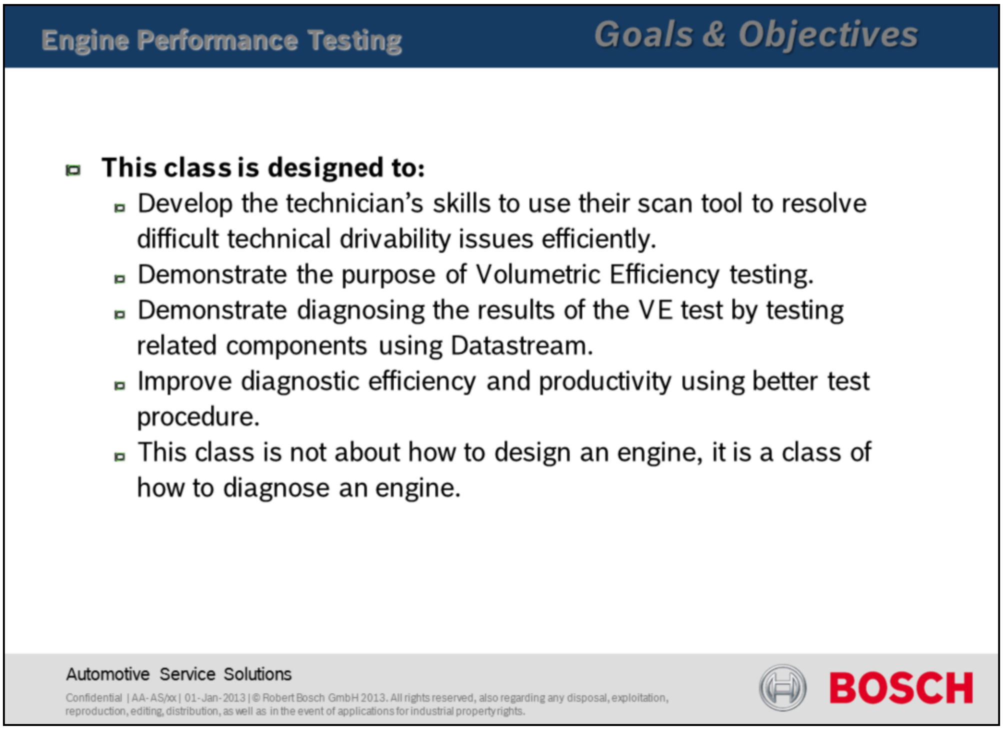
Volumetric Efficiency Test and Diagnostics

Engine Performance Testing

Steve Zack



<u>This class is designed to:</u>

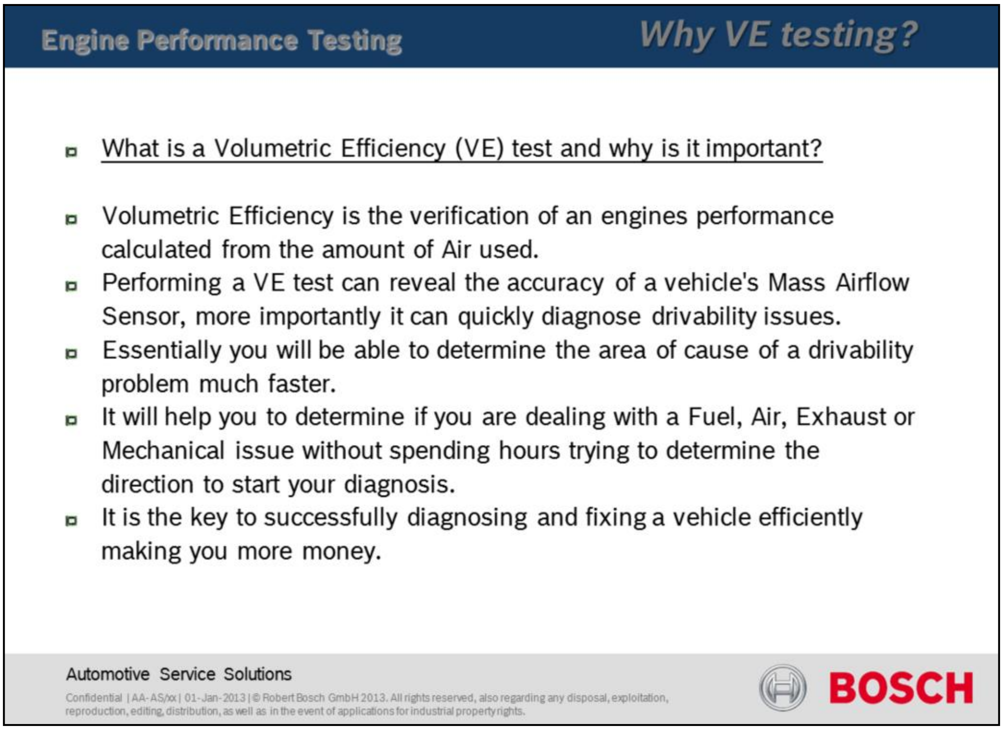
Develop the technician's skills to use their scan tool to resolve difficult technical drivability issues efficiently.

Demonstrate the purpose of Volumetric Efficiency testing.

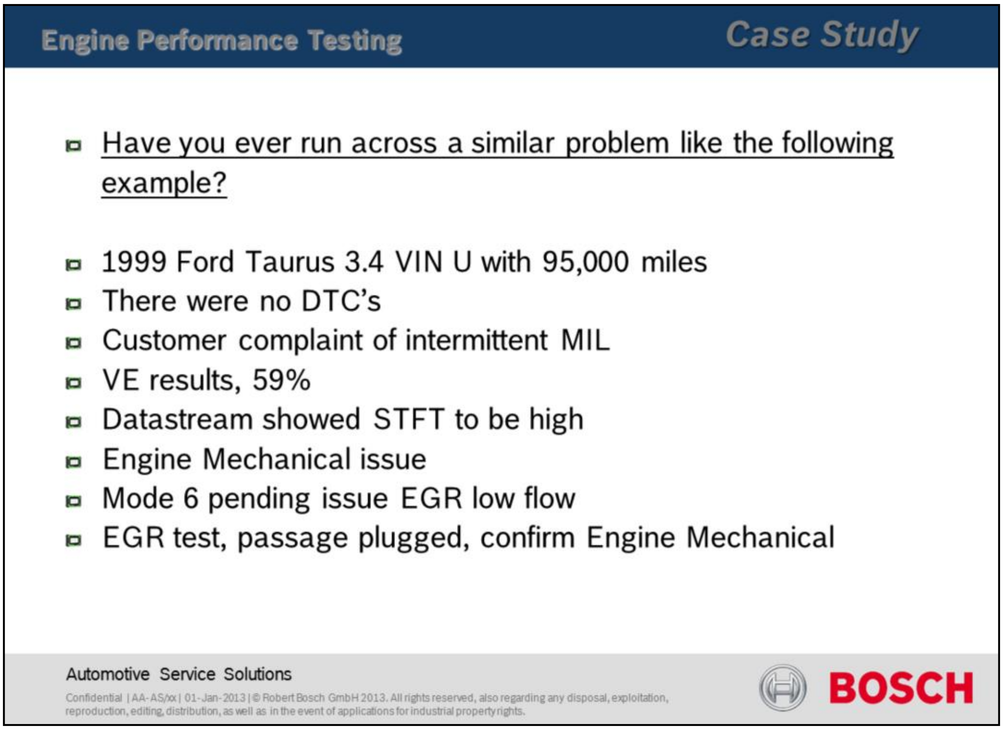
Demonstrate diagnosing the results of the VE test by testing related components using Datastream.

Improve diagnostic efficiency and productivity using better test procedure.

This class is not about how to design an engine, it is a class of how to diagnose an engine.

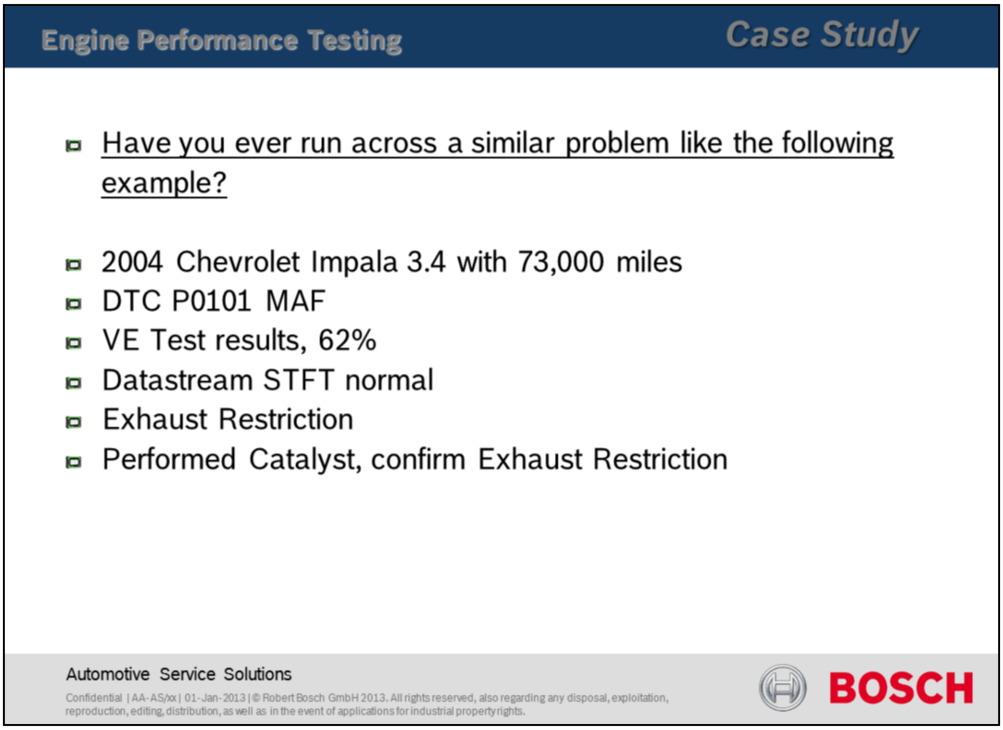


Volumetric Efficiency is the verification of an engines performance calculated from the amount of Air used. Performing a VE test can reveal the accuracy of a vehicle's Mass Airflow Sensor, more importantly it can quickly diagnose drivability issues. Essentially you will be able to determine the area of cause of a drivability problem much faster. It will help you to determine if you are dealing with a Fuel, Air, Exhaust or Mechanical issue without spending hours trying to determine the direction to start your diagnosis. It is the key to successfully diagnosing and fixing a vehicle efficiently making you more money.



<u>Have you ever run across a similar problem like the following example?</u>

Recently at a shop I was presented with a 1999 Ford Taurus 3.4 VIN U with 95,000 miles. There were no DTC's, just a customer complaint of intermittent MIL. I did the VE Test which was low at 59%. A review of Datastream showed STFT to be high, this info combined with the results from the VE test lead me to believe an engine Mechanical issue. Upon checking Mode 6 there was a pending issue of an EGR low flow. Mode 6 test values were just above the minimum but not below, thus not setting an EGR DTC. The combined results confirmed a mechanical problem. I performed an EGR test proving the EGR passage was plugged. After cleaning the EGR passage the problem was solved.



Have you ever run across a similar problem like the following example?

Another shop had an issue with a 2004 Chevrolet Impala 3.4 with 73,000 miles. I reviewed the DTC, it had a P0101 MAF. I then did the VE Test which was lower than normal level for a vehicle of that age, 62%. A review of Datastream showed STFT to be normal, combined with the results from the VE test lead me to believe an Exhaust Restriction. I did a quick Catalyst test and discovered I had a partially plugged Catalytic Convertor, confirming an Exhaust Restriction. After replacing the Catalytic Convertor the problem was solved.

Volumetric Efficiency Tests

Calculating VE

Volumetric Efficiency Calculator

OTCtools.com/ve

Diagnosing Low VE

Mechanical Engine Diagnostics
- MAP Sensor Test

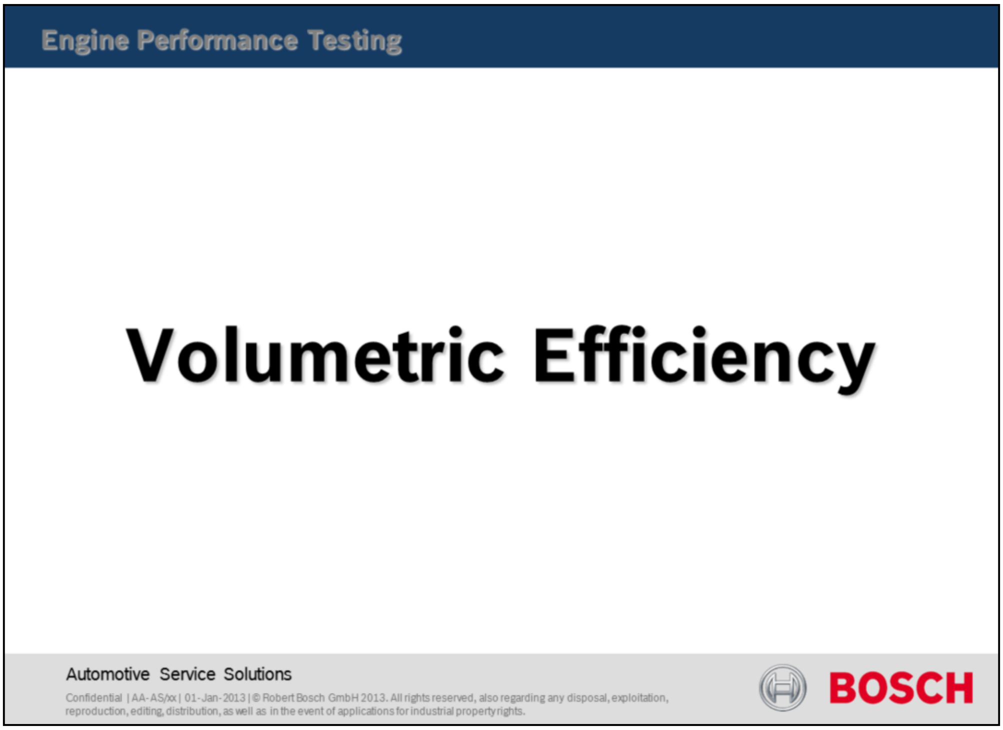
MAF Diagnostics
- MAF Test

Fuel Systems Diagnostics
- Fuel Trim
- H02S Test
- AFR Sensor Test
- FRP – Fuel Rail Pressure Sensor

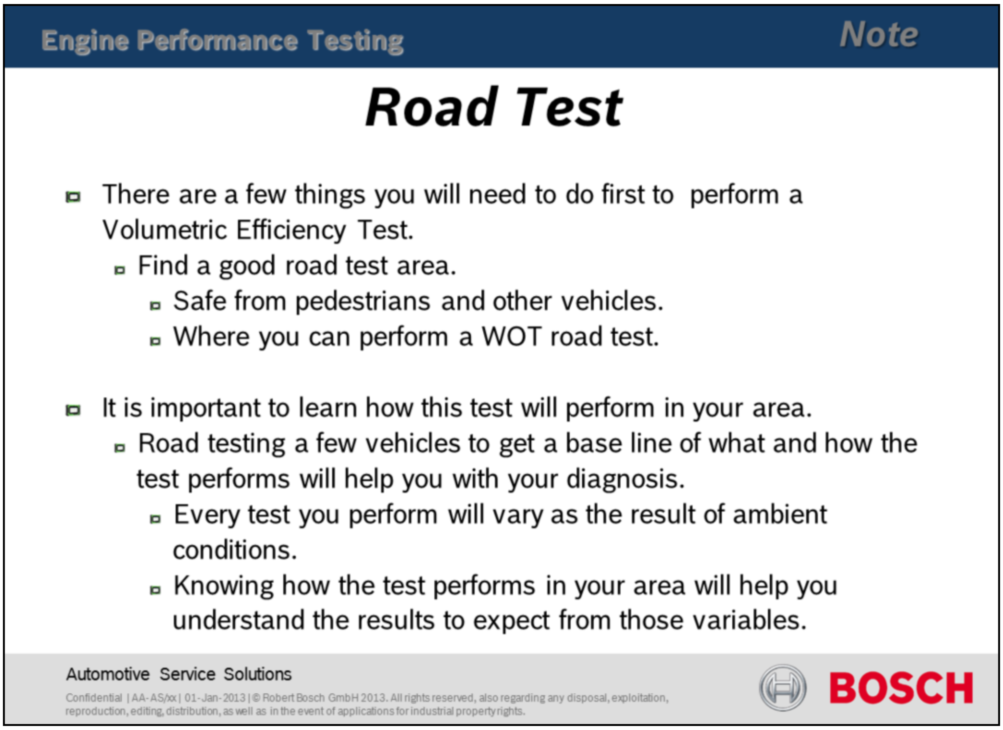
Intake Air Restriction
- MAF Test

Exhaust Restriction
- Catalyst Tests

Contents



Understanding the math is not an absolute necessity as there are calculators available on the internet which I will show you. The reason for reviewing the math is so you will understand better how it works to help you with your diagnostics. Bear with me as I walk you through the formula and then I will show you an internet calculator and how to use the VE calculator as a diagnostic tool.



There are a few things you will need to do first to perform a Volumetric Efficiency Test:

1. Find a good road test area
2. Safe from pedestrians and other vehicles
3. Where you can perform a WOT road test

It is important to learn how this test will perform in your area. Road testing a few vehicles to get a base line of what and how the test performs will help you with your diagnosis. Every test you perform will vary as the result of ambient conditions. Knowing how the test performs in your area will help you understand the results to expect from those variables.

Road Test

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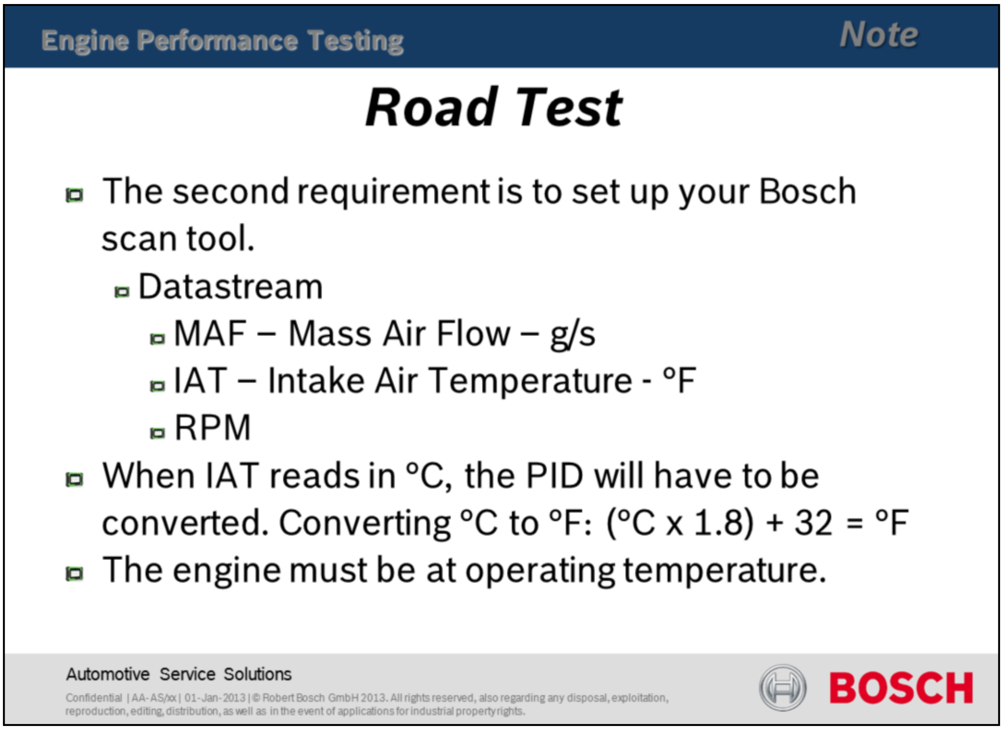
Road Test area must be Safe from pedestrians, obstruction and other vehicles.



The second requirement is to set up your Bosch scan tool to show Datastream recording the following:

1. MAF – Mass Air Flow – g/s
2. IAT – Intake Air Temperature - °F
3. RPM

When IAT reads in °C, the PID will have to be converted.

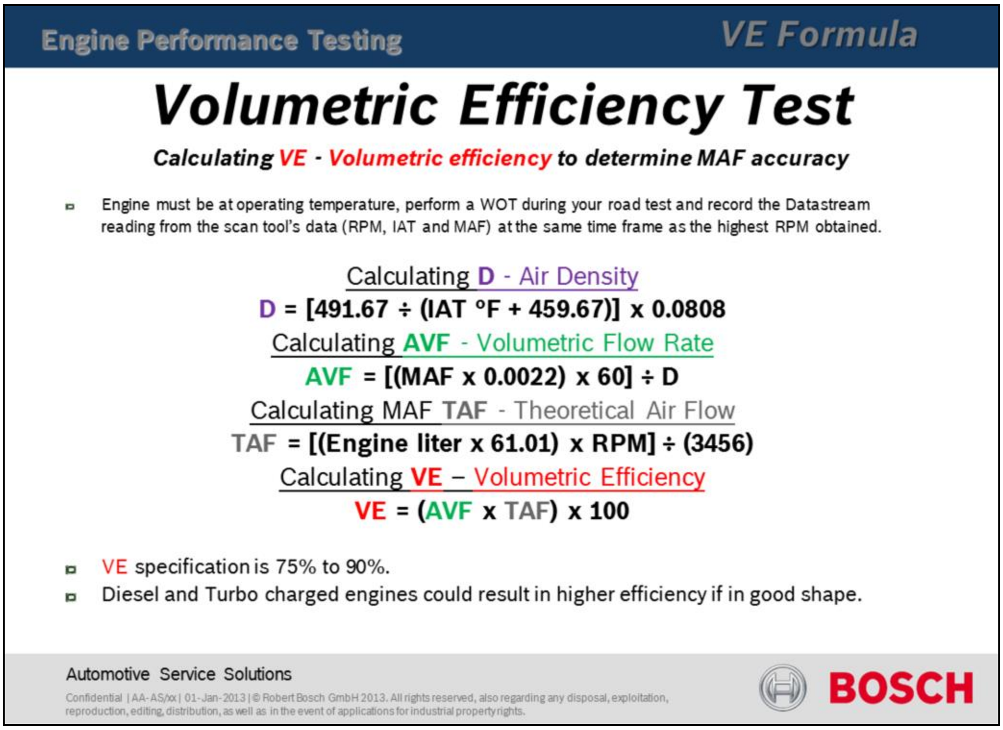
Converting °C to °F: (°C x 1.8) + 32 = °F

The engine must be at operating temperature.

While performing many of these tests, to obtain the fastest possible Datastream refresh rate, please select individual Datastream PID’s you are using for your diagnostic strategy and display them only.

°C	°F
-40.00 °C	-40 °F
-34.44 °C	-30 °F
-28.89 °C	-20 °F
-23.33 °C	-10 °F
-17.78 °C	0 °F
-12.22 °C	10 °F
-6.67 °C	20 °F
-1.11 °C	30 °F
0 °C	32 °F
4.44 °C	40 °F
10.00 °C	50 °F
15.56 °C	60 °F
21.11 °C	70 °F
26.67 °C	80 °F
32.22 °C	90 °F
37 °C	98.6 °F
37.78 °C	100 °F
43.33 °C	110 °F
48.89 °C	120 °F

Your Datastream reading during the WOT needs to be recorded from the scan tool's data at the same time frame of the highest RPM obtained.



Purpose of this test is to verify MAF function and engine performance.

Engine must be at operating temperature, perform a WOT during your road test and record the Datastream reading from the scan tool's data (RPM, IAT and MAF) at the same time frame as the highest RPM obtained.

Calculating **D** – Air Density

$$D = [491.67 \div (IAT\ °F + 459.67)] \times 0.0808$$

Calculating **AVF** – Actual Volumetric Flow Rate

$$AVF = [(MAF \times .0022) \times 60] \div D$$

Calculating MAF **TAF** – Theoretical Air Flow

$$TAF = [(\text{Engine liters} \times .61.01) \times RPM] \div 3456$$

Calculating **VE** – Volumetric Efficiency

$$VE = (AVF \div TAF) \times 100$$

The calculation does not apply a correction factor for Altitude, Temperature and Humidity. The calculation assumes the necessary modifications for ambient condition through the use of IAT and MAF.

VE specification = 75% to 90%.

Diesel and Turbo charged engines could result with higher than 90% efficiency if in good shape.

Engine Performance Testing — VE Formula

Volumetric Efficiency Test

Solving D – Air Density for Volumetric efficiency

- **D = [491.67°R ÷ (IAT °F + 459.67°R)] x 0.0808**
- Calculate Air Density – **D**
- Convert °F to °Rankine
- IAT reading °F and add 459.67
- IAT °F + 459.67°R = °Rankine
- Ex: 118°F + 459.67°R = 577.67°R
- Air Density is the mass per cubic foot of air available for the engine to use.

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<u>Purpose of calculating Air Density: How much air is available for the engine to use.</u>

First you need to calculate Air Density which is also known as the symbol D. To do that you have to convert °F to °Rankine which is relatively easy, just take your IAT reading which should be in °F and add 459.67 to it. Now the temperature is reading °Rankine. Here is the formula:

IAT °F + 459.67°R = °Rankine

Ex: 118°F + 459.67°R =577.67°R

D = [491.67°R ÷ (IAT °F + 459.67°R)] x 0.0808

<u>Air Density:</u>

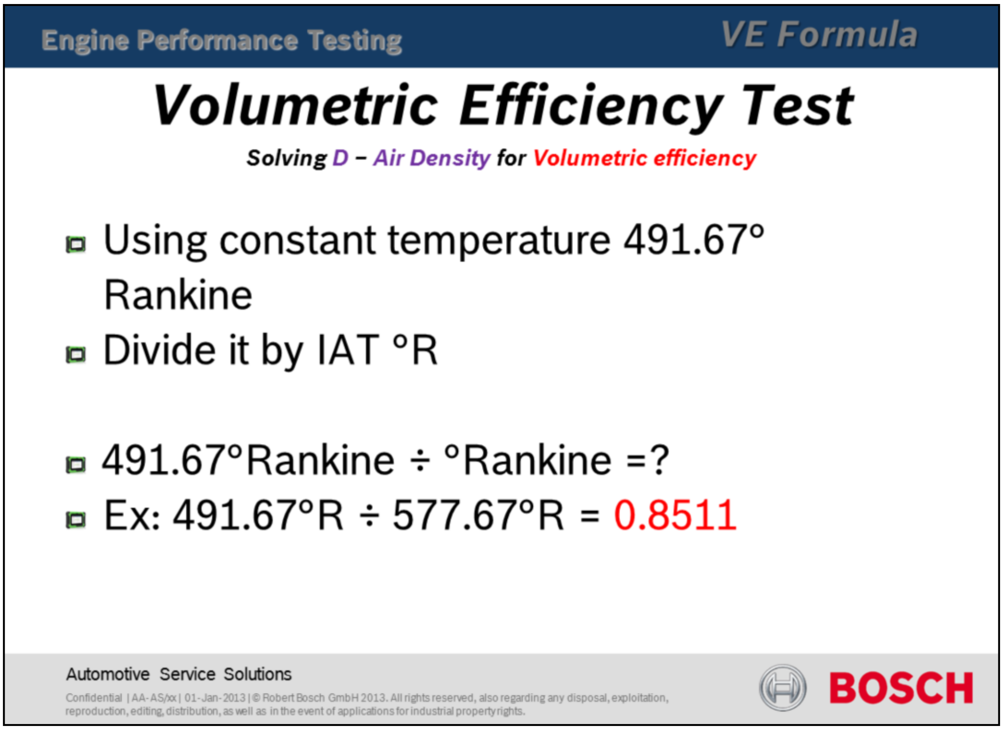
Air Density is the mass per cubic foot of air available for the engine to use. Earth's atmosphere which changes with the changes in altitude, temperature and or humidity.

<u>Convert to Rankine:</u>

The use of Rankine versus Fahrenheit provides for greater set of variables to use in the calculation, greater number of points on the scale, 1° F = 460.67° R. Rankine is measured in 100ths, 0.01. The chart below is broken down in tenths, 0.10, to show the difference of °F versus °R.

The vehicle used for the example on pages 13 to 23 is a 2001 Chevrolet Tahoe having a 5.7l engine with the scan tool reporting at WOT: IAT 118°F, MAF 128 g/s, RPM 3274

°F	0									1									2										3
°R	459.67	459.77	459.87	459.97	460.07	460.17	460.27	460.37	460.47	460.57	460.67	460.77	460.87	460.97	461.07	461.17	461.27	461.37	461.47	461.67	461.77	461.87	461.97	462.07	462.17	462.27	462.37	462.47	462.57	462.67



Now we will use a known constant temperature of 491.67° Rankine and divide that by what you just converted. This known constant temperature will always be the same every time you perform this calculation on any car you are working on.

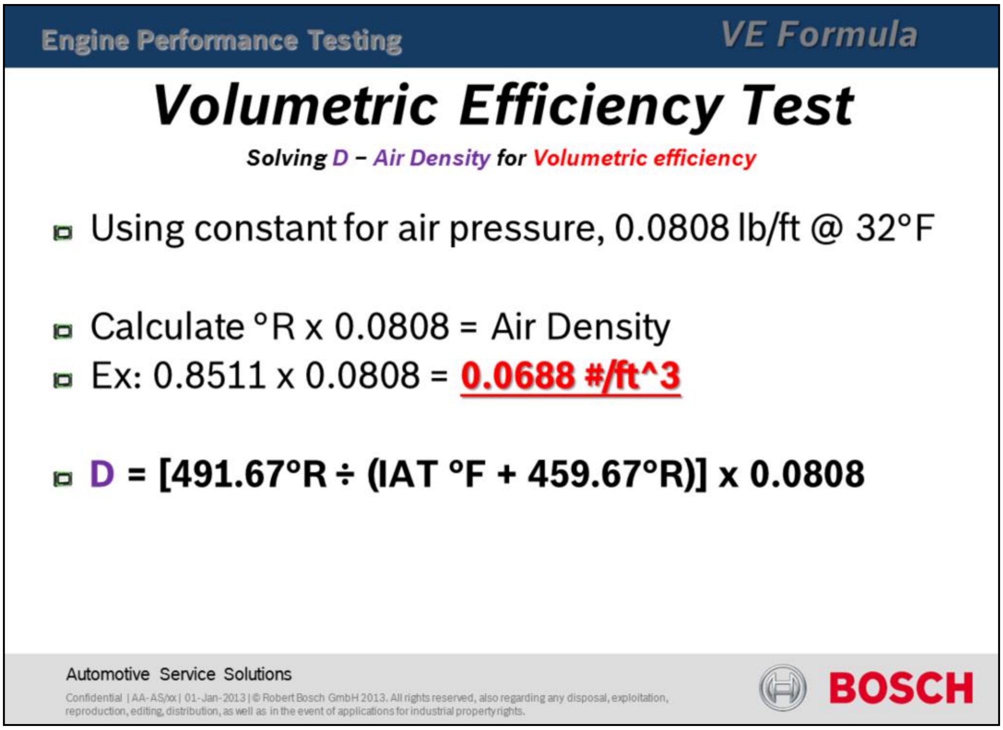
491.67°Rankine ÷ °Rankine =?

Ex: 491.67°R ÷ 577.67°R = 0.8511

I always round up to the 4th decimal place.

Constant in Math:

With a constant as the calculation begins to expand or degrade the constant is used to keep the base number as you recorded so it does not degrade or expand beyond the number used to calculate the results. When dealing with combustion as the temperature changes during the Volumetric Efficiency test the constant will sure that all temperature and pressure measurement remain as recorded and do not expand or degrade from the original recorded number.



Now for the final step of calculating Air Density, we need to use a constant for air pressure at a known density at a given temperature which is .0808 lb/ft at 32°F. This number will always be the same every time you perform this calculation, just like the constant for known temperature.

Calculate °R x 0.0808 = Air Density

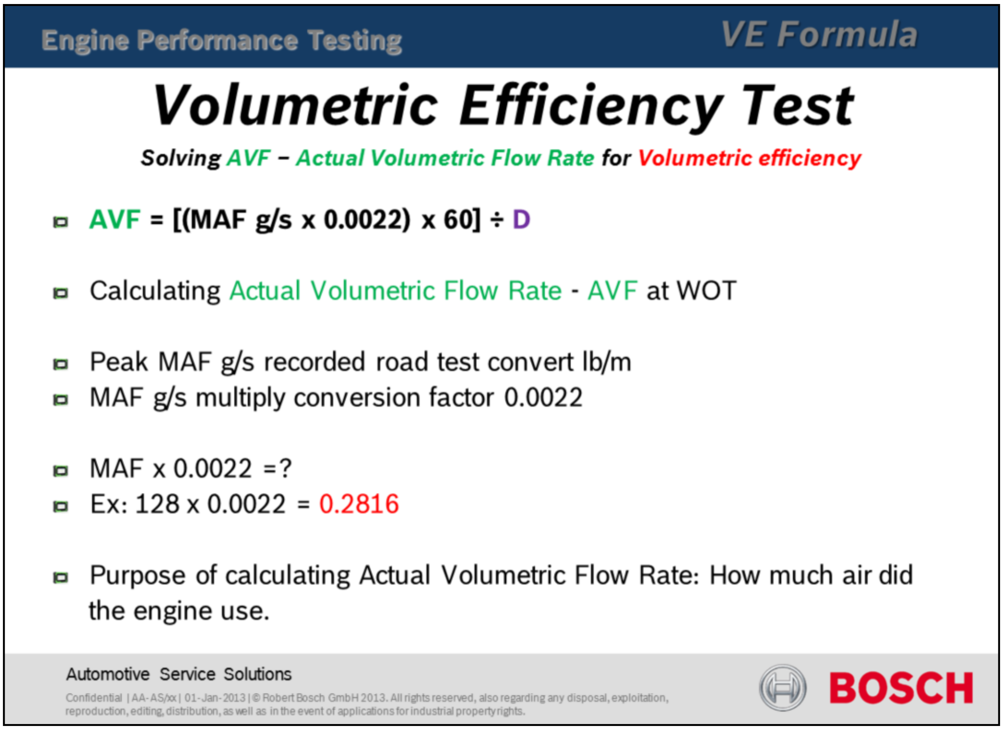
Ex: 0.8511 x 0.0808 = <u>0.0688 #/ft^3</u>

The actual formula is stated as:

D = [491.67°R ÷ (IAT °F + 459.67°R)] x 0.0808

<u>Constant in Math:</u>

With a constant as the calculation begins to expand or degrade the constant is used to keep the base number as you recorded so it does not degrade or expand beyond the number used to calculate the results. When dealing with combustion as the temperature changes during the Volumetric Efficiency test the constant will sure that all temperature and pressure measurement remain as recorded and do not expand or degrade from the original recorded number.



Purpose of calculating Actual Volumetric Flow Rate: How much air did the engine use.

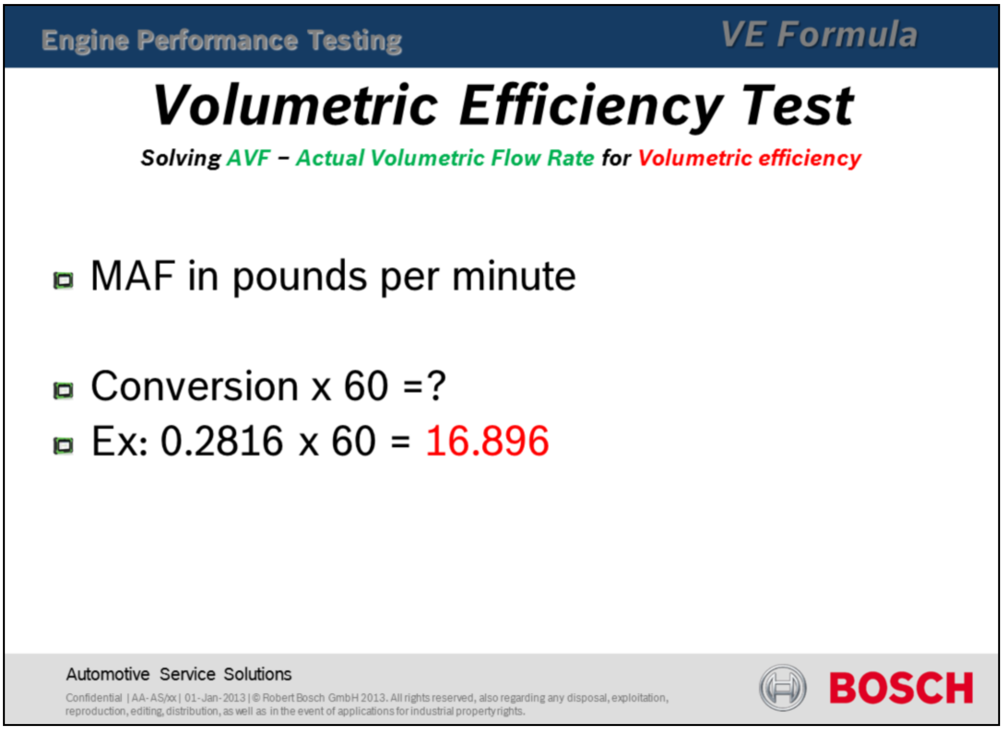
Now that you know the weight of the air the engine is using let's calculate how much air it used during the WOT. We have a ways to go yet, so relax and bear with me as I show you how to perform the next step of the calculation. The next step is calculating Actual Volumetric Flow Rate that the engine has consumed during the WOT road test, also known as AVF. For this we will take the highest MAF value recorded during the road test which is in grams per second, g/s, and convert that to pounds per minute, lb/m. This is going to be easy, you take the MAF reading and multiply it by the conversion factor of .0022 and then multiply that number by 60. Here is the breakdown of the formula:

MAF x 0.0022 =?

Ex: 128 x 0.0022 = 0.2816

Again I rounded up to the fourth decimal place.

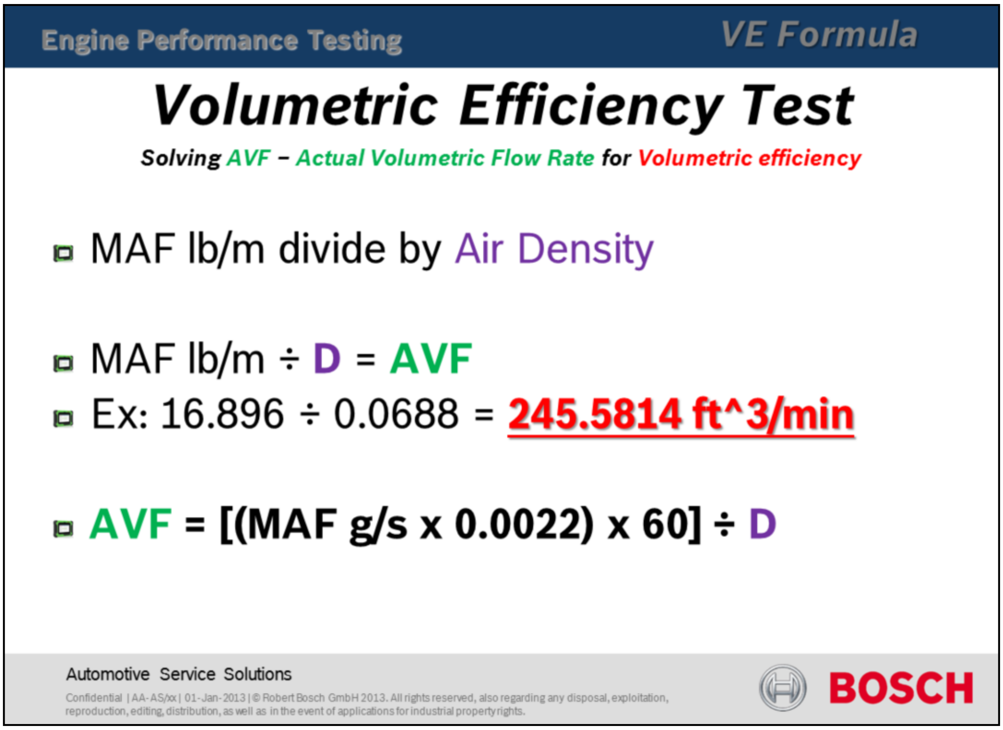
AVF = [(MAF g/s x 0.0022) x 60] ÷ D



Now let's do the second step of converting MAF to pounds per minute.

Conversion x 60 =?

Ex: 0.2816 x 60 = 16.896



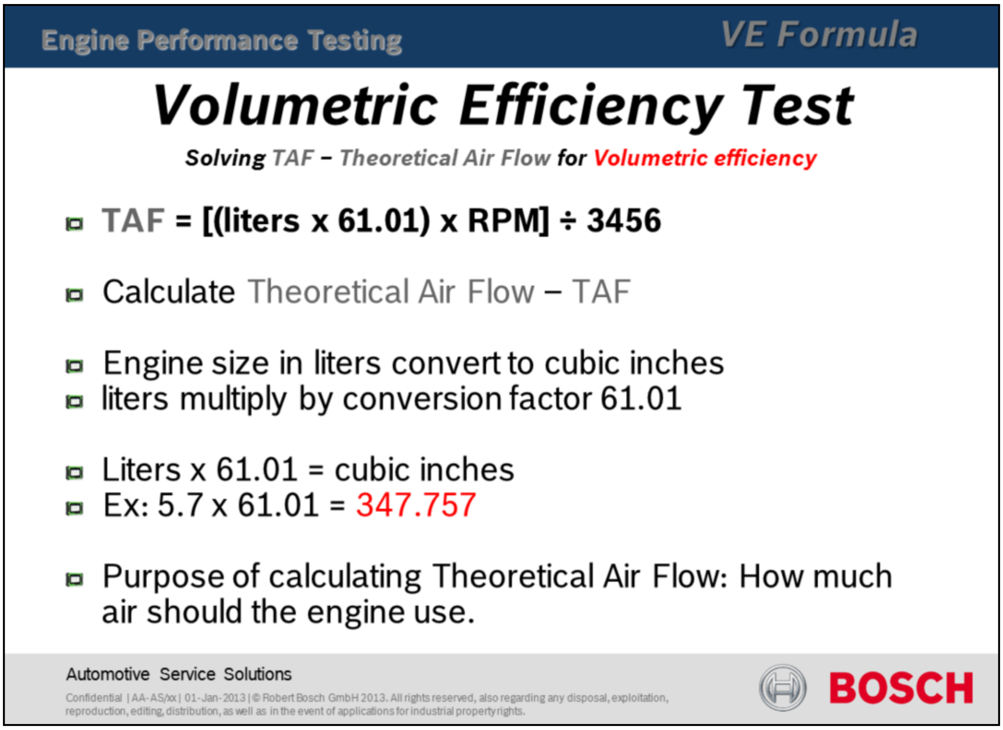
For the final part of calculating AVF you need to take the MAF in lb/m and divide that by the Air Density, D:

MAF lb/m ÷ D = AVF

Ex: 16.896 ÷ 0.0688 = 245.5814 ft^3/min

The complete formula for determining how much air the engine consumed during the WOT road test is:

AVF = [(MAF g/s x 0.0022) x 60] ÷ D



<u>Purpose of calculating Theoretical Air Flow: How much air should the engine use.</u>

For this part of the calculation you are going to calculate Theoretical Air Flow, how much air should the engine have used, which is also known as TAF. To perform this test you will need to know the engine size in liters and you will then convert that to cubic inches. If you already know the engine size in cubic inches you are in luck and things are little easier. Take the engine size in liters and multiply that by the conversion factor of 61.01.

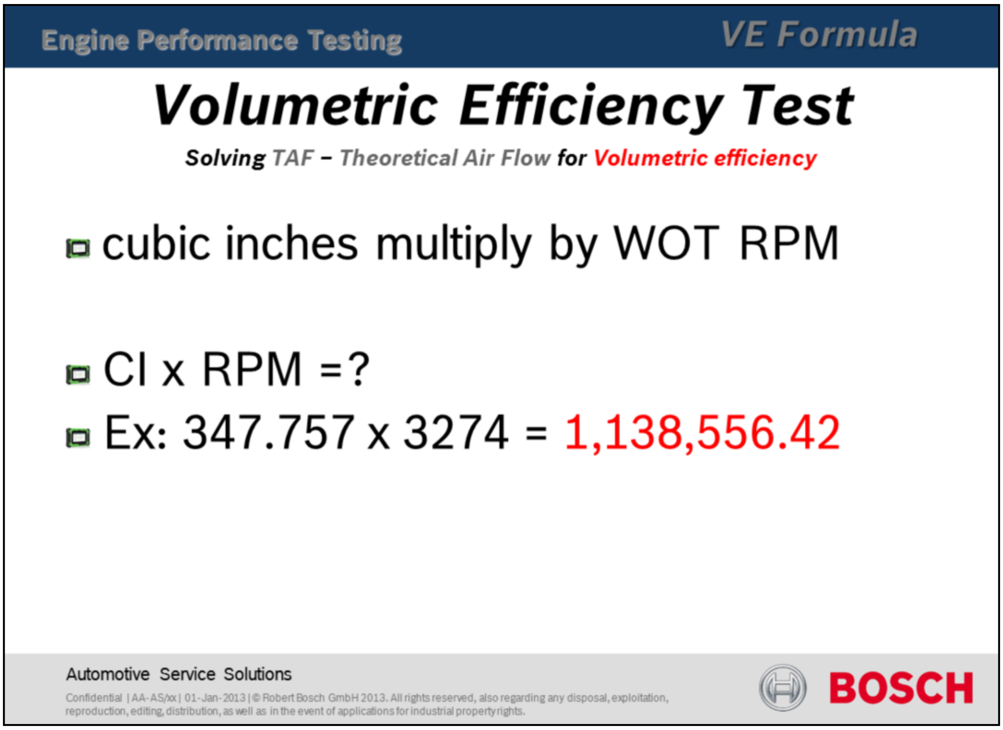
Liters x 61.01 = cubic inches

Ex: 5.7 x 61.01 =347.757

TAF = [(liters x 61.01) x RPM] ÷ 3456

<u>Constant in Math:</u>

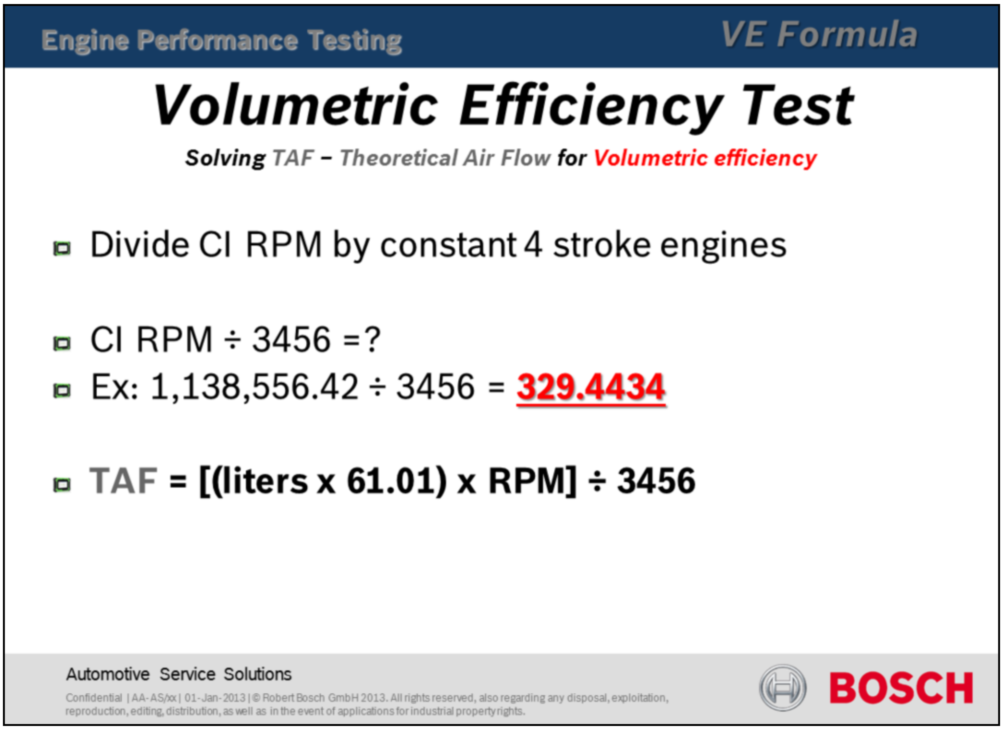
With a constant as the calculation begins to expand or degrade the constant is used to keep the base number as you recorded so it does not degrade or expand beyond the number used to calculate the results. When dealing with combustion as the temperature changes during the Volumetric Efficiency test the constant will sure that all temperature and pressure measurement remain as recorded and do not expand or degrade from the original recorded number.



The next step is to multiply the cubic inches by the WOT RPM you recorded.

CI x RPM =?

Ex: 347.757 x3274 =1,138,556.42



The last step for calculating TAF requires you to take that big long number you just calculated and divide it by a known constant for a four stroke engines. This constant, just like the other two, will always be the same each time you perform the calculation.

CI RPM ÷ 3456 =?

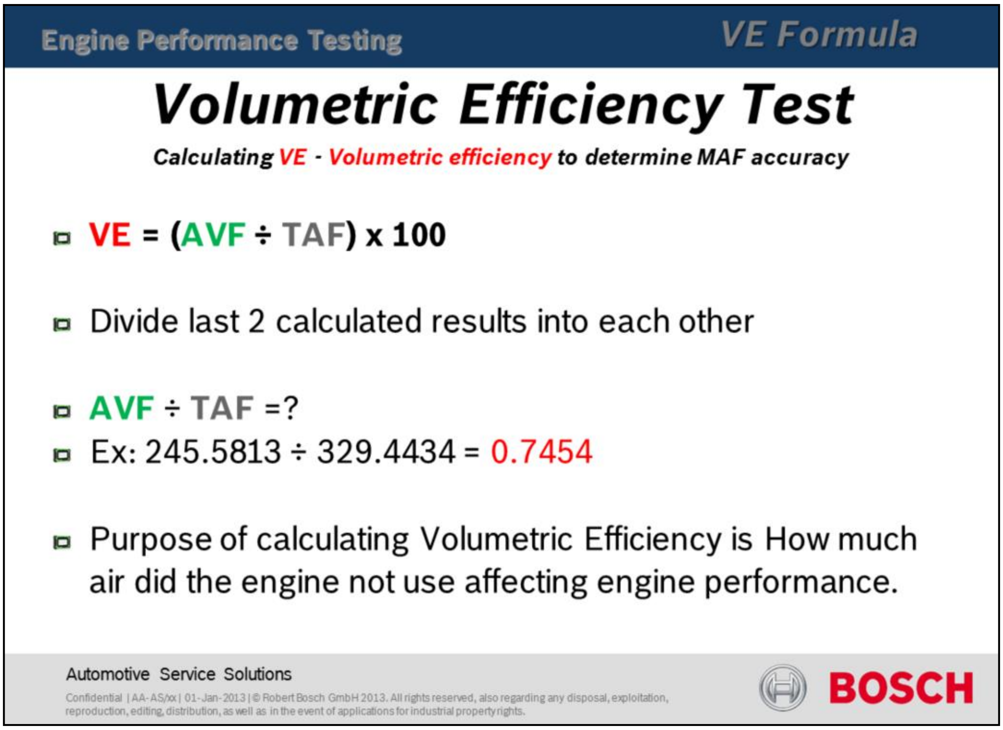
Ex: 1,138,556.42 ÷ 3456 =329.4434

The complete formula for TAF looks like this:

TAF = [(liters x 61.01) x RPM] ÷ 3456

Constant in Math:

With a constant as the calculation begins to expand or degrade the constant is used to keep the base number as you recorded so it does not degrade or expand beyond the number used to calculate the results. When dealing with combustion as the temperature changes during the Volumetric Efficiency test the constant will sure that all temperature and pressure measurement remain as recorded and do not expand or degrade from the original recorded number.



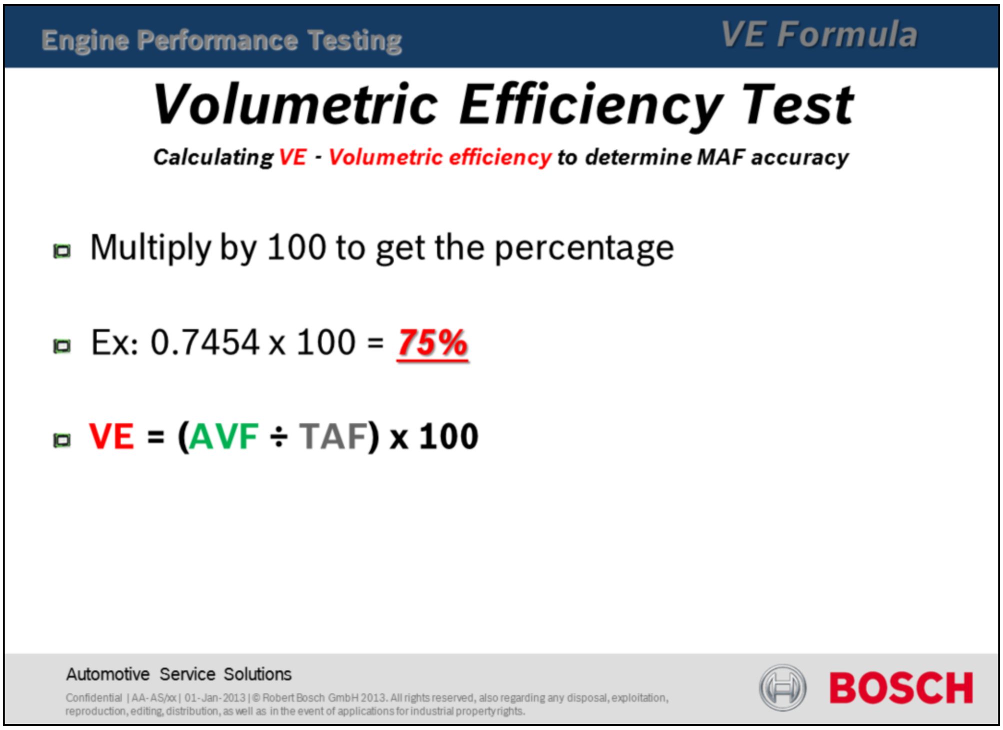
<u>Purpose of calculating Volumetric Efficiency: How much air did the engine not use affecting engine performance.</u>

Now we are near the end of the calculation for Volumetric Efficiency so you can figure out why your customer's engine is not performing as they want it to. The hard part is already done, all you have to do now is take the last two calculated results and divide them into each other and then multiply by 100. So let's go do the final part of the calculation and see what the Volumetric Efficiency for this 2012 Ford Focus is.

AVF ÷ TAF =?

Ex: 245.5813 ÷ 329.4434 = 0.7454

VE = (AVF ÷ TAF) x 100



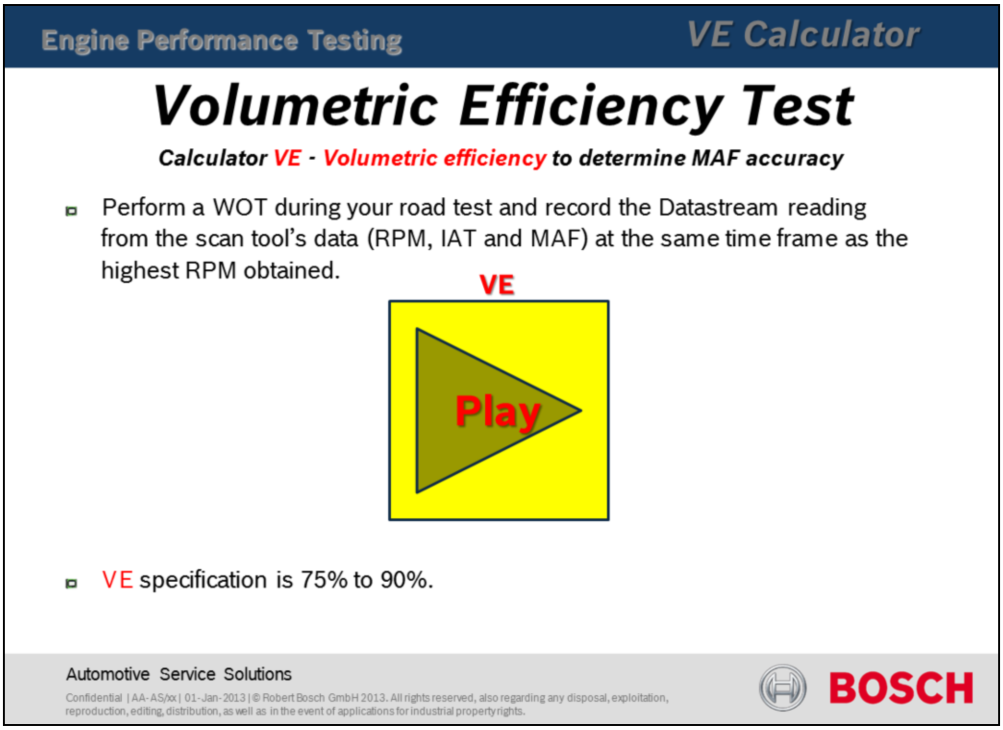
Now we need to multiply by 100 to get the percentage.

Ex: 0.7454 x 100 = 75%

Round off to the nearest whole number.

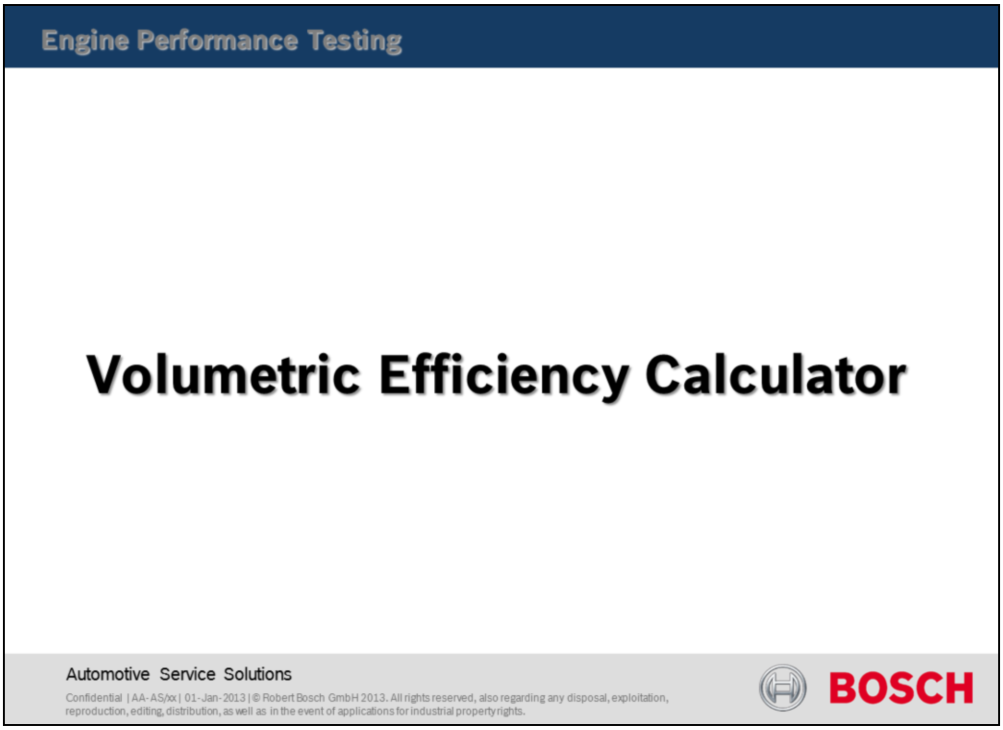
The final formula is stated as:

VE = (AVF ÷ TAF) x 100

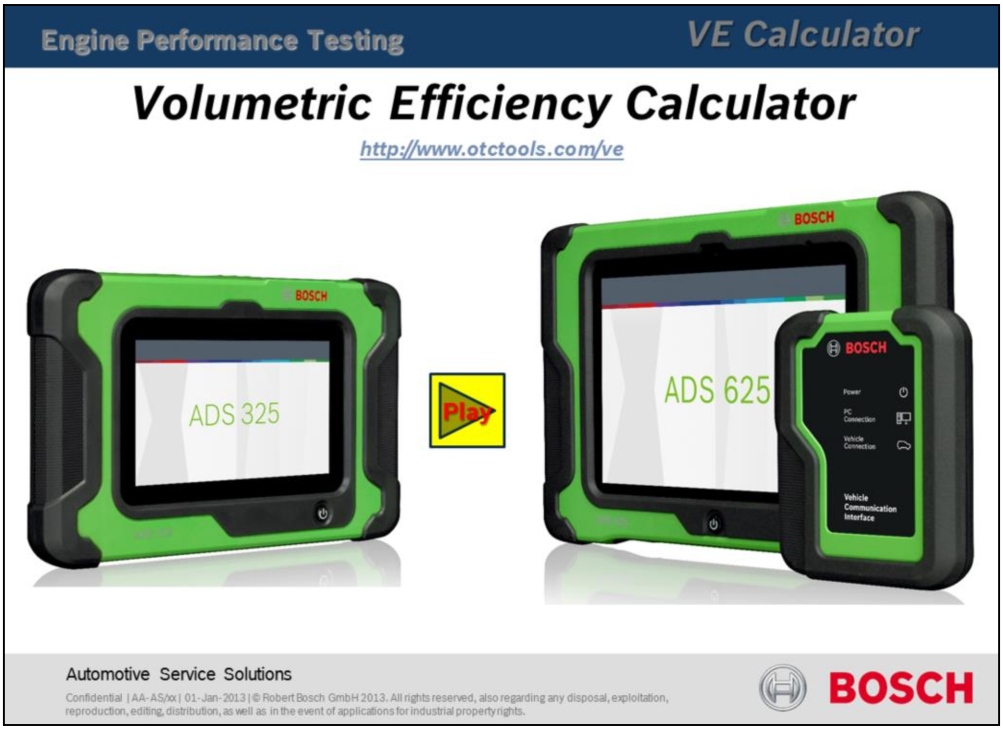


<u>VE specification = 75% to 90%.</u>

Perform a WOT during your road test and record the Datastream reading from the scan tool's data (RPM, IAT and MAF) at the same time frame as the highest RPM obtained.

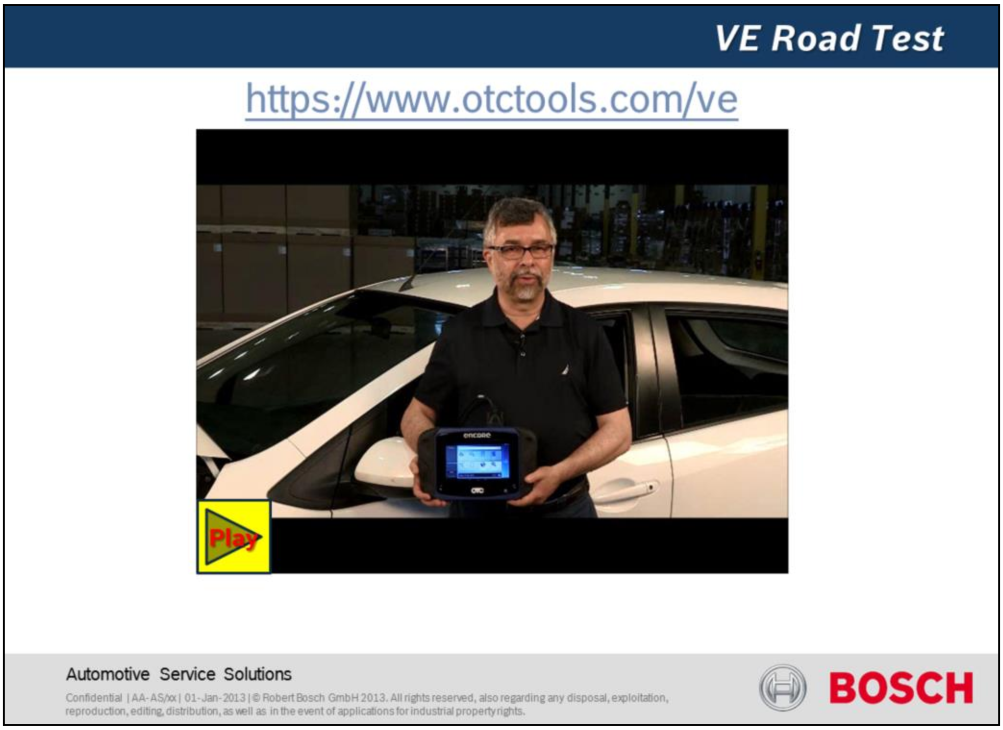


Bosch OTC has available for your use a calculator on our website.

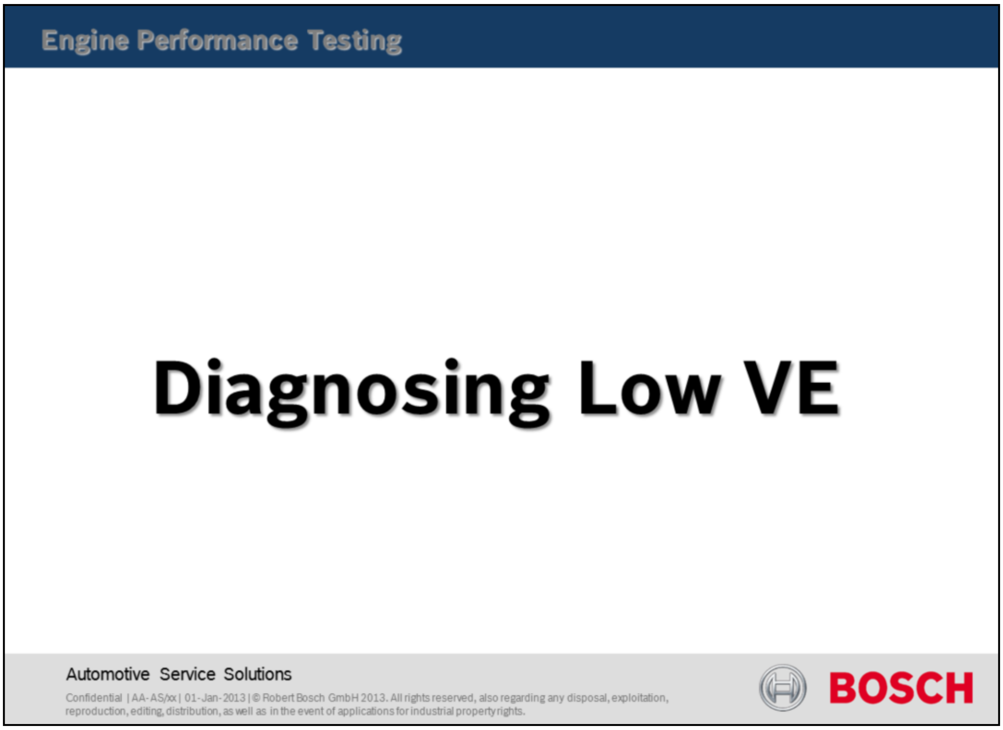


http://www.OTCtools.com/ve

Your Datastream reading during the WOT needs to be recorded and inputted to the calculator from the scan tool's data (RPM, IAT and MAF) at the same time frame of the highest RPM obtained.



Click on the picture to launch the video clip.

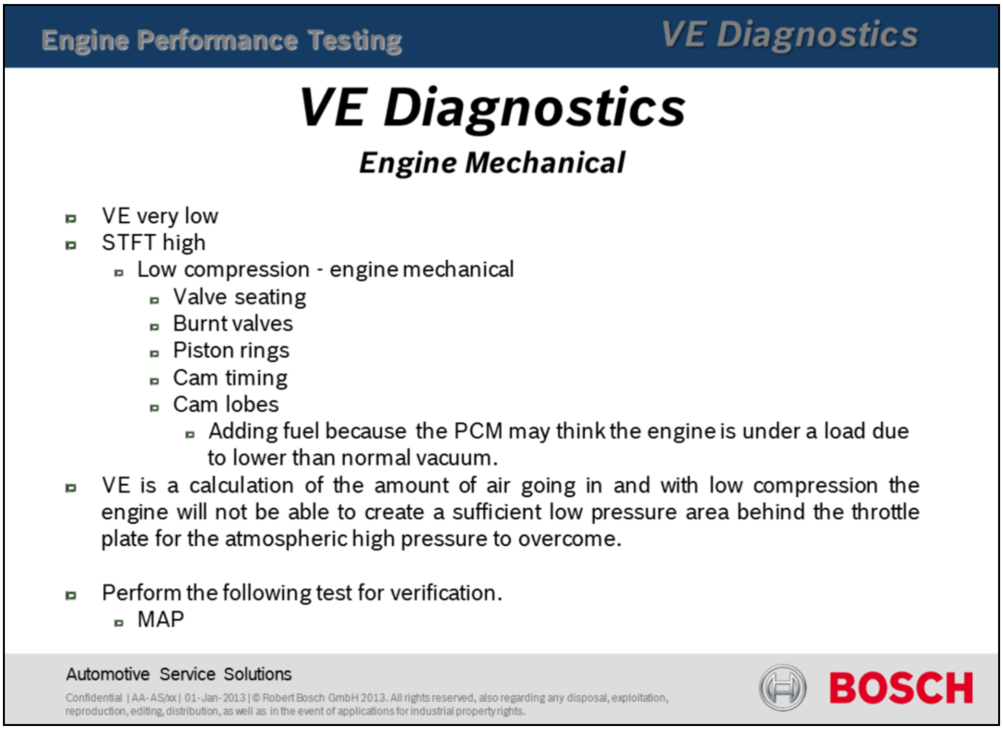


Let's review what could cause VE to be out of specification and cause poor engine performance. To determine the cause of an out of spec VE calculation you need to monitor MAF, AFR or HO2S and STFT at idle with the engine at operating temperature.

Fuel Trim are the results the PCM calculated from the MAF sensor's measurement of the air entering into the intake system.

While performing many of these tests, to obtain the fastest possible Datastream refresh rate, please select individual Datastream PID's you are using for your diagnostic strategy and display them only.

Most components will use similar test procedures from vehicle manufacturer to vehicle manufacturer with a change only in specifications.



<u>Engine Mechanical</u>

Test results: Very low VE

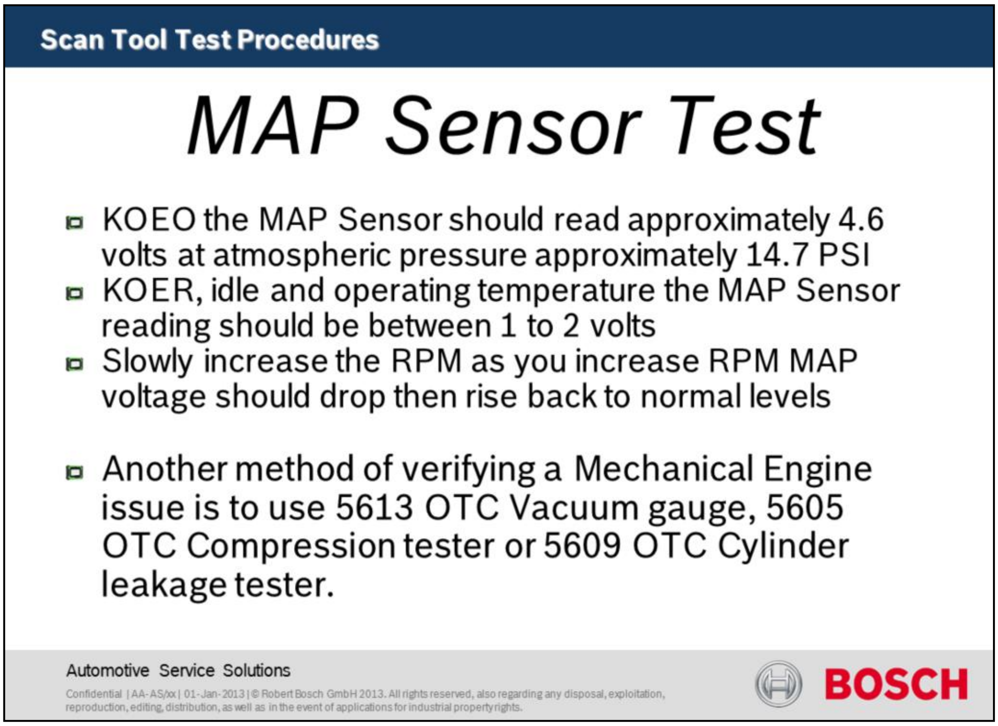
STFT high

Cause: Engine mechanical which would be caused by those components that would cause low compression, such as valve seating, burnt valves, piston rings, cam timing and cam lobes. Low compression results with STFT adding fuel because the PCM may think the engine is under a load due to lower than normal vacuum.

Conclusion: VE is a calculation of the amount of air going in, with low compression the engine will not be able to create a sufficient low pressure area behind the throttle plate for the atmospheric high pressure to overcome.

Perform this test to verify: MAP

Another method of verifying a Mechanical Engine issue is to use 5613 OTC Vacuum gauge, 5605 OTC Compression tester or 5609 OTC Cylinder leakage tester.



Purpose of this test is to test sensor function.

KOEO the MAP Sensor should read approximately 4.6 volts at atmospheric pressure approximately, 14.7 PSI.

KOER, idle and at operating temperature the MAP Sensor reading should be between 1 to 2 volts

Slowly increase the RPM as you increase RPM MAP voltage should drop then rise back to normal levels

Honda MAP specification: 500 RPM 23 KPA

2250 RPM 24 KPA

Atmospheric Pressure (“hg) – Engine Vacuum (“hg) = Manifold Pressure (“hg)

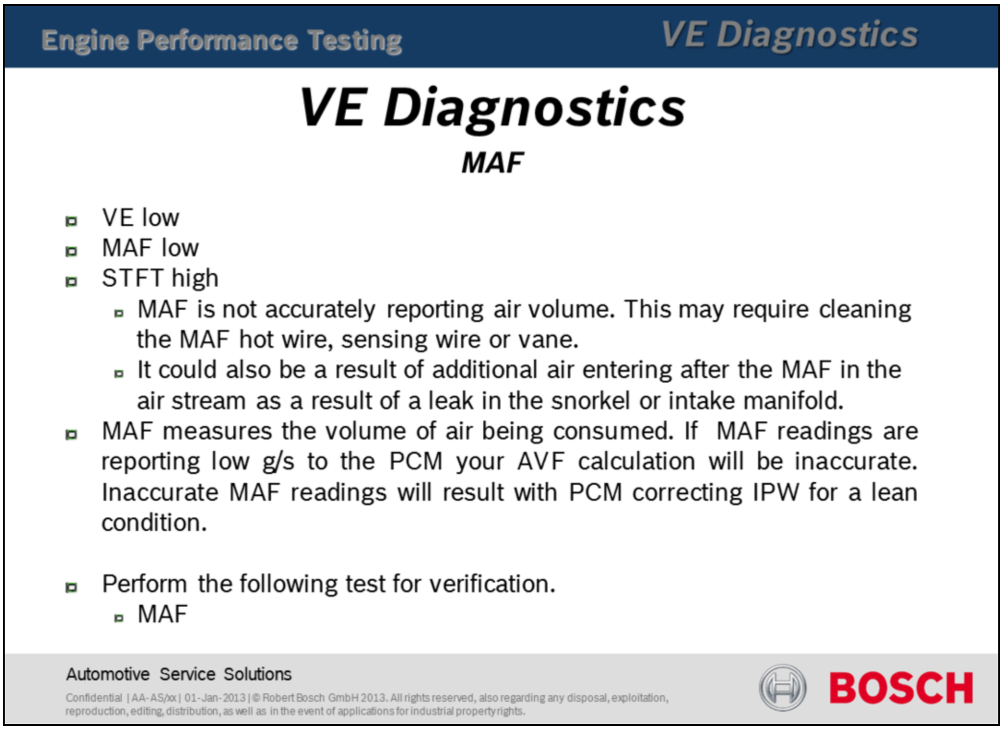
Ex: 30” – 18” = 12”

To convert KPA to “Hg: 1 KPA = 0.30 “Hg

Ex: 23KPA x 0.30 = 6.9 “hg

Vacuum iHg	Barometric Pressure @ Sea Level iHg	Manifold Pressure iHg	MAP Voltage
0"	30"	30"	4.5v - 4.7v
3"	30"	27"	4.0v - 4.2v
6"	30"	24"	3.5v - 3.7v
9"	30"	21"	3.0v - 3.2v
12"	30"	18"	2.5v - 2.7v
15"	30"	15"	2.1v - 2.3v
18"	30"	12"	1.5v - 1.7v
21"	30"	9"	0.9v - 1.1v

Click on the picture to launch the video clip.



<u>MAF</u>

Test results: VE low

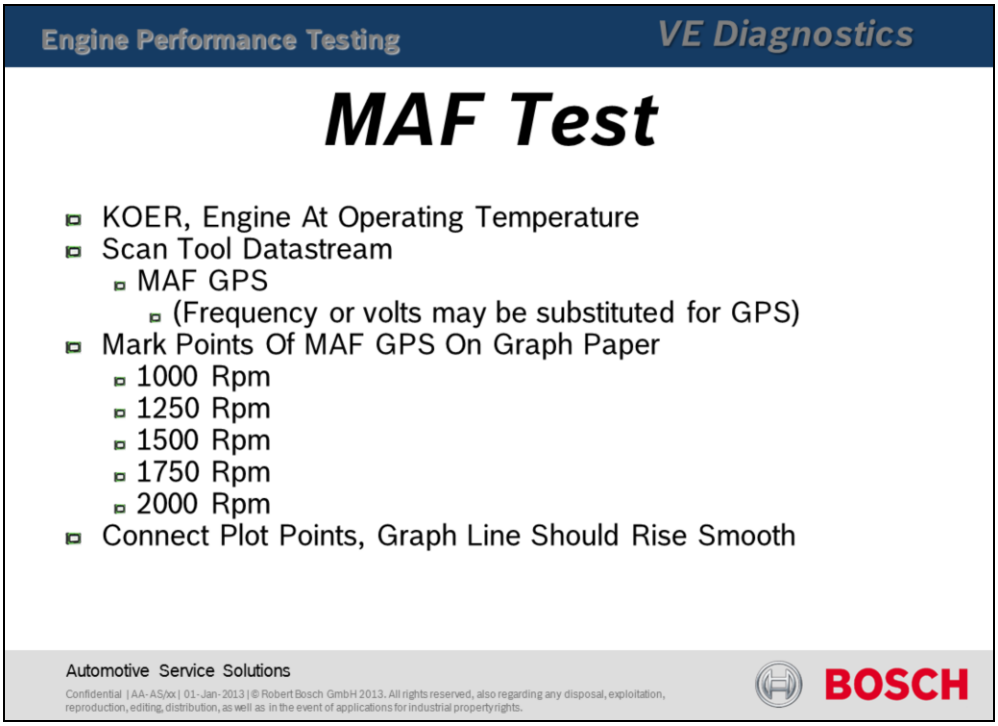
MAF low

STFT high

Cause: MAF is not accurately reporting air volume. This may require cleaning the MAF hot wire, sensing wire or vane. It could also be a result of additional air entering after the MAF in the air stream as a result of a leak in the snorkel or intake manifold.

Conclusion: MAF measures the volume of air being consumed. If MAF reports incorrectly to the PCM, AVF calculation will be inaccurate. Inaccurate MAF readings will result with PCM correcting IPW for a lean condition.

Perform this test to verify: MAF



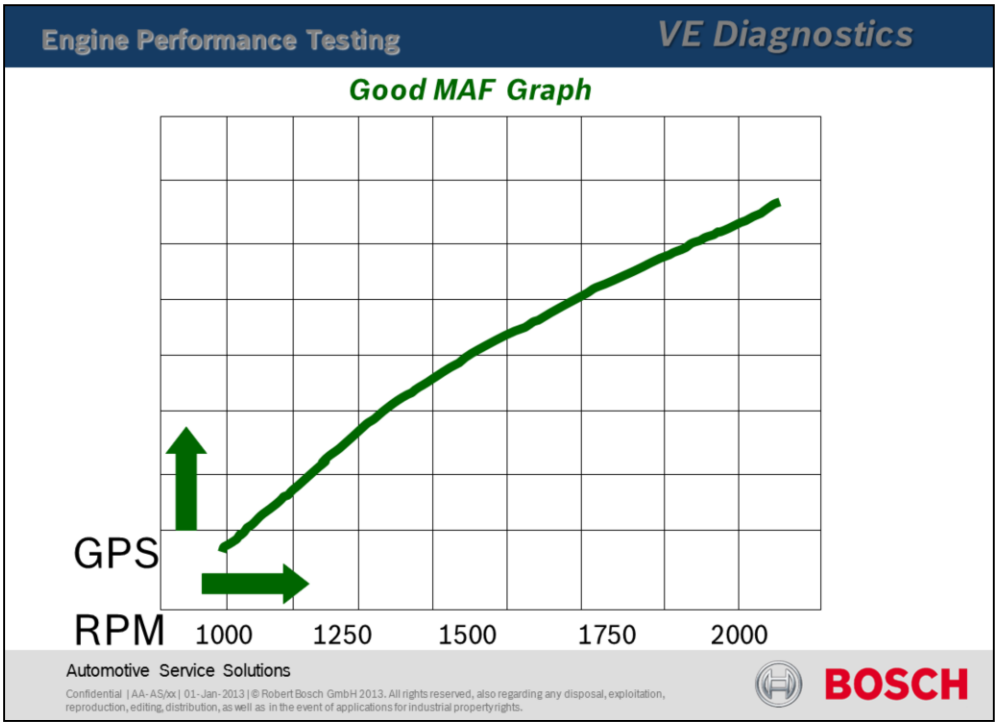
Purpose of this test is to test sensor function.

Graph the MAF in GPS, Frequency or Voltage to allow plotting of readings.

Pick one and graph the readings at 250 RPM increments from 1000 RPM.

The graph plot points should be in a straight line.

Once you have learned how to perform this test on paper you will eventually be able to use the graphing feature on the tool.



This graph show a good MAF as it increases with speed in linear graph pattern.

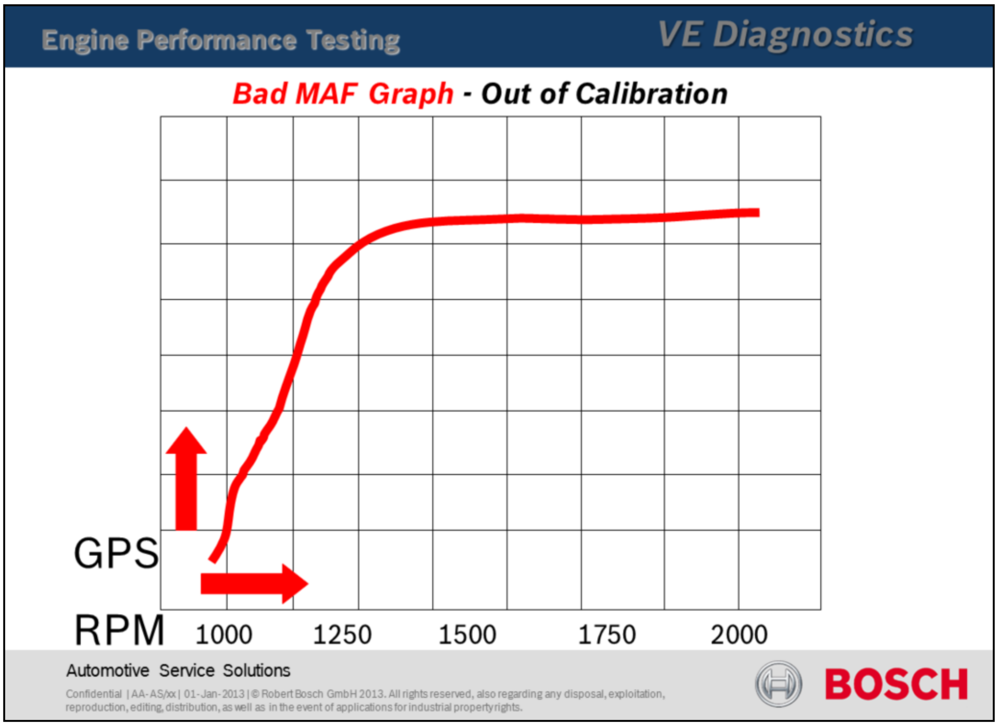
The TP and MAF should follow each other with RPM increases.

Adding a graph reading of Long Term Fuel Trim - LTFT will give an idea if the MAF is out of calibration.

If there is large difference in the LTFT from idle to cruise, could mean there is a contaminated MAF sensor.

Green graph means good test results.

Once you have learned how to perform this test on paper you will eventually be able to use the graphing feature on the tool.



This graph would give low power or acceleration symptoms.

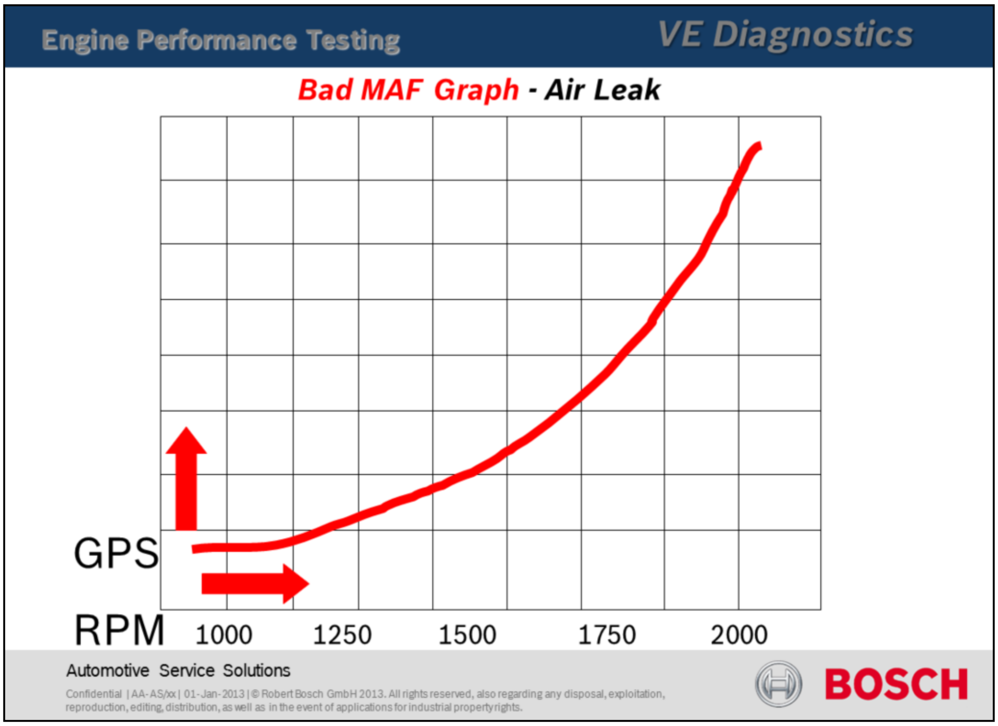
The MAF Sensor output increases too fast in reaction to increase in RPM.

The PCM would quickly increase injector pulse-width at the lower end of the RPM scale causing an acceleration problem.

The MAF Sensor may be out of calibration or contaminated.

Red graph means bad test results.

Once you have learned how to perform this test on paper you will eventually be able to use the graphing feature on the tool.

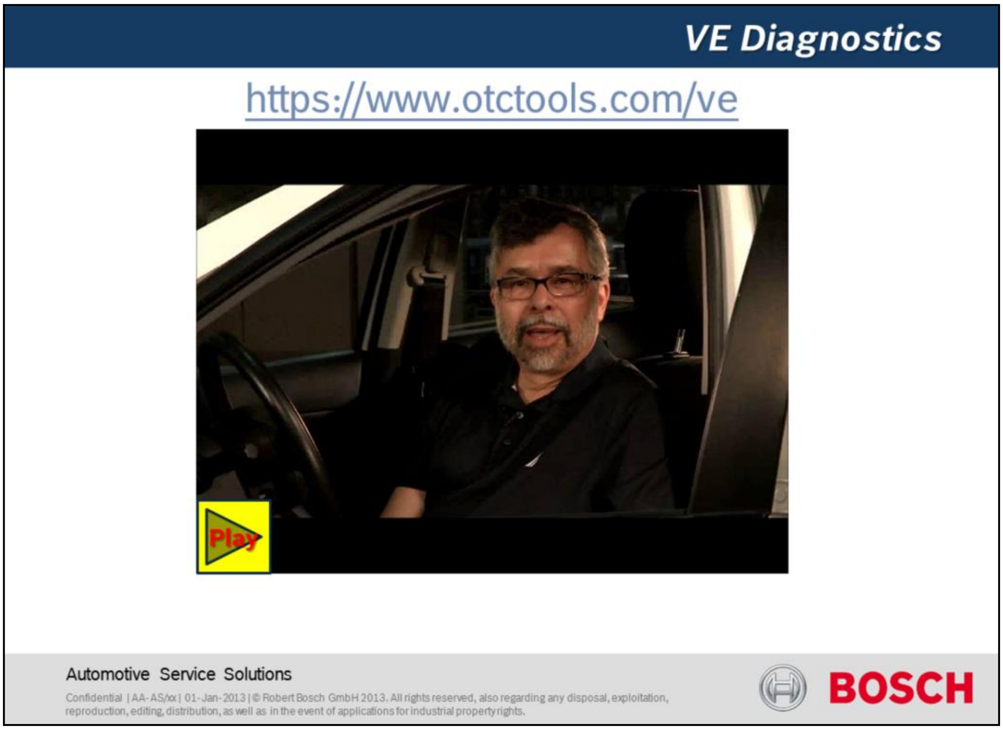


Check for dirty sensing wire on the MAF Sensor.

This graph shows either a dirty sensing wire or an air leak downstream of the MAF Sensor, as a result the extra air at the leak is unmeasured.

Red graph means bad test results.

Once you have learned how to perform this test on paper you will eventually be able to use the graphing feature on the tool.



Click on the picture to launch the video clip.

Engine Performance Testing — VE Diagnostics

VE Diagnostics

Fuel System

- VE low
- STFT high
- HO2S or AFR lean
  - Dirty fuel filter
  - Low fuel pump pressure
  - Low fuel pump volume
  - Restricted injector flow.
- If the engine does not have enough fuel to add to the combustion chamber, power will be limited resulting in the pressure behind the throttle plates being lower than required. As a result, air volume during wide open throttle will be low. The HO2S or AFR sensor will report a lean condition at idle as a result of the low fuel volume and the PCM will compensate with adding fuel commanding plus number for Fuel Trim.
- Perform the following test for verification:
  - Fuel Trim
  - HO2S
  - AFR
  - FRP

Automotive Service Solutions

BOSCH

<u>Fuel System</u>

Test results: VE low

STFT high

HO2S or AFR lean

Cause: If STFT reads high and HO2S or AFR read lean you have a fuel related issue. This could be a result of a dirty fuel filter, low fuel pump pressure, low fuel pump volume and or restricted injector flow.

Conclusion: If the engine does not have enough fuel to add to the combustion chamber, power will be limited resulting in the pressure behind the throttle plates being lower than required. As a result, air volume during wide open throttle will be low. The HO2S or AFR sensor will report a lean condition at idle as a result of the low fuel volume and the PCM will compensate with adding fuel commanding plus number for Fuel Trim.

Perform these tests to verify: Fuel Trim

HO2S

AFR

FRP

You can verify that you have a fuel pressure or fuel volume issue using the 5630 OTC Fuel Pressure gauge, check the specification available at Identifix.

Fuel Trim Diagnostics

Idle	2500 RPM	Possible Causes
+ 5% and Up	0%	Vacuum Leaks
0%	+ 5% and Up	Low Fuel Volume
+ 5% and Up	+ 5% and Up	Low Fuel Pressure
-5% and lower	0%	Contaminated Crankcase
-5% and lower	-5% and lower	Injectors

Fuel Trim is the corrections the PCM is commanding from the results calculated using the MAF sensor's measurement of the air entering into the intake system. The PCM is commanding injector pulse width: + adding fuel for a Richer correction, - reducing fuel for a leaner correction.

Specification: ±5%

Possible causes of Short Term Fuel Trim that is out of calibration.

OBD II O2 monitor may pass yet the vehicle exhibits drivability complaints or fails emissions.

Even though the O2 sensor is switching slowly the OBD II monitor only looks at 1.1 times per second as good.

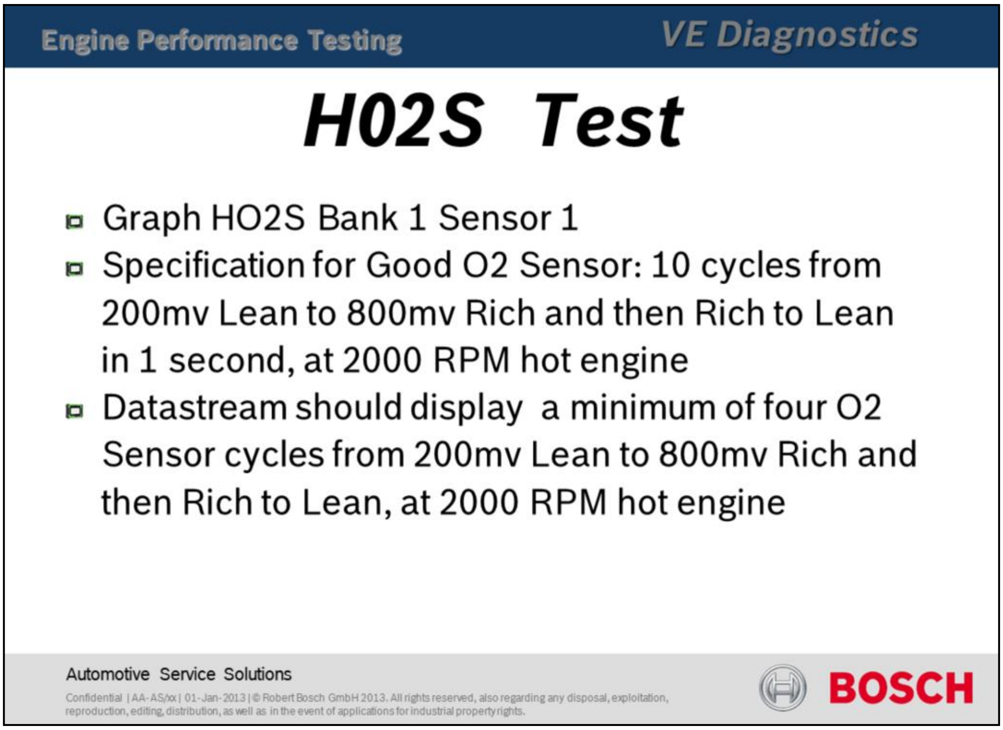
The minimum for true catalyst function is 1 time in less than 100ms.

The Short Term Fuel Trim values change rapidly in response to the HO2S or AFR inputs. These changes fine tune the engine fueling. The Long Term Fuel Trim values change in response to trends in Short Term Fuel Trim.

The Long Term Fuel Trim makes coarse adjustments to fueling in order to re-center and restore control to Short Term Fuel Trim.

+10, + Plus numbers on STFT means the PCM has received a lean signal from the HO2S sensor and the PCM will command the Injector Pulse Width to widen for a rich correction.

-10, - Minus numbers on STFT means the PCM has received a rich signal from the HO2S sensor and the PCM will command the Injector Pulse Width to narrow for a lean correction.



Purpose of this test is to test the HO2S sensors function and to verify a possible lean condition.

While viewing Datastream, High light, Select and Graph HO2S Bank 1 and 2 Sensor 1.

Specification for a Good O2 Sensor: 10 cycles, 1 each of rich and then lean, from 200mv Lean to 800mv Rich and return to lean from 800mv to 200mv for a total of 10 in 1 second, at 2000 RPM hot engine, each swing up or down must be completed in less than 100ms.

OBD II Global 2 samples second 92 seconds record time with a minimum of 9 O2 Swings up and down.

OBD II OEM 4 Samples Second 46 seconds record time with a minimum of 5 O2 swings up and down.

CAN OEM 7 samples second 26 seconds record time with a minimum of 3 O2 swings up and down.

Frame/sample rate=seconds/10=O2 swings

Engine Performance Testing — VE Diagnostics

AFR Sensor Test

- Engine at operating temperature
- No DTC's present for AFR or AFR Heater circuit
- From idle raise engine to 2500 RPM
- AFR should read 3.30 volts
- Snap the throttle to 4000 RPM
  - AFR voltage will fall Rich

OEM PID	Global OBDII PID	Amperage
2.50 Volts	0.50 Volts	Positive

OEM PID	Global OBDII PID	Amperage
3.80 Volts	0.78 Volts	Negative

- After throttle is closed and at return to idle
  - AFR voltage should rise Lean
- If no change check AFR heater circuit
- Always verify AFR specification with Identifix

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The purpose of this test is to verify the functionality of an AFR Sensor and verify a possible lean condition.

The AFR will only function if the AFR heater has reached operating temperature of 1200 ° F. The engine must be at operating temperature and there must be no DTC's present for the AFR or the AFR Heater circuit while performing this test.

From idle, raise engine to 2500 RPM, the AFR should read 3.30 volts for Enhanced data and 0.66 volts for Global OBD II.

Snap the throttle to 4000 RPM and the AFR will read 2.50 volts for Enhanced data and 0.50 volts for Global OBD II. The PCM will maintain positive amperage. This is a Rich condition.

After the throttle is closed and the engine has return to an idle, the AFR voltage should rise to 3.80 volts for enhanced data and 0.78 volts for Global OBD II. The PCM will compensate with negative amperage. This is a Lean condition.

If no change during this test, check the AFR heater circuit.

The PCM will control the amount of amperage to maintain stoichiometric throughout the drive cycle. When a rich command occurs the PCM will supply positive current to the AFR, when a lean command occurs the PCM will supply negative current to the AFR. The PCM will convert the amperage supplied to the AFR for Datastream as a voltage reading.

Datastream specifications vary from manufacturer to manufacturer; please check Identifix for the specification.

OEM PID	Global OBD II	A/F	Amperage	A/F Ratio
2.4v	.48v	Rich 0.84 Lambda	Positive +0.004	12.0
2.5v	.50v			12.3
2.6v	.52v			12.6
2.7v	.54v		0.003	12.9
2.8v	.56v			13.2
2.9v	.58v			13.5
3.0v	.60v		0.001	13.8
3.1v	.62v			14.1
3.2v	.64v			14.4
3.3v	.66v	Stochiometric 1.00 Lambda	0.000	14.7
3.4v	.68v			15.3
3.5v	.70v			15.9
3.6v	.72v		-0.001	16.5
3.7v	.74v			17.2
3.8v	.76v			17.8
3.9v	.78v			18.4
4.0v	.80v	Lean 1.25 Lambda	Negative -0.002	19.0

FRP - Fuel Rail Pressure Sensor

Ford Fuel Pressure

- Read FRP in datastream at idle.
- Check engine vacuum at idle and divide by two.
  - 20 iHg ÷ 2 = 10.
- Then take datastream reading of FRP of 40 psi and subtract the 10 and fuel pressure at the gauge should read 30 psi.
- FRP – (engine vacuum/2) = Fuel Pressure gauge.
  - Ex: 40 – (20/2) = 30
- You can verify that you have a fuel pressure or fuel volume issue using the 5630 OTC Fuel Pressure gauge, check the specification available at Identifix.

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The purpose of this test is to verify fuel pressure which may be causing a lean condition.

Fuel Rail Pressure Sensor measures pressure difference between fuel rail and the intake manifold.

FRP Sensor data will have a higher pressure readings than fuel pressure measured with a fuel pressure gauge.

Check engine vacuum at idle and divide by two to get the pressure drop from vacuum.

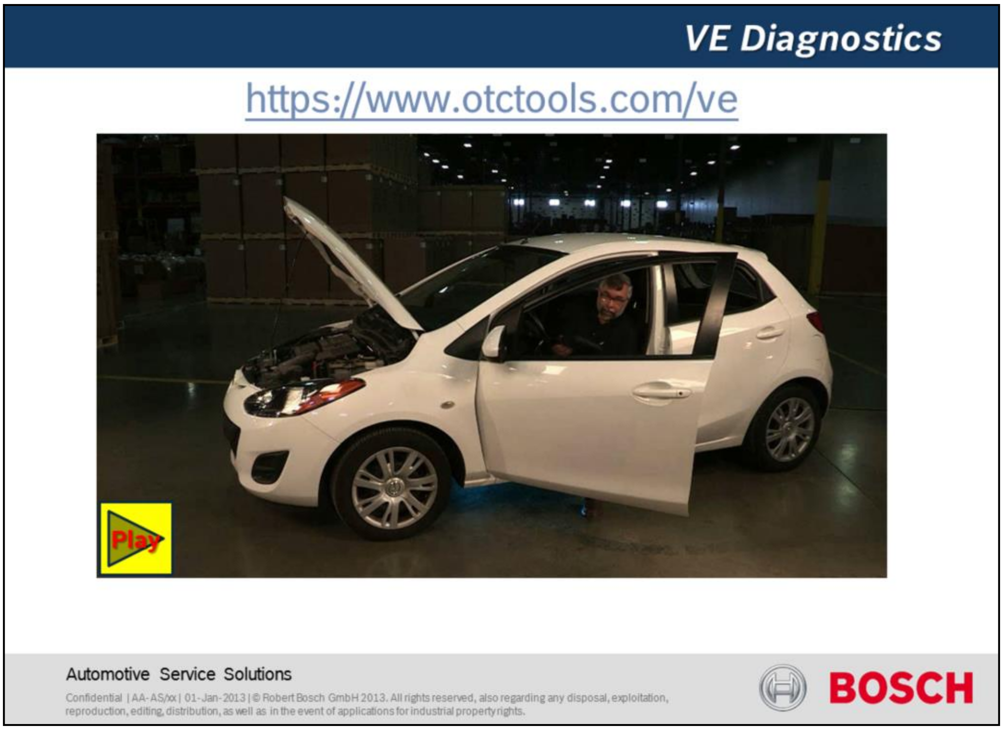
Ex: 20 divided by 2 = 10

FRP – Engine Vacuum/2 = Fuel Pressure at the gauge.

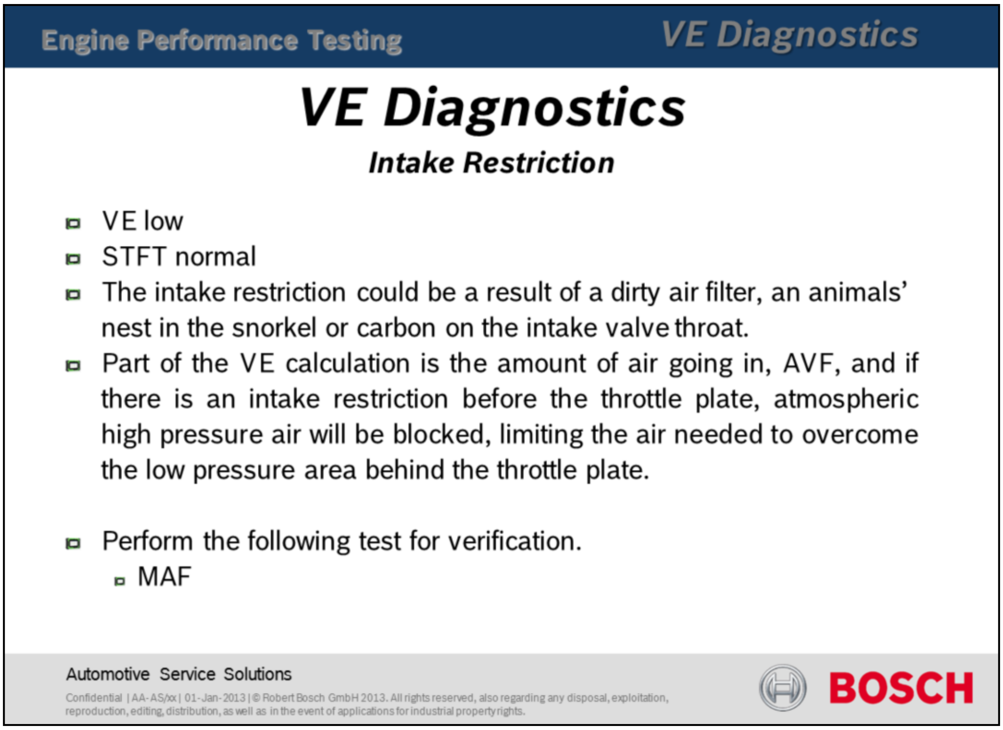
If we measure engine vacuum at idle with a reading 20 iHg divided by 2 equals 10. Then take datastream reading of FRP of 40 psi and subtract the 10 and fuel pressure at the gauge should read 30 psi.

Ex: FRP datastream is 40 psi – 10 = 30 psi reading at the fuel gauge.

The PCM uses FRP sensor data to command fuel pump driver module to vary pump speed by varying voltage to the fuel pump. The voltage fluctuates between 4.5 volts at 70 psi and 1.6 volts at 20 psi.



Click on the picture to launch the video clip.



<u>Intake Restriction</u>

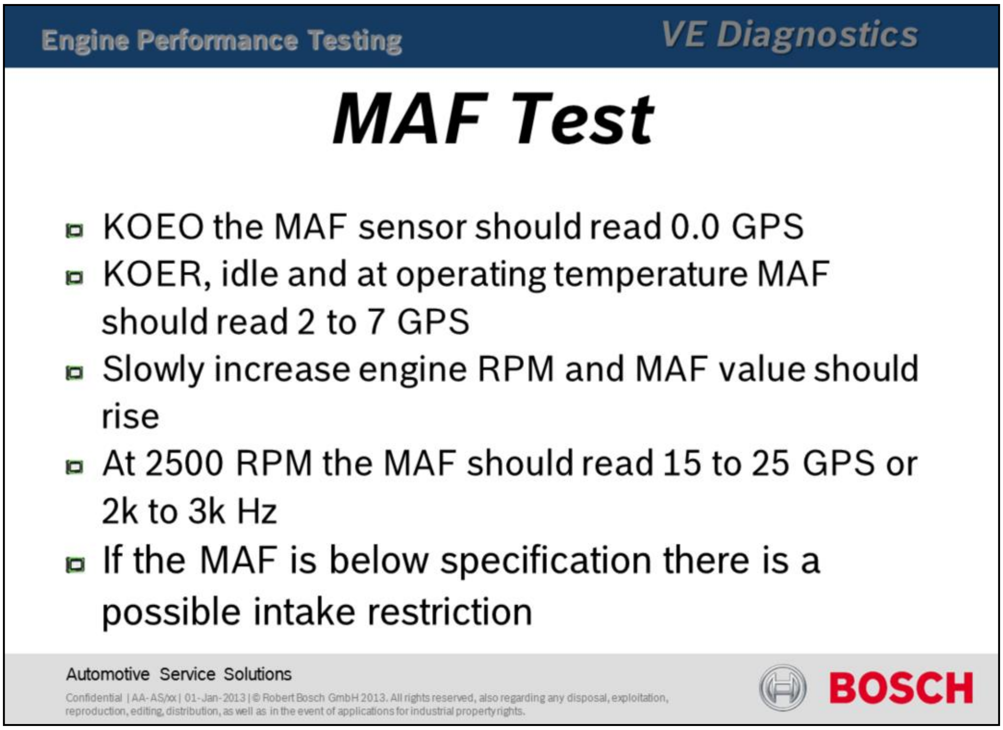
Test results: VE low

STFT normal = 0

Cause: The intake restriction could be a result of a dirty air filter, animals' nest in the snorkel or carbon on the intake valve throat.

Conclusion: Part of the VE calculation is the amount of air going in, AVF, and if there is an intake restriction before the throttle plate, atmospheric high pressure air will be blocked, limiting the air needed to overcome the low pressure area behind the throttle plate.

Perform this test to verify: MAF



Purpose of this test is to test for an intake restriction.

KOEO the MAF sensor should read 0.0 GPS

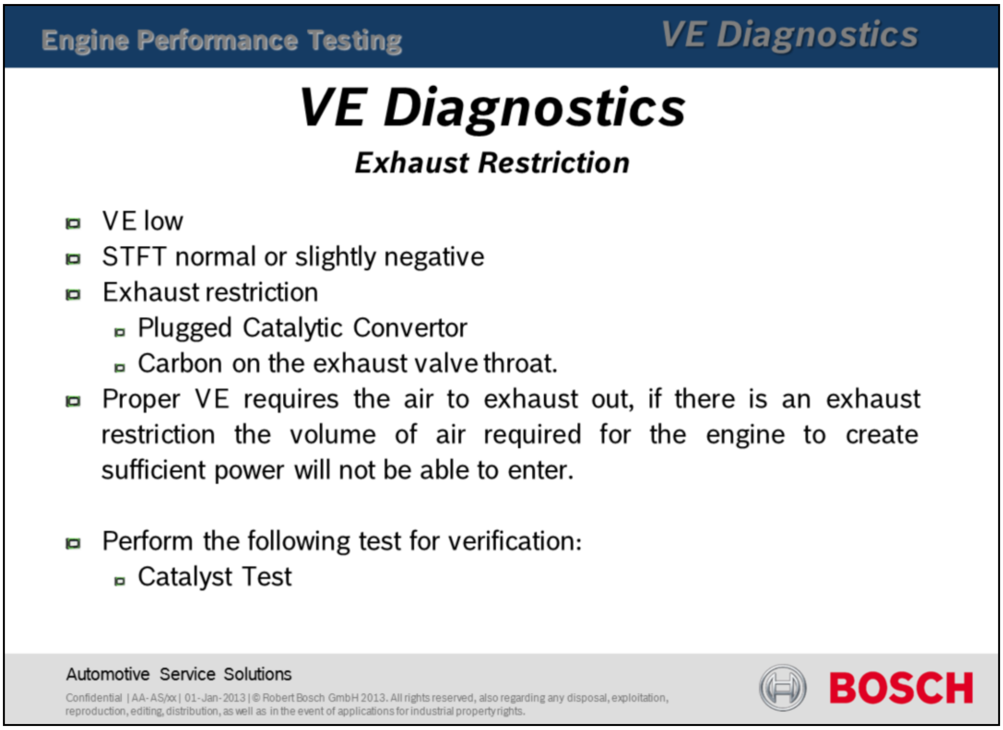
KOER, idle and at operating temperature MAF should read 2 to 7 GPS

Slowly increase engine RPM and MAF value should rise

At 2500 RPM the MAF should read 15 to 25 GPS or 2k to 3k Hz

If the MAF is below specification there is a possible intake restriction

Click on the picture to launch the video clip.



<u>Exhaust Restriction</u>

Test results: VE low

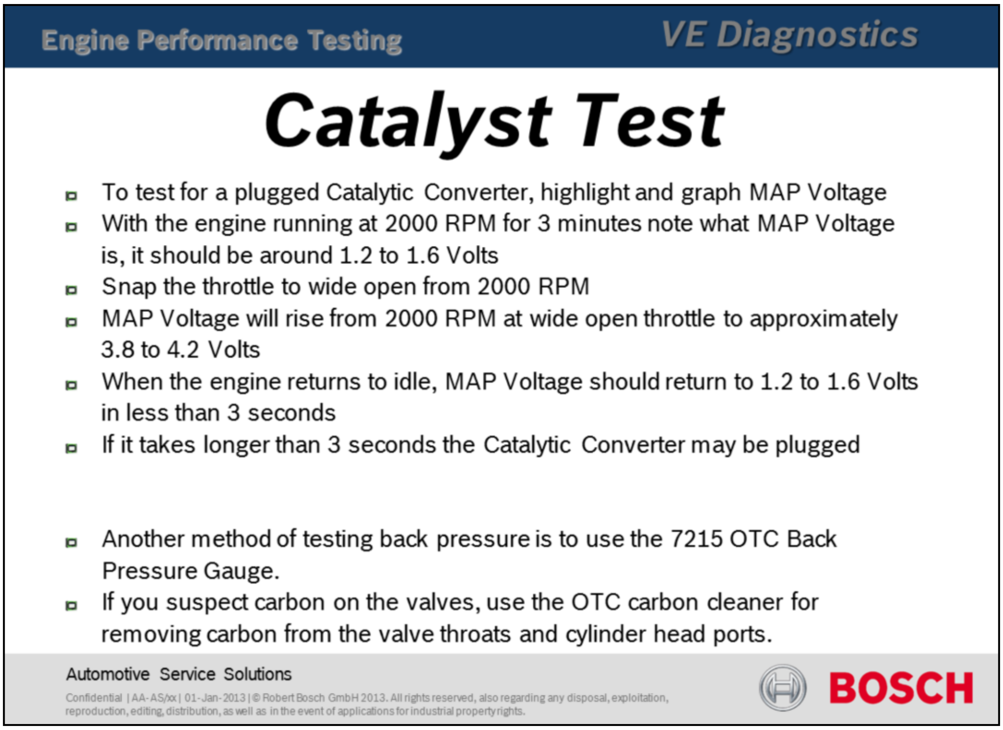
STFT normal or slightly negative

Cause: Exhaust restriction as a result of a plugged Catalytic Convertor or carbon on the exhaust valve throat.

Conclusion: Proper VE requires the air to exhaust out, if there is an exhaust restriction the volume of air required for the engine to create sufficient power will not be able to enter.

Perform this test to verify: Catalyst Test

Another method of testing back pressure is to use the 7215 OTC Back Pressure Gauge. If you suspect carbon on the valves, use the OTC carbon cleaner for removing carbon from the valve throats and cylinder head ports.



The purpose of this test is to test for a plugged Catalytic Converter.

Highlight and graph MAP Voltage.

With the engine running at 2000 RPM for 3 minutes, note what MAP Voltage is, it should be around 1.2 to 1.6 Volts.

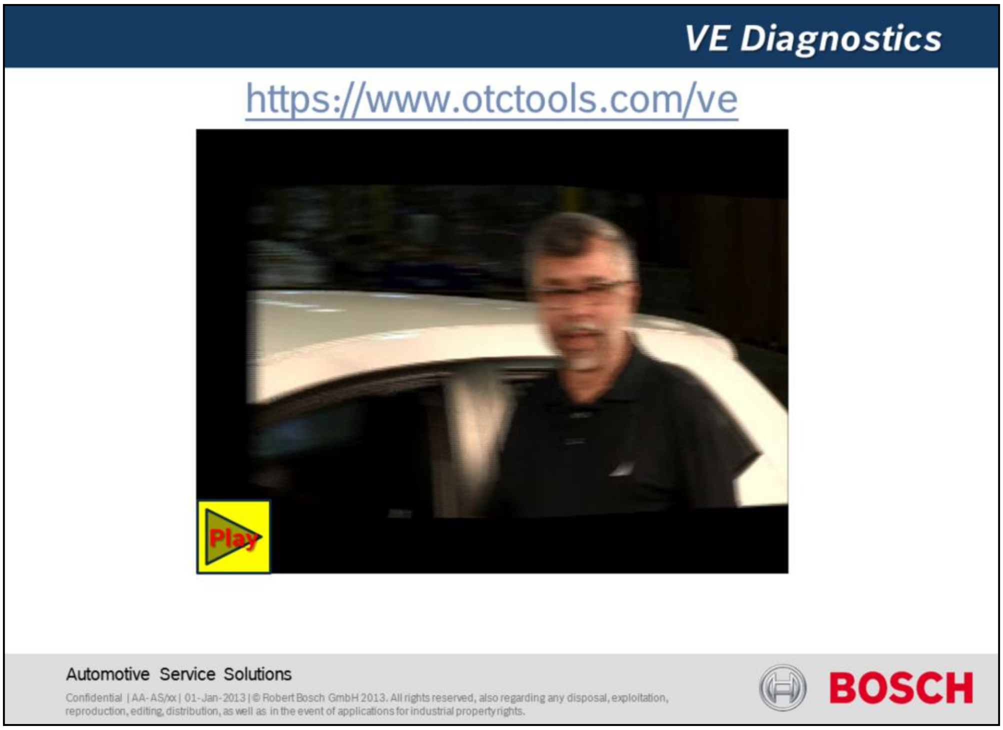
Snap the throttle to wide open from 2000 RPM.

MAP Voltage will rise from 2000 RPM at wide open throttle to approximately 3.8 to 4.2 Volts.

When the engine returns to idle MAP Voltage should return to the 1.2 to 1.6 Volts in less than 3 seconds.

If it takes longer than 3 seconds the Catalytic Converter may be plugged.

If the MAP PID is not available go to Global OBD II and select Engine Calculated Load PID. With the engine at operating temperature, and at idle, record Calculated Load, typically 20 to 40%. With the engine at 2000 RPM snap the throttle wide open, the Calculated Load will immediately climb to 100%. When the throttle closes Calculated Load will drop to 0% and it should return to the idle reading in less than 3 seconds.



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