available as a PDF, and if the Owner is a subscriber to Engine Angel, in the database for time series graphics of the scores over time.
CHANNEL x	The channel identifier tells which of several SenX FirstLook® sensors is attached to which channel on the oscilloscope. The options for where to place the SenX FirstLook sensor are provided in a pull-down.
COMMENTS	Comments are free text entries on a signature index to help retrieve them in the future.
Company	A company is the paying customer of an EnginePolygraph subscription. It typically is a vehicle maintenance/repair facility. It may have one or more locations, but multiple locations should each have their own subscription unless their customer vehicles are serviced at multiple locations.
CONDITION	The condition of an engine describes the state of the engine during a single signature file. The values are obtained from a pull-down, including idle, load, and cold crank (c-c). Idle is typically under 1000 RPM, load is about 1500 RPM or higher, cold crank occurs when the engine is turning over under the power of the starter.
CONFIG or Engine Configuration	Config is short for configuration. The configuration of an engine describes the number of cylinders in the orientation of the cylinders with respect to each other. Its value is obtained from the EngineAngel database for the selected engine model. (E.G., V6 or I4)
DATE	Date is short for ‘measurement date’. The measurement date is the date when the associated ‘signature’ file was created using an Engine Polygraph kit.
Diagnostic report	The Diagnostic report is an analysis of the data from a ‘Signature’ file of data, data about the engine model being tested, and some test conditions data. The report evaluates the ‘physical integrity’ of the engine AND an Expert System evaluates ‘Abnormal Observations’ detected to produce a list of possible causes of the Abnormal Observations along with a confidence that the indicated cause is correct and suggestions that might remedy the problem.
DISP or Displacement	Disp is short for displacement. The displacement of an engine is the volume swept out as the pistons move up and down one time for each cylinder. It is provided by the system from the Engine Model database and reported in liters.

Distributor	A company that typically sells SenX FirstLook® sensors and kits who have an agreement with Predictive Fleet Technologies to offer their customers 'Price Keys' with special pricing and terms for the customer and with commission terms that Predictive Fleet Technologies promises to pay the distributor.
Engine Angel	Engine Angel® is the name of the software produced by PFT to analyze the signatures. See www.engineangel.com. Engine Angel also provides a broad range of Fleet Management functions.
Engine Angel Assessment?	The Engine Angel Assessment is a question asking if the system should generate an Assessment. There is the normal charge for the Fleet Engine Angel account if the Owner is an Engine Angel subscriber, or the EnginePolygraph subscriber's account will be charged if the Owner is not an Engine Angel subscriber to SenX Assessments.
Engine Angel Subscriber	Engine Angel Subscriber is a checkbox filled by the system when it recognizes the Owner you have input as the same as the Fleet ID in Engine Angel. This causes new adds (when the Vehicle ID is known as belonging to the Fleet ID) to analyzed by Engine Angel and the Assessment data sent to the Fleet ID database of Engine Angel.
Engine Features	Ignition method, Firing Order and cylinder-to-bank assignment are provided by PFT when known.
Engine Flaws	Common Engine Flaws for an Engine Model and time-period are listed for the user's consideration when made know to PFT through manufacturer communications or mechanic blogs.
Engine Poly Purpose	Engine Poly Purpose is a selection from a pull-down to indicate the purpose of this signature: ***Single*** if it is a 'one-off'; ***Before*** if it is preliminary to a planned 'procedure'; ***After*** if it follows a procedure; or ***Base*** if it is an 'as-new' signature for future reference for deterioration.
Engine Polygraph	Engine Polygraph® is a trademark for the use of EnginePolygraph.com to compare the 'before repair/treatment' with an 'after repair/treatment' to demonstrate the effectiveness of the work done. URL is www.enginepolygraph.com.
Engine Technologies	Distinctive Engine Technologies are listed engine technologies identified for the indicated engine model design by the National Insurance Crime Bureau (NICB). Only those considered relevant to Signature analysis are listed.
EPReader	EPReader is a PC software to aid in the reliable collection of engine signatures for analysis and reports provided by the Engine Polygraph and Engine Angel Internet applications.
FILE	File is the name of the file created by the oscilloscope. It contains the details of the waveform generated by the FirstLook® sensor.
FirstLook	FirstLook® is the registered trade name of the sensor product produced by SenX. Often referred to as 'FLS'.
Fleet ID	Fleet ID is the identifier of the Fleet that owns the Vehicle being tested as known in the Engine Angel application.
LOCATION	Location is a description for the shop or garage where the signatures are collected.
MANUFACTURER	Manufacturer is the name/acronym of the **engine** manufacturer. It is selected from a pull down list. Although most of the engine manufacturers can be determined from the vehicle brand/manufacturer, buyouts and joint ventures can 'cloud the waters'. In rare cases, you may need to search the internet to pin down unusual situations.
MODEL	Model is an identifier of the **engine** model manufactured by the selected engine manufacturer. It is selected from a pull-down list of the models previously made by the Engine Manufacturer.

ODOMETER	On the vehicle odometer at the time of the visit when the signatures are taken. It is quite important that either kilometers or miles are consistently used for all vehicles maintained by the company. Or it may be 'Hours of Operation' for the engines in a fleet.
oscilloscope	An oscilloscope is an instrument that converts the analog signals to a voltage from the FirstLook® sensor to a digital value that is recorded in the file.
OWNER	The owner **Owner** identifies the vehicle owner or Fleet name. NOTE: If the name you enter in the Owner field is the name for a Fleet that has a subscription to Engine Angel Fleet Management software and has requested that your company provide reports, the Fleet name will appear in the Fleet field and the Engine Angel Subscriber box will be checked.
Report Selection	Parameter selected from a pull-down list to specify the report desired from the signature: ***Assessment***, ***Diagnostic***, or ***none*** (when storage of the signature is all that is desired for the submitted signature.
Polygraph	Engine Polygraph® is a trademark for the use of EnginePolygraph.com to compare the 'before repair/treatment' with an 'after repair/treatment' to demonstrate the effectiveness of the work done.
RPM	RPM is the number of revolutions per minute of the engine while the signature is being recorded in the file.
RPM Source	1. Some engines (many diesel engines) have an electronic speed control by means of a computer attached to the Electronic Control Module (ECM). If you use such a capability, enter the rpm that you had set as the controlled engine speed in the **RPM** value AND choose 'Set RPM' from the **RPM Source** pulldown. 2. If you have an OBDII Reader connected to EPReader, the system will retrieve the rpm value and engine coolant temperature from the ECM if you select 'ECM' from the **RPM Source** pulldown. 3. If you have more than two channels on your PicoScope and an induction clamp to enclose a spark plug wire or COT (depending on your engine's technology), you will want to leave the **RPM** value blank or 0 AND select 'Spark trigger' from the **RPM Source** pulldown. Then chose a channel (usually 'C') on the PicoScope for the input of the induction clamp cable and set the value for that Channel on the screen to 'trigger'. In such a case, the signal will be analyzed to achieve an accurate RPM. 4. If you have an accurate tachometer, you may input the **RPM** value you will run the engine at while the data is being collected. It will be important that the value you provide will be within 15% of the actual value or you may get an erroneous analysis. In this case, select 'Guess' from the **RPM Source** pulldown. 5. If you do not have an accurate **RPM** value, leave the value field blank or 0 AND select 'None' from the **RPM Source** pulldown. In this case, an estimate will be provided from the **Condition** option you select [Load, Idle, c-c (Cold-crank)] and the number of cylinders in the engine. Often this estimate is accurate enough to give a good analysis, but this is the least reliable of the options.
Rumble	The EP score assigned to the relative intensity of vibrations in a low frequency range in the crankcase when engine speed is 1500 RPM
Scrape	The EP score assigned to the relative intensity of vibrations of high frequencies in the crankcase when engine speed is 1500 RPM

Send Assessment to:	This box allows the user to specify an email address as the destination of the PDF Assessment report.
SenX	SenX® is the registered trade name of the company that manufactures the FirstLook® sensors.
Serial Number	Serial Number is the engine manufacturer's serial number provided by the Engine Angel Engine table IF the Owner is an Engine Angel subscriber and the Vehicle is registered in that Engine Angel Engine table.
Signature	A signature is the name of one or more waveforms taken simultaneously with FirstLook® sensors from a specific engine under given operating conditions in one file.
Signature index	The signature index is a set of attributes describing the vehicle, owner, operating condition with date and location to allow easy retrieval in the future.
TEMP or Engine Temperature	Temp is short for the temperature of the engine coolant at the time the signature is taken. It is important that the temperature always be reported in either degrees Celsius or degrees Fahrenheit in a given one shop.
Trigger Cylinder	The cylinder number (according to the OEM's engine block layout) of the cylinder you have placed a trigger to identify that cylinder on the EP graphics and the firing sequence of the test engine. You must also identify the channel that contains the trigger signals to the PicoScope.
USER	User is the identifier of a person authorized to access the EnginePolygraph system. Users are added and authorizations given by a specific group of users called Administrators.
Upload File	The Choose File button prompts a window for the search of the User terminal's attached storage devices to identify the signature recorded by the oscilloscope. The result is to store the selected file in the EnginePolygraph database for later reference.
VEHICLE	Vehicle is the identifier of the chassis containing the engine that is being serviced and whose signature is being recorded. In the case of a fleet vehicle, is commonly the identifier painted on the vendor or door of the vehicle; in the case of personal automobiles or pickups, it might be the license plate number or other unique identifier.