Adaptive Fuel Systems

Models affected: All in Current Production (Triumph models)

Introduction

Adaptions make an important difference to the way the engine performs; the engine can suffer from poor starting, poor idling, and poor engine performance when riding, until it has adapted correctly. All of these symptoms will create a negative experience for the customer and can be avoided if the motorcycle is handed over correctly adapted.

The motorcycle should be adapted when new, prior to customer hand over, and also after a service, or repair or replacement of any engine, fuel or ignition system components.

Items or conditions which may require the motorcycle to be adapted include (but are not limited to) throttle bodies, throttle position sensor, idle speed control stepper motor, high engine friction (new engine), incorrect valve clearances, SAI system, air leaks, fuel pressure issues, changes in fuel quality, air or fuel filter blockages etc. Riding style, riding the motorcycle at high or low altitude, or downloading a new tune, do not affect the adaptions.

What is an adaptive fuel system?

An adaptive fuel system is one where the system automatically adjusts to cope with differences in motorcycle condition (an intake air leak or low fuel pressure etc), tolerances (a new, tight engine, tolerances in injectors or fuel pressure etc) or fuel quality. The base fuel map (or tune) developed by Triumph around a 'nominal' motorcycle (in terms of engine load, air leakage, fuel pressure etc) may need to be modified (adapted) to suit a particular motorcycle in service.

Once the base fuel map has been modified to suit the individual motorcycles requirements, this modification value will be stored in the ECM’s memory, ensuring that a full adaption is not necessary every time the engine is started.

The adaption data is stored in the ECM’s memory every 10 minutes, and on each controlled power down of the ECM.

The motorcycle can be checked to see if it has adapted or not using the Triumph diagnostic tool. This is described on page 2.

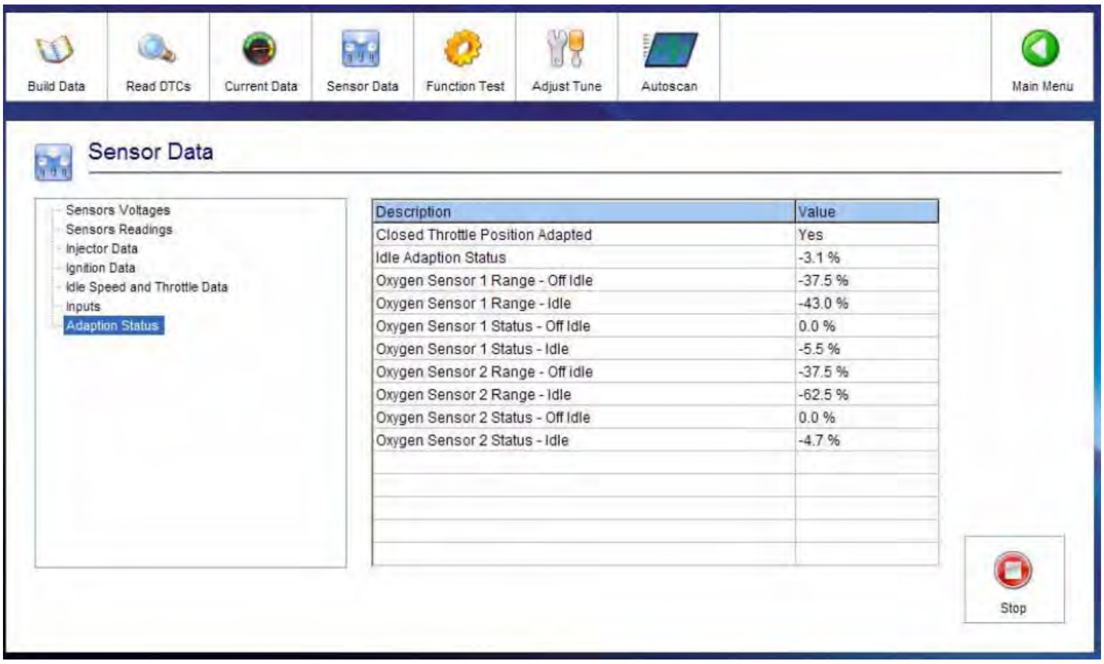
There are two methods of adapting the motorcycle - 'Standard' and 'Fast' adaption. These are described in '**How to Reset the Adaptions'** on page 4.

Three areas of the fuel system are adaptive, these are the closed throttle position, idle speed control system and the closed loop system.

These three systems are described in detail in '**Further Reading**' on page 4.

Checking the Adaption Status Using the Triumph Diagnostic Tool

Connect the Triumph diagnostic tool to the motorcycle and navigate to Adaption Status as described in the Triumph Diagnostic Tool User Guide. To view the adaption status screen, the motorcycle must have reached a temperature of 90°C (60°C on all Bonneville, Scrambler, Thruxton, America and Speedmaster models) or higher.



Description	Value
Closed Throttle Position Adapted	Yes
Idle Adaption Status	-3.1 %
Oxygen Sensor 1 Range - Off Idle	-37.5 %
Oxygen Sensor 1 Range - Idle	-43.0 %
Oxygen Sensor 1 Status - Off Idle	0.0 %
Oxygen Sensor 1 Status - Idle	-5.5 %
Oxygen Sensor 2 Range - Off idle	-37.5 %
Oxygen Sensor 2 Range - Idle	-62.5 %
Oxygen Sensor 2 Status - Off Idle	0.0 %
Oxygen Sensor 2 Status - Idle	-4.7 %

Autoscan

Alternatively, the adaption status can be checked using the Autoscan feature on the Triumph diagnostic tool. Connect the Triumph diagnostic tool to the motorcycle and navigate to Autoscan as described in the Triumph Diagnostic Tool User Guide. Autoscan will perform a range of tests, including the adaption status. Once the Autoscan has completed, a message will confirm if the motorcycle has passed or failed the Autoscan; the motorcycle will not pass if it is not adapted. The pass/fail limit for adaption range in Autoscan is 75%.

Closed Throttle Position

The closed throttle position will show as either adapted or not adapted. The closed throttle position may not adapt if certain faults are present, such as a faulty or mis-adjusted throttle position sensor, erratic idle speed or an incorrect idle speed (either too high or too low).

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Oxygen Sensor 1 Status - Idle	-5.5 %
Oxygen Sensor 2 Range - Off idle	-37.5 %
Oxygen Sensor 2 Range - Idle	-62.5 %
Oxygen Sensor 2 Status - Off Idle	0.0 %
Oxygen Sensor 2 Status - Idle	-4.7 %

Idle Adaption Status

Idle adaption status figures close to 0% ±10% indicate the Idle system is adapted. Figures greater than this indicate that the idle system is not yet adapted.

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Oxygen Sensor Range

The term 'range' indicates how much (in percentage terms) of the adjustment range has been used to reach the current operating status. Figures at or near 75% indicate a fault and should be investigated; minus figures indicate a rich mixture, positive figures indicate a lean mixture.

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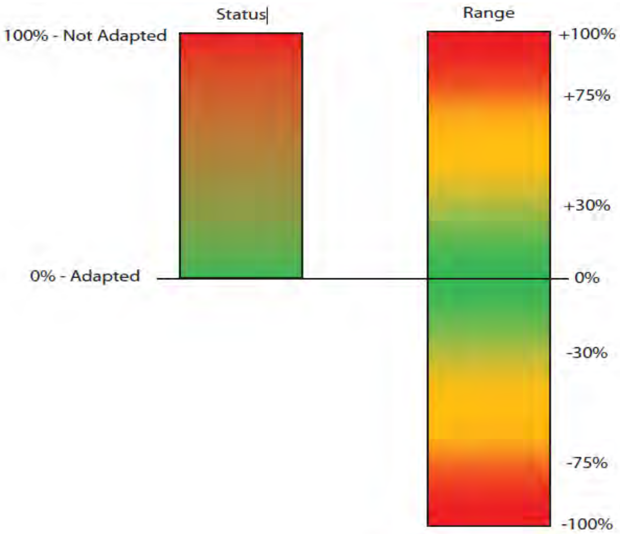
Status versus Range

It is important to remember that a motorcycle may be fully adapted, and show status figures of 0%, but may have a minor fault which will have used up all of the adjustment range available in order for it adapt. In this case the range figures will be high. Range figures of 30% or less are ideal; if positive or negative range figures of 75% or above are observed, investigate and rectify the cause and then allow the motorcycle to adapt. Range and status are described below:

- **STATUS** - Indicates how far the present operating parameter is from the nominal value. The nearer these figures are to zero the better as this indicates that the motorcycle has adapted.
- **RANGE** - Indicates how much (in percentage terms) of the adjustment range has been used to reach the current adaptive status.



Status Versus Range

High positive or negative range figures can be due to a number of faults but the most likely causes could be one of the following:

- Air leaks at the throttle bodies or airbox;
- Air leaks/blockage at the map sensor(s) or sensor air lines;
- Blocked, contaminated or a non standard air filter;
- Blocked fuel filter;
- Faulty injectors;
- Faulty spark plugs;
- Low/high fuel pressure;
- Incorrect valve clearances;
- Incorrect valve timing.

How to Reset the Adaptions
There are two methods of adaption reset, these are described below:

Note:
- **Resetting adaptions with the motorcycle connected to an exhaust extraction system may cause incorrect values to be set, causing poor engine running. Always reset the adaptions with the engine disconnected from any exhaust extraction system whilst ensuring the motorcycle is positioned in a well ventilated area.**

Standard Adaption
To start a standard adaption:
1. Ensure the transmission is in neutral.
2. Ensure the ECM has no stored faults (DTCs).
3. WITHOUT TOUCHING THE THROTTLE, start the engine and allow it to warm up to 90°C (60°C on Bonneville, Scrambler, Thruxton, America, and Speedmaster models).
4. Leave the engine to idle for a further 12 minutes.

Note:
- **If during an adaption cycle the conditions are no longer met, for example if the motorcycle is ridden, the motorcycle may not be fully adapted. The adaption process will continue each time the conditions are met again, and the engine has idled for longer than 3 seconds.**

Fast Adaption
To start a fast adaption:
1. Connect the diagnostic tool, select ADJUST TUNE (see the Triumph Diagnostic Tool User Guide) and select RESET ADAPTIONS. This will force a fast adaption routine to take place in around 5 seconds. For this to happen, the engine MUST be running, it must be at normal operating temperature and in closed loop control mode.
   Under any other conditions (such as with the engine not running) fast adaption will not take place and may cause default values to be loaded, which may then require a normal 12 minute adaption routine to be run.

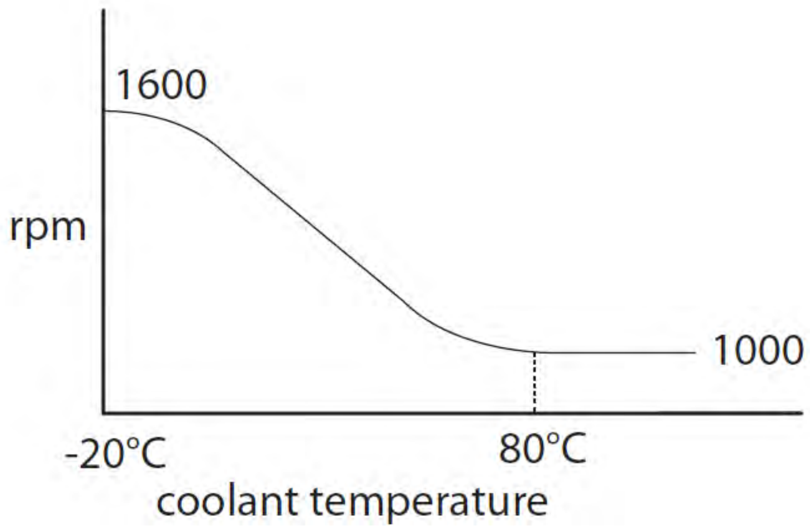
Note:
- **Using the fast adaption method above with the engine off and the ignition on will reset the adaptions to their default (not adapted) factory settings. A full 12 minute adaption routine will then be required.**
- **Both methods only adapt the idle area - the off idle area can only be adapted when the motorcycle is ridden under load, i.e. on the road.**
- **The off idle adaption area covers cruise sites from 30 to 90 mph (50 to 145 kmh), so the motorcycle must be ridden in this area to adapt. As it is not always possible for dealers to adapt motorcycles in this way, it is recommended that dealers inform the customer that the motorcycle will continue adapting during normal use.**

Further Reading
The Adaptive Fuel System
On the following pages is a detailed description of the three areas of the adaptive fuel system and how they work.

Closed Throttle Position
The ECM uses a digital table of values (stored as part of the tune) to determine the fuel required by the engine at any given throttle voltage and engine speed. The nominal closed throttle position is 0.6 volts (all models). If the closed throttle position is, for example, 0.62 volts, the ECM will increase the fuelling at the same engine speed as a result, as it believes the throttle to be partly open. In a non-adaptive system this would result in a rich mixture and therefore poor running and fuel economy. In an adaptive system this error is compensated for and corrected.

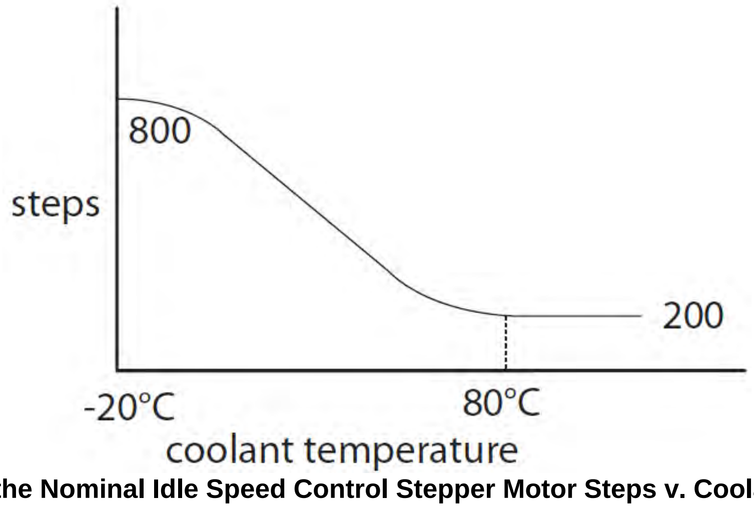
The ECM will take the difference between the actual reading and the 0.6 volts standard value (0.2v in the above example) and adjust the entire fuel map by this amount. This offset ensures that the ECM is applying the correct value from the fuel map.

Idle Speed Control
The ECM controls the idle speed control stepper motor to adjust the actual idle speed. The stepper motor is opened or closed in increments called steps. In a cold engine the stepper motor is opened (steps added on) until a pre-determined, or target, idle speed is achieved. This idle speed is then slowly lowered (steps removed) as the engine reaches its normal operating temperature.



Graph Showing the Target Idle Speed v. Coolant Temperature

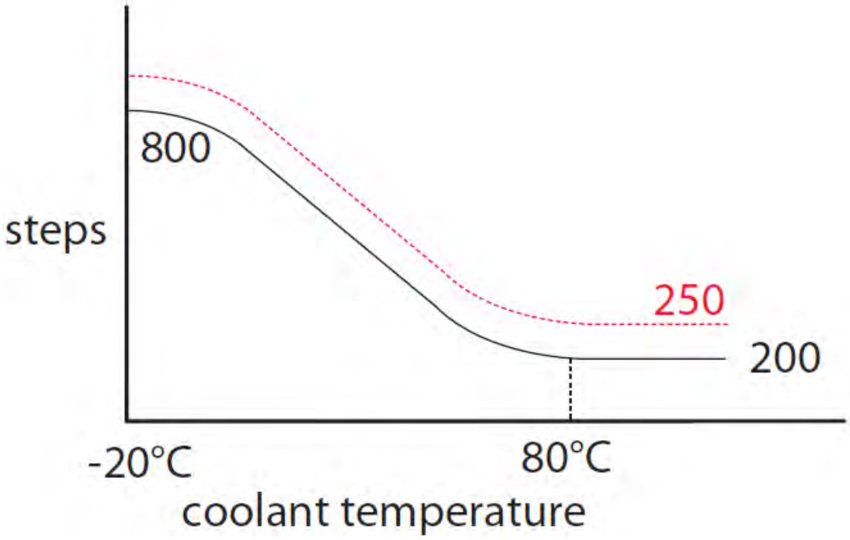
Once the engine is warm the ECM will attempt to achieve the correct idle speed (called the target idle speed) with the stepper motor at a nominal position of 120 to 200 steps (value dependant on model).



Graph Showing the Nominal Idle Speed Control Stepper Motor Steps v. Coolant Temperature

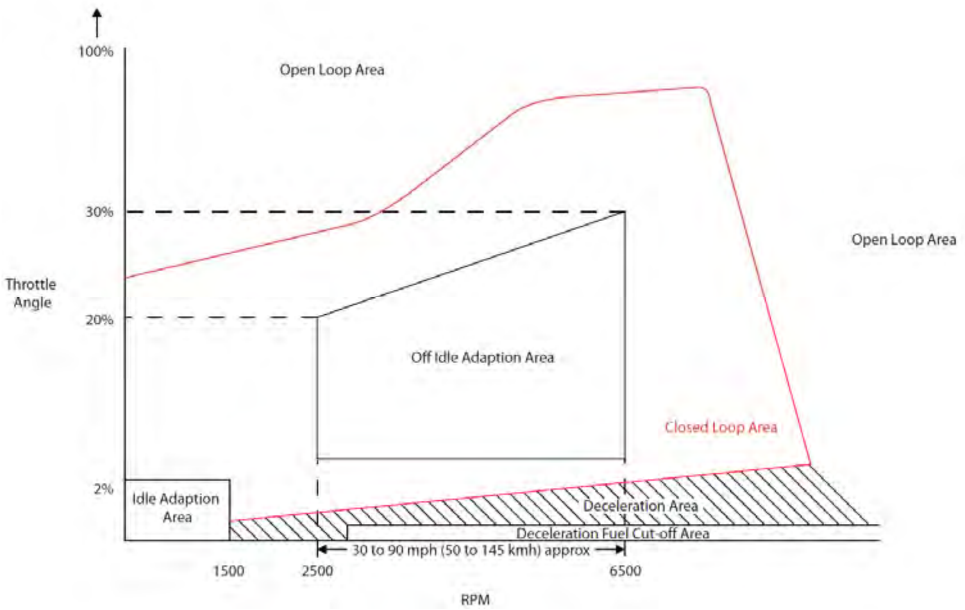
If the target idle speed cannot be achieved, the ECM will add or remove steps to the stepper motor until the target idle speed is reached. The ECM will then maintain this idle speed by further adjusting the stepper motor as necessary.
The ECM will take the number of steps on the stepper motor and compare this figure to the nominal value. The difference is then slowly added to or removed from the nominal value to bring the nominal value and therefore the idle speed to the correct value. Once adapted, this value is stored and applied to the full stepper motor range to allow accurate idle speed control at all engine temperatures.
For example, a brand new engine has a target idle speed of 1000 rpm at operating temperature, at a nominal stepper motor position of 200 steps. Because the engine is new and therefore tighter than a run-in engine, the stepper motor achieves this idle speed at 250 steps.
The ECM will add 50 steps to the nominal value of 200 steps and will make the adapted stepper position 250 steps.

Every time the engine is subsequently started, the ECM will use the adapted value of 250 steps to provide the correct idle speed. This is called adaptive stepper offset.
As the engine becomes run-in this figure will reduce each time the motorcycle adapts, as the reduced engine friction will require less steps on the stepper motor to achieve the 1000 rpm idle speed, so the adapted number of steps will gradually change.



Graph Showing the Adapted Idle Speed Control Stepper Motor Steps (in Red) v. Coolant Temperature

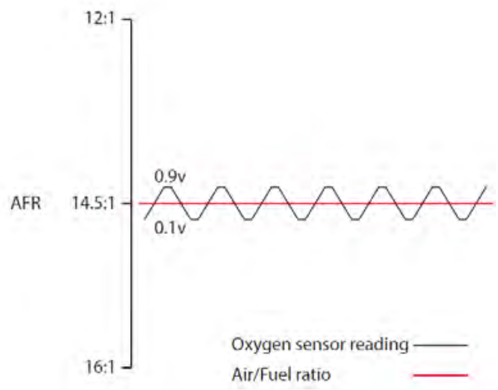
Closed Loop System
The ECM uses a map (stored as part of the tune) to determine the fuel required by the engine at any given throttle angle and engine speed. A typical map is shown below.



Typical Closed Loop Map

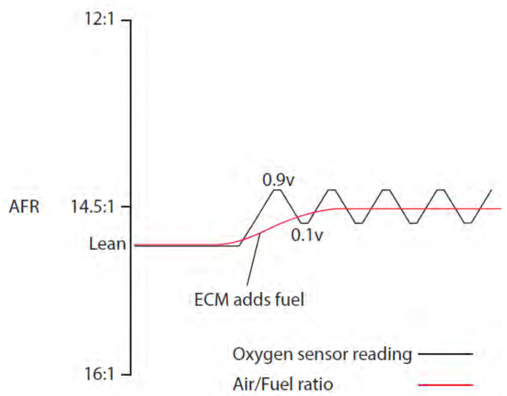
Note that the off idle adaption area will begin and end at different engine speeds on different engines, but the 30 to 90 mph range will be similar on all motorcycles.
The closed loop system uses the oxygen (Lambda) sensor(s) positioned in the exhaust to measure the oxygen in the exhaust gas. The oxygen sensor generates a variable voltage dependant on the oxygen present in the exhaust; the ECM interprets this voltage from the oxygen sensors as either a rich or lean mixture and adjusts the injector opening time to compensate. This rich/lean switching of the oxygen sensors happens constantly in closed loop mode. This system provides a feedback 'closed loop' to provide continuous accurate control of the fuel mixture.
The closed loop system adjusts the air/fuel ratio (AFR) to 14.5:1 at idle speed and light throttle openings (cruising speeds). At larger throttle openings and under acceleration or deceleration, or when the engine is cold, the system reverts to open loop operation and runs a richer fuel/air mixture to protect the engine from potentially damaging lean mixtures, and to produce good power.

All engine and fuel system components have tolerances, and these tolerances may impact on the fuel mixture in a negative way. These components include fuel injectors (higher or lower flow than nominal), compression ratios, fuel pressure (fuel pump or fuel pressure regulator tolerances).



Graph Showing the Air Fuel Ratio Compared to the Oxygen Sensor Output in a Nominal Engine

In an engine built with combinations of tolerances or one that has a minor fault, such as an air leak (lean mixture) or fuel pressure regulator fault (high fuel pressure will give a rich mixture, low fuel pressure a will give lean mixture) this basic fuel map would be incorrect. In this case, the ECM adjusts the amount of fuel injected to achieve the correct AFR.



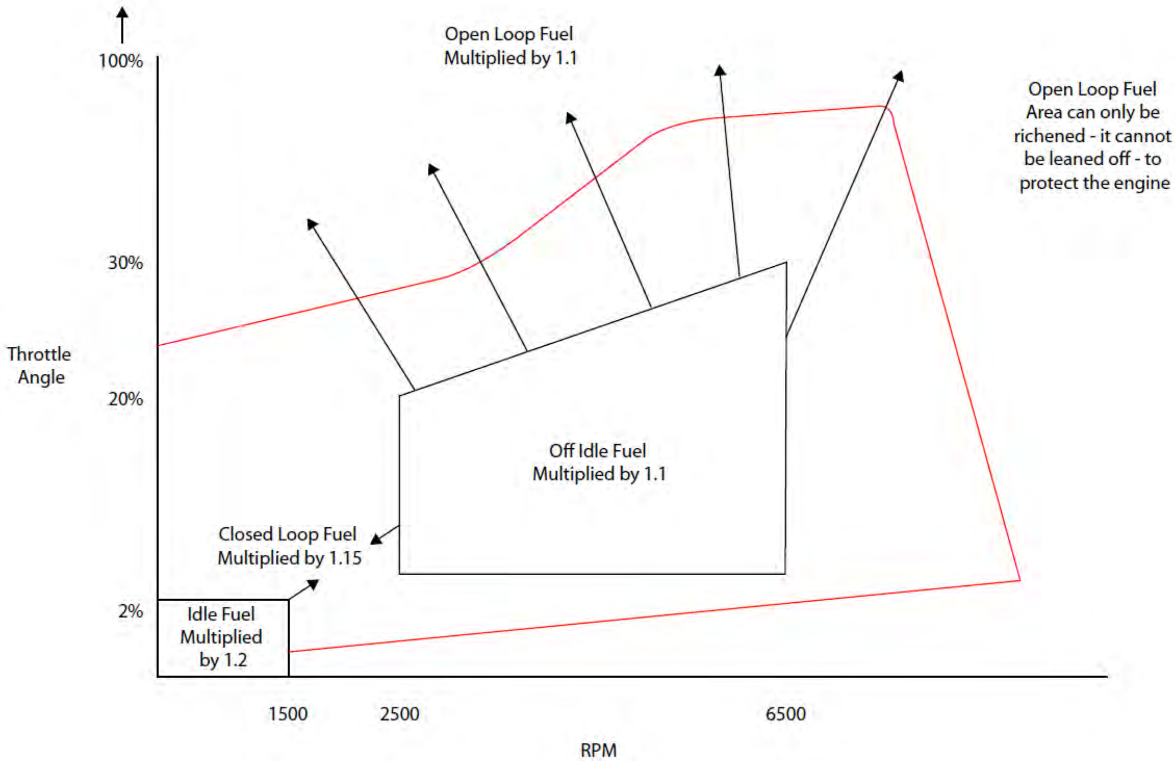
Graph Showing the Air Fuel Ratio Compared to the Oxygen Sensor Output in an Engine Running Lean

For example, in a motorcycle where the engine is running lean due to an air leak, the engine will require more fuel to correct the mixture at idle. The ECM compensates for this lean mixture by adding more fuel (increasing the injector opening time) until the mixture is rich, at which point it begins to reduce fuel again to correct the mixture. The ECM then looks at the difference in the amount of fuel being injected compared to its base fuel map. The difference between the two figures is the amount the system needs to be adapted. The base map is adjusted by this figure to give the correct air fuel ratio.

Throttle Angle (Degrees open)	RPM 720	1100	1300	1500	1700	1900	2100	2300	2500	2600	2700	To Redline → 2900
0	1.275	1.501	1.429	1.397	1.336	1.292	1.282	1.258	1.206	1.192	1.163	1.13
1	1.649	1.66	1.627	1.568	1.516	1.492	1.466	1.449	1.372	1.338	1.288	1.261
2	1.764	1.798	1.754	1.706	1.65	1.628	1.588	1.559	1.507	1.472	1.437	1.363
3	1.881	1.889	1.87	1.827	1.76	1.679	1.659	1.66	1.629	1.597	1.542	1.465
4	2	2.04	2.043	1.953	1.893	1.791	1.741	1.733	1.717	1.696	1.671	1.642
5	2.135	2.218	2.167	2.138	2.027	1.968	1.91	1.893	1.872	1.865	1.836	1.807
6	2.208	2.28	2.236	2.191	2.107	2.064	2.006	2.006	1.977	1.962	1.951	1.922
8	2.436	2.496	2.462	2.385	2.284	2.248	2.226	2.227	2.215	2.191	2.188	2.151
10	2.664	2.712	2.688	2.579	2.46	2.432	2.445	2.447	2.454	2.419	2.425	2.38
15	2.744	2.808	2.752	2.649	2.519	2.502	2.503	2.555	2.57	2.568	2.564	2.544
20	2.808	2.856	2.776	2.641	2.55	2.549	2.547	2.618	2.691	2.694	2.696	2.644
25	2.888	2.968	2.875	2.727	2.632	2.612	2.64	2.728	2.797	2.824	2.804	2.72
30	3.064	3.096	2.952	2.824	2.728	2.692	2.728	2.824	2.917	2.944	2.939	2.823
35	3.224	3.321	3.112	2.952	2.873	2.868	2.944	3.048	3.199	3.184	3.128	2.98
40	3.339	3.403	3.117	2.987	2.975	2.971	3.075	3.274	3.448	3.396	3.296	3.099
50	3.452	3.585	3.189	3.096	3.041	3.091	3.213	3.462	3.572	3.524	3.39	3.2
60	3.592	3.738	3.38	3.189	3.148	3.186	3.355	3.654	3.692	3.65	3.477	3.268
70	3.78	4.004	3.619	3.362	3.287	3.376	3.752	4.07	4.1	3.872	3.676	3.464
78	3.888	4.064	3.774	3.5	3.429	3.5	3.849	4.164	4.164	3.936	3.784	3.513
100	3.984	4.144	3.998	3.612	3.525	3.548	4.009	4.276	4.276	4.112	3.928	3.657

Typical Base Fuel Map (Figures in the Table Cells are Injector Opening Time in Milliseconds)

The closed loop mode adapts in two areas of the fuel map, idle and off idle. The adapted figures are then read across to the remaining closed loop areas (shown red below) and the open loop areas of the fuel map, where no closed loop mixture correction is possible, in order to improve driveability in these areas.



Fuel Map Showing how Adapted Values are Applied to Open Loop Areas

There is a limited amount of adjustment of the air fuel ratio, once this limit is reached the system will not adapt any further. This limit is indicated on the Triumph diagnostic tool as range figures of 100%. Figures of 30% or less are ideal; if positive or negative figures of 75% or above are observed, investigate and rectify the cause and then allow the motorcycle to adapt.

Note:

- **A positive figure indicates the engine is running lean, and the ECM is adding more fuel to compensate, a negative figure indicates the engine is running rich and the ECM is removing fuel to compensate.**