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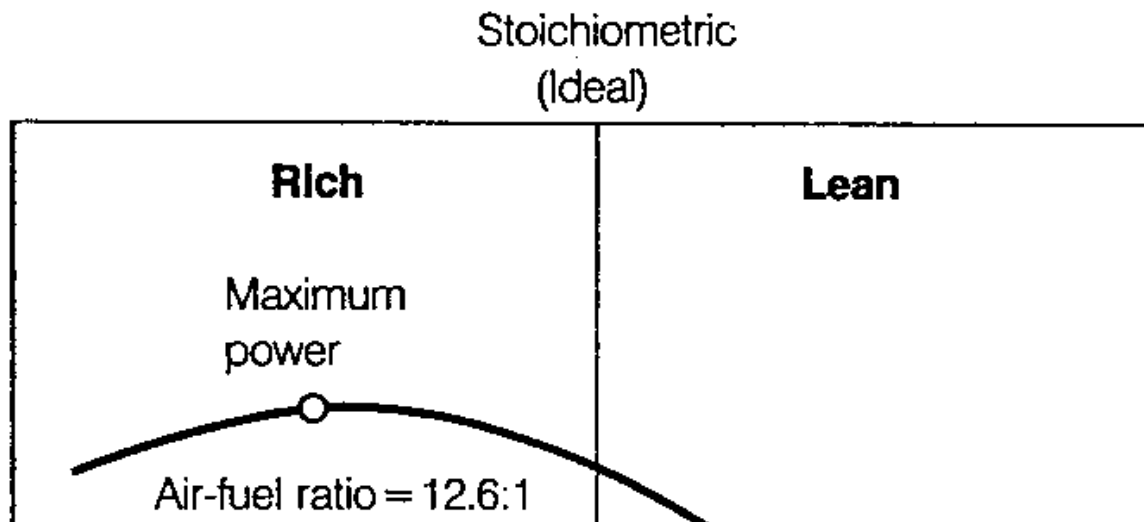
## AEPs Guide to Precision Tuning

Tuning your engine for better performance can be a time consuming and tedious job, especially when the tools required to gather engine operating data are unavailable. While for the enthusiast commercial tune-ups can leave much to be desired with respect to performance because the engine is typically tuned to factory specs rather than performance specs.

For years plug reading was recommended by automotive author's as the way to 'read' the engine, but plug reading only gives a ball park feeling that is inferior to actual measurement. Gastester is the rational alternative to plug reading because it accurately measures the level of carbon monoxide in exhaust gas, and carbon monoxide is the principle indicator of fuel mixture. Why is it important to know the fuel mixture? Variations in the fuel mixture affect power output, fuel consumption and pollutant levels, so the ability to measure the fuel mixture is critical for successful engine tuning. Gastester is indispensable when replacing or tweaking the existing carburetor, when replacing the carburetor with aftermarket fuel injection, or when preparing for a state mandated emissions test.

Too often carbureted engines are set by ear and run richer than necessary to ensure drivability and performance under all operating conditions. However, a fuel mixture richer than necessary wastes fuel and spews excessive pollutants. The ability to accurately measure fuel mixture lets you tune so that maximum power is maintained while reducing fuel consumption and pollutants.

Auto Expert Products Co. And Gastester make precision tuning information possible and easy. AEP includes with every Gastester a power curve and a fuel mixture/percent carbon monoxide equivalence chart. The power curve runs from rich to lean and shows typical fuel mixture values for maximum power, low emissions, and balanced performance. The fuel mixture chart equates Gastester's percent carbon monoxide readout to a more performance oriented fuel mixture value. Simply pick a performance level on the power curve and note the fuel mixture value. Then adjust the fuel mixture screw until Gastester's readout displays the percent carbon monoxide that is equivalent to the fuel mixture selected. For example, a 12.6:1 fuel mixture provides maximum power equating to a Gastester readout of 5.0 percent carbon monoxide.



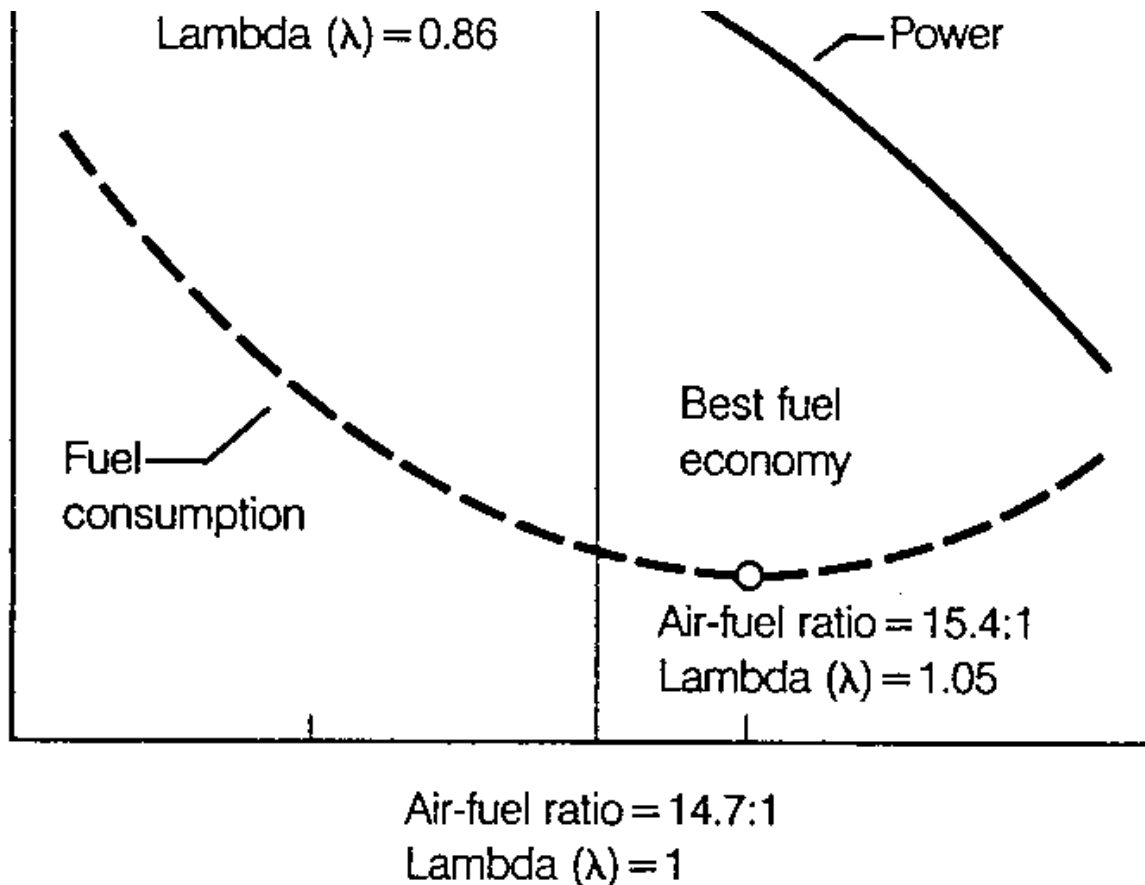


Figure 1.

The exhaust gases from a well tuned and mechanically sound engine are made up of relatively harmless nitrogen, water vapor and carbon dioxide. The actual pollutants, hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) amount to only around 2% of the total.

These pollutant levels are related to the air fuel mixture strength, especially CO emissions which are very low with weak mixture levels but rise steadily as fuel content increases. HC and NOx levels are also dependent upon ignition timing, with the hydrocarbon content showing an increase with both advanced and retarded ignition, whereas the NOx levels rise with ignition advance.

Gastester works on the 'hot wire' or thermal conductivity principle. According to this principle, the thermal conductivity of a gas depends on the particular mixture of gases present, and is largely independent of gas temperature. In practice the thermal conductivity of exhaust gas varies only with the amount of carbon dioxide (CO<sub>2</sub>) that is present. Gastester measures the thermal conductivity of the exhaust gas, and therefore measures its carbon dioxide content. However, since there is an inverse relationship between carbon dioxide and carbon monoxide, as CO<sub>2</sub> goes up CO goes down and vice versa. Gastester senses CO<sub>2</sub> but displays CO levels. The 'correct' CO level will generally result in improved performance, better fuel consumption, and cleaner more environmentally friendly exhaust emissions.

With Gastester you can tune your car for the way you drive. As shown in figure 1 (from the Bosch Fuel Injection and Engine Management book) the air/fuel ratio can be set for maximum power or minimum fuel consumption, or optimized. Gastester only measures CO, but the levels of hydrocarbons (HC) and oxides of nitrogen (NOx), -- the other pollutants typically measured -- can be inferred from the CO level. These three pollutants are related to the air/fuel ratio as described in the Bosch Fuel Injection and Engine Management book and as shown in figure 2.

Since the CO/HC/NOx relationship is constant and predictable, you simply adjust the fuel mixture until you get a CO value that is less than or equal to your state's CO limit for your make and model car. If your car is in tune and set up to manufacturers specs you can be fairly confident that the hydrocarbon and NOx levels are within limits. If possible give yourself a cushion of at least .5% CO to account for Gastester's accuracy. Note: the level

of NOx is also affected by timing advance. The greater the timing advance the higher the NOx level. Referring to figure 2, the ideal air/fuel ratio yields the best compromise for control of CO, HC, and NOx before the catalytic converter (a) or after it (b).

## How to prepare your classic car engine for state emissions testing.

A well maintained car is likely to pass state emissions testing without difficulty, so regular attention to maintenance is recommended. This will also result in more satisfying and more reliable driving, and will also be cheaper in the long run. The recommended order of maintenance/emissions testing preparation is:

- ensure the air filter is clean or replace.
- ensure valve clearances are correctly set.
- service ignition system/plug leads/set points (if any)
- set carburetor air balance where multiple carburetors are used.
- set air/fuel mixture strength
- change the engine oil.

Carbon Monoxide, chemical CO, is a very poisonous gas that is present in small quantities in exhaust gas. The level of CO in the exhaust gas indicates whether the engine is running rich or weak. For this reason, car manufacturers now use CO as an accurate indicator of whether the jets of the carburetor are correctly adjusted.

Gastester CO exhaust gas analyzer, proven by testing to be very accurate and reliable.

Colortune Mixture strength indicator. If used according to instruction will enable mixture to be set to below 4.5%. Also used for air/fuel in multiple carburetors.

Carbalancer For balancing air flow of multiple carburetor engines, prior to setting mixture.

Hydrocarbons (HC) is the name given to a group of chemicals that are found in gas. Some of the fuel passes through the engine unburned and can be detected in the exhaust gas.

The amount of HC in the exhaust gas is generally very low, and therefore, is measured in part per million (PPM). Note that 1% is the same as 10,000 PPM.

The presence of excessive HC in an engine in good condition, are typically 100-300 PPM. For an engine in very bad condition, for instance, one cylinder not firing at all, the level can be as high as 20,000 PPM.

A wide range of faults can cause excessive HC in the exhaust, but common causes are: faulty spark plugs and ignition system, faulty ignition timing.

There is no simple equipment available for measuring HC. However, an engine that is well maintained should be able to pass state emissions test.

## **PREPARATIONS BEFORE USING GASTESTER**

Any service maintenance such as air filter renewal, valve adjustment, carburetor maintenance, ignition maintenance including ignition timing, should be carried out before setting the carburetor or fuel injection mixture adjustment. Fuel mixture setting should be the FINAL ADJUSTMENT in any engine tuning work.

Carbon monoxide is an EXTREMELY POISONOUS gas. ANY work on the car with the engine running should therefore ALWAYS be carried out IN THE OPEN AIR. The user should take care NOT TO BREATHE IN exhaust gas when using Gastester near the exhaust pipe with the engine running.

The car should be thoroughly warm before the tests begin. It is not enough to leave the car to warm while parked. The car should be taken for a drive, and the tests not started until water temperature, engine, and exhaust system are thoroughly heated, and are at normal running temperature.

Study the workshop manual for the particular car (or consult the information given later in this booklet) to identify the correct adjustment screws that control the mixture strength and the idle speed. Identify the direction to turn the screws to achieve the desired effect (i.e. mixture richer or weaker, idle speed faster or slower). If in doubt, make a note of the initial position of the adjustments before starting work, so that in case of difficulty, or if the wrong adjustment is changed, the setting can be restored to its original position.

Check the workshop manual or label in the engine compartment for the correct CO level and IDLE RPM value. Have on hand the correct tools for making the necessary adjustments.

## **INSTRUCTIONS FOR USE**

(a) Ensure that the car is thoroughly warm as mentioned above, that it is parked in a convenient position in the open air, with the handbrake applied. Note: THE INSTRUMENT SHOULD NOT BE PLACED DIRECTLY IN THE EXHAUST STREAM. CLEAN AIR IS REQUIRED IN THE REFERENCE CELL FOR ACCURATE READINGS.

Note: Bright sunlight on the instrument will make visibility of the LED display difficult

(b) Place Gastester Professional on a convenient flat surface close to the vehicle's exhaust pipe outlet. Switch off the engine temporarily while making connections. Connect the RED and BLACK clips to the vehicle's 12 V battery (RED to +, BLACK to -), and the BLUE pickup lead to the COIL NEGATIVE terminal to obtain RPM readings.

THE PROBE SHOULD BE FITTED TO THE INSTRUMENT BUT DO NOT INSERT THE EXHAUST PROBE INTO THE EXHAUST PIPE AT THIS STAGE.

(c) Restart the engine and allow a period of 8 minutes for the instrument to warm up with the probe in air. Observe the display for a further 2 minutes to ensure that the reading has stabilized.

IF NOT, ALLOW A FURTHER PERIOD BEFORE SETTING THE CO CALIBRATION

During the warm up period other ranges will give accurate readings and it is therefore useful to check and adjust engine IDLE RPM.

(d) Switch to the CO range with the probe in air. DO NOT INSERT THE EXHAUST PROBE INTO THE EXHAUST PIPE AT THIS STAGE. Use the rotary calibration control to carefully set to the CALIBRATE reading of 2.0% CO. Having set the CALIBRATE condition do not move the instrument, or move to a different location during subsequent CO tests. (Note: The CALIBRATE position represents what the instrument should register when the probe is in air. It is coincidental that air should measure the same as exhaust gas with 2% CO. When the probe is subsequently inserted into the exhaust pipe, displayed CO reading may move down or up from the CALIBRATE condition, depending on whether the exhaust has less than, or more than. 2% CO).

(e) Ensure that the engine is set to the IDLE RPM stated by the manufacturer. NOW INSERT THE PROBE INTO THE VEHICLE EXHAUST PIPE, to a minimum of 3/4 of its length, i.e. 8" or 20cm. In order for the automatic water drain to function, the probe pipe should fall continuously from the exhaust end to the inlet end to allow water droplets to run down. Otherwise the water will collect at the lowest point and will have to be drained manually.

(f) wait for a period of 15 seconds for the meter to respond and a further 1 minute to stabilize. Make a note of the reading of the CO level on the meter display. If the reading is not between the manufacturer's recommended maximum and minimum, or below that specified as a legal requirement, then adjustment of the carburetor or fuel injection system will be required.

(g) If the indicated CO reading is too high or too low, then make a small adjustment to the mixture screw, and correct the idle speed by adjusting the idle speed screw (or throttle bypass screw if fitted - see section). Do this repeatedly in small increments, allowing approximately one minute for the reading to stabilize at each mixture setting.

## **FURTHER INFORMATION**





It should be noted that an engine, even in good overall condition, will show a fluctuation in idle CO over a period of time, of typically 0.5%. Bearing in mind this fluctuation, and also errors and drift in the instrument, the user should aim to set the average CO reading to be midway between the limits set by the manufacturer, or at a reasonable margin below the prescribed legal limit. Periodically, during the tests, examine the lowest point of the transparent plastic pipe to see if it contains water to a degree that might impede the flow of gas, and if it does, remove the pipe at the instrument gas inlet end and clear the pipe by allowing the water to drain out, then reconnect the pipe and carry on with the tests. If the transparent pipe falls continuously from the exhaust to the pump the automatic drain should operate and keep the pipe clear of water. NOTE; Operation of the pulse pump will usually be audible as the pulsation's in the exhaust cause the internal diaphragm to vibrate. If the instrument ceases to respond to changes in mixture setting or the sound from the pulse pump becomes irregular, check the sample pipe for collected water.

## **MAINTENANCE**

The calibration of the instrument may be checked at any time. Simply remove the exhaust probe and wait at

least five minutes, or ten minutes in still air, for the exhaust gas to disperse from the collector box. If necessary, the calibration may then be adjusted using the calibration control knob. The user is advised to periodically check the calibration of the instrument during particularly extended tests.

Some motor car engines will not readily "tick over" at idle speeds for long periods. The speed may become erratic, and engine misfiring may occur. With the prolonged testing of such engines, it may be necessary to occasionally "purge" the engine by, for instance, increasing the speed to 2000 rpm - 3000 rpm for 15 seconds. This may be done at any time during the tests but the exhaust probe should preferably be removed beforehand.

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