Actual Values Information To Aid in Vehicle Diagnosis

Subject: **Actual value information to aid in vehicle diagnosis**

The following information is intended to aid in the understanding of actual values. It describes the functionality of different sensors and how this is reflected in the actual values. This information may not include all details surrounding an actual value, and should not be used to replace any published information (e.g. workshop manual). Additional information pertaining to actual values can be found at the beginning of each diagnosis (Group 0) workshop manual. As a first step to diagnose a vehicle, a **V**ehicle **A**nalysis **L**og (VAL) should always be downloaded with the PIWIS Tester.

Ambient Air Pressure

The ambient pressure value is determined from the pressure sensor (Piezo sensor) located in the DME. The value is used in the calculation of correction factors (map shifts) due to altitude.

Altitude Correction Factor

The altitude correction factor value is derived from the ambient pressure sensor (Piezo sensor) within the DME. This value is used to make corrections in mapped data (e.g. mass air flow sensor monitoring) due to the different operating conditions at different altitudes. It also disables certain diagnosis routines such as secondary air, tank ventilation and leak detection in high altitudes. The correction factor is 1.0 at sea level and an air temperature of 77° F. (25° C.) and 0.84 at 5,300 feet (Denver) and an air temperature of 77° F. (25° C.).
Note: As you increase in elevation, this value will decrease.

Engine Load (otherwise known as Cylinder Charge)

The cylinder charge is the energy release potential of the particular air / fuel mixture contained within a cylinder. The engine load value is the inducted air / fuel mixture along with residual gases found in the cylinder once the intake valves are closed. The throttle plate regulates the amount of air to pass onto the cylinders and therefore has a direct relationship to the charge of the engine. Variable intake valves (lift and timing) and the geometry of the intake system will also play a role with the cylinder charge potential. This value displayed as a percentage is approximately 100% at full throttle on a naturally aspirated engine and more than 100% on a turbo charged engine.

Load Activated Charcoal Filter / Carbon Canister Load

The load activated charcoal filter value provides information on the saturation of the carbon canister. The carbon canister absorbs fuel vapors that would otherwise be released into the atmosphere and allows the engine to utilize the stored vapor mixture, via a purge valve, in the combustion process. The load values range from 0 (pure air, canister empty) to approximately 32 (completely saturated with fuel, canister full). e.g. an interpretation of the value: 1 corresponds to $\lambda = 1$; 2 is twice richer ($\lambda = 0.5$). It is possible that a negative load value (< 0) or a higher load value (> 32) is displayed if the mixture (fuel trim) adaptations are not completed. The load value is used for fuel metering while purging and as disable condition for certain diagnosis (e.g. leak detection).

Relative Fuel Quantity via Tank Ventilation

The relative fuel quantity via the tank ventilation value is a mixture control value. It is based on the engine pulled portion (in percent) of fuel mass flowing from the charcoal canister through the purge valve to the intake tract during the purging process of the carbon canister. Otherwise stated, the “relative fuel quantity via tank ventilation” is the percentage of fuel that does not come from the fuel injector valves but from tank venting. A negative value would mean that the air-fuel mixture from the carbon canister through the purge valve is leaner than 14.7 / 1 and therefore additional fuel must be injected to compensate. Tank venting does not occur during the mixture adaptation phase (e.g. RKAT, FRA). Consequently, the value would be set to “0” during adaptation.

Oxygen Sensing, Fuel Trim Mean Value

“Oxygen sensing” (986, 996) and “Fuel trim, mean value” (987, 997, Cayenne, Carrera GT) return the actual values of the lambda regulator. The lambda regulator compensates for fluctuations of the actual lambda value. The actual lambda value is determined by the actual content of oxygen in the exhaust system measured by the upstream O_2 sensor. The air / fuel ratio λ (lambda) indicates the extent, to which the instantaneous O_2 sensor monitored air / fuel ratio deviates from the theoretical ideal or stoichiometric (the ideal air / fuel mixture for maximum catalyst efficiency is 14.7 Kg air to 1 Kg fuel or lambda λ 1.0).

$$\lambda = \frac{\text{actual inducted air mass (X)}}{\text{theoretical air requirement (14.7)}}$$

Richer fuel mixtures result in $\lambda < 1$ and leaner fuel mixtures result in $\lambda > 1$. Accordingly, the lambda regulator (Oxygen sensing, Fuel trim mean value) enriches the mixture for $\lambda > 1$ and makes it leaner for $\lambda < 1$ and reacts opposite to the actual lambda value.

Remark: In addition to the lambda regulator values (Oxygen sensing, Fuel trim mean value) the measured value “Actual Lambda value” is displayed in the PIWIS Tester for models that use continuous oxygen sensors ahead of catalysts.

FRA (U)/(O) (bank 1/bank 2)

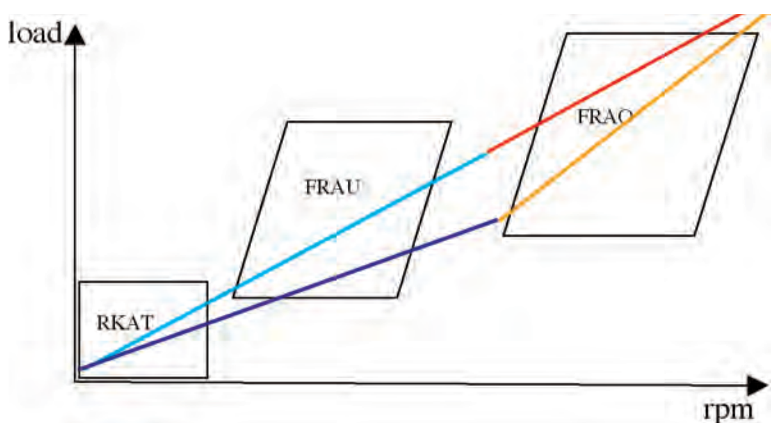
The FRA (U) (O) value is the adapted value of lasting deviations of the air / fuel mixture that occurs under load.

- **FRA** stands for "Faktor Regelung Adaption" or adaptive regulation factor
- **U** is the German word "untere" or lower,
- **O** is the German word for "obere" or upper load ranges

The injection time for a given load and RPM is stored as a model in the DME assuming a standard engine. The FRA(U)/(O) adaptation is being done while the engine is operated under part load (lower part load (U), higher part load (O)). FRA(U)/(O) are numeric multiplicative factors meaning they are multiplied by the injection time to correct dominant deviation from the ideal mixture. Deviations corrected by the multiplicative factors are dominant during part load and usually occur as fuel supply problems, e.g. coking of the injection valves or MAF deviation. The ideal value for FRAU and FRAO is 1.00.
A value < 1.00 means the air / fuel mixture was made leaner (compensating for a rich mixture) whereas a value > 1.00, the air / fuel mixture was made richer (compensating for a lean mixture) over the basic mapping. FRAU is also applied on close to idle load; that's why FRAU has to be adapted before values in RKAT become relevant.

Example:

FRAU = 1	FRAU < 1
FRAO = 1	FRAO > 1



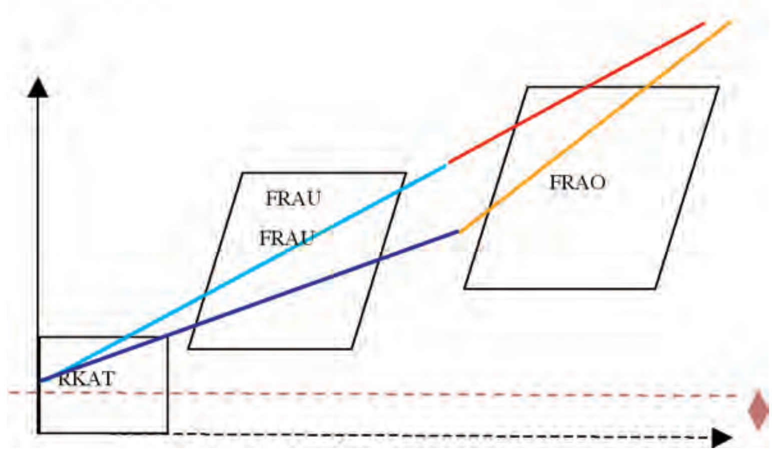
RKAT (bank 1/bank 2)

Long Term Fuel Trim up to 4.5% +/-

The RKAT (**R**elative **K**raftstoffmenge (fuel amount) **A**dditive and **T**ime) value is the adapted value of long-term deviations of the air/fuel mixture that occur at or close to idle. The injection time at or close to idle is stored as a model in the DME assuming a standard engine. The RKAT adaptation is being done while the engine is operated at or close to idle. RKAT is an additive value meaning it is added to the injection time to correct dominant deviation from the ideal mixture. An RKAT of 2.0% would mean that at relative engine load of 20% needs a relative fuel amount of 22% (+2.0% from RKAT). Errors corrected by the additive factor are dominant at or close to idle (e.g. an air leak in the intake system). The ideal value for RKAT is 0.00%. A value < 0.00 means the air / fuel mixture was made leaner (compensating for a rich mixture) whereas a value > 0.00 the air / fuel mixture was made richer (compensating for a lean mixture) over the basic mapping (e.g. an intake air leak will usually result in a RKAT value being positive).
Note: False air behind throttle has a greater effect at idle than under load. Deviation of the air mass sensor signal can also influence the values significantly.

Example:
RKAT = 0
RKAT > 0

Short Term Instant Fuel trim is the actual Oxygen Sensing Lambda value. .75 to 1.25



There is a dependence between the 2 adaptation values FRA (U/O) and RKAT. That's why several adaptation phases under different load conditions are necessary before the system is fully adapted.

Camshaft Actual Angle (bank 1/bank 2)

The camshaft actual angle value is the actual angle of the camshaft in relation to the crankshaft. See Camshaft deviation.

Camshaft Deviation (bank 1/bank 2)

The camshaft deviation values is the measured amount the intake camshaft deviates from its ideal position in relationship to the crankshaft, displayed in crankshaft degrees. This is an adaptive value, which means it is continuously monitored during engine operation. It is not compensated and must be relearned after a loss of battery power. The relative positions of the crankshaft and camshaft are monitored via an inductive type sensor at the crankshaft flywheel and a Hall effect sensor at the intake camshaft for each cylinder bank. The deviation value is determined by comparing the inputs from the camshaft position sensor to the input from the crankshaft position sensor. If the camshaft deviation value exceeds a preset limit, a fault code is set and camshaft variation is disabled in order to avoid possible mechanical engine problems.
Note: False readings can be displayed if the camshaft sensor wheel is loose, damaged or offset. Great care should be taken when handling the camshaft. Inaccurate measurements will result in poor engine performance although the camshafts are in their correct positions.

Camshaft Specified Angle (bank 1/bank 2)

The camshaft specified angle value is the intended angle of the inlet camshaft in relation to the crankshaft as specified by the DME. In general, the actual angle should match the specified angle. If not, a mechanical, hydraulic or electrical problem may exist (depending on the system) in the VarioCam assembly.

Air Mass Deviation, Secondary Air (bank 1/bank 2)

The air mass deviation, secondary air value is the calculated mass of secondary air entering the exhaust system from the secondary air pump and is measured using the O_2 sensors. The calculated secondary air mass is compared with a reference figure stored in the DME. A value of 100% represents the expected secondary air mass.

Tank Ventilation Valve, Duty Cycle

The tank ventilation valve, duty cycle value represents the actuation of the purge valve by means of a Pulse Width Modulated (PWM) signal. The value can range between 5% (closed) and 95% (completely open).

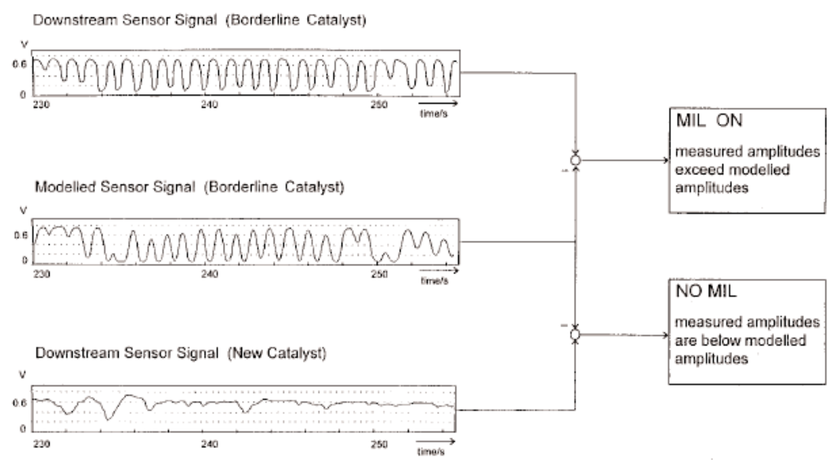
Status of Catalyst, Catalytic Converter Status (bank 1/bank 2)

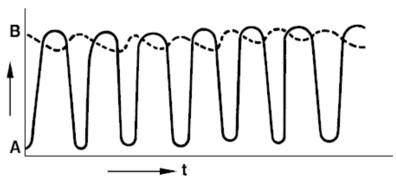
The status of catalyst (986, 996, 987, 997) / catalytic converter status (Cayenne) value is the result of monitoring the condition of the catalyst in relation to its ability to convert pollutant emissions. The diagnosis uses the oxygen storage capacity as a measure for the catalyst condition.

There are 3 different types of catalyst diagnoses depending on the vehicle:

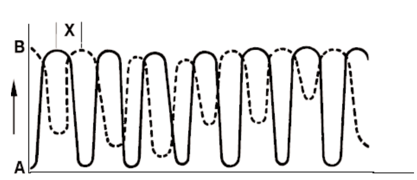
986 / 996 / 997 (only MY05)

These models use 2-point oxygen sensor ahead and behind the catalysts. During diagnosis (once per driving cycle), the amplitude of the O_2 sensor after the catalytic converter is evaluated and compared against a model (simulated oxygen storage capability of a borderline deteriorated catalyst) in the DME. As the catalyst ages, this value will increase showing a decrease in storage capacity. If the rear sensor is similar to the front sensor, the catalyst is not operating sufficiently and the emissions will increase. A fault is set if a predetermined threshold is exceeded and an internal flag is set. If the fault reoccurs in the next driving cycle, the check engine light is illuminated.





TWC OK



TWC not OK

A: Sensor amplitude ahead of TWC
B: Sensor amplitude after TWC
X: Delay due to gas running time

A: Sensor amplitude ahead of TWC
B: Sensor amplitude after TWC

Cayenne

The Cayenne uses continuous oxygen sensors ahead and 2-point oxygen sensors behind the catalysts. During diagnosis (once per driving cycle), an oscillation similar to the signal of a 2-point oxygen is applied to the fuel/air mixture. The following diagnosis is similar to the above described one (986, 996, 997 (MY05)).

987 / 997 (as of MY06)

These models use continuous oxygen sensors ahead and 2-point oxygen sensors behind the catalysts. During diagnosis (once per driving cycle), the engine is operated for a few seconds under richer fuel mixture conditions ($\lambda < 1$) to remove all oxygen from the catalyst. Directly after that, the engine is operated under leaner fuel mixture conditions ($\lambda > 1$) and the time required to reach lean conditions at the rear sensor is measured (this time of course depends on the engine load). The better condition a catalyst is in, the more oxygen it can store and the longer it takes to see lean conditions at the rear sensor. As the catalyst ages, the measured time will decrease indicating a decrease in oxygen storage capacity and therefore catalyst efficiency. A fault is set if the measured time is less than a predetermined threshold. If the fault reoccurs in the next driving cycle, the check engine light is illuminated.

Uneven/Rough Running Reference

The uneven running reference value is the upper limit of the running roughness for the given cylinders (6 or 8 cylinder engines). This value varies with load and RPM. If the actual value of the running roughness of one cylinder exceeds the reference, a misfire is then counted in the misfire counter.

Uneven/Rough Running Cylinder 1 – 8

The uneven running cylinder is a calculated value for the (missing) portion of each combustion to the crankshaft rotation. If this value exceeds the reference value, a misfire is counted. Before calculating uneven running, an adaptation of the flywheel has to be carried out in order to differentiate between geometrical imperfections on the flywheel and engine roughness. The first part of this adaptation takes place on deceleration of the engine and with fuel cut-off.

Misfire Counter Cylinder 1 – 8

The misfire counter value detects the number of misfires for each cylinder. There are several methods for determining misfires for the various conditions of an engine. Common to all methods is the exact detection of engine speed, calculated by the DME, using the signal created by an inductive sensor (speed sensor) that is counting the 60 minus 2 teeth of the tooth wheel on the flywheel. Misfires can only be detected once engine roughness is adapted to avoid misdiagnosis. The DME uses this data to form the angular segments. The time elapsed in a given segment (segment time) corresponds to the interval between two ignitions. Consequently, variances in the rotational speeds (segment times) can be concluded as misfires.

Area of Misfires, Minimum Speed or Misfire Range, Minimum RPM

This value is the recorded minimum engine speed (RPM) when a misfire has occurred.

Area of Misfires, Maximum Speed or Misfire Range, Maximum RPM

This value is the recorded maximum engine speed (RPM) when a misfire has occurred.

Area of Misfires, Minimum Load or Misfire Range, Minimum Load

This value is the recorded minimum engine load when a misfire has occurred.

Area of Misfires, Maximum Load or Misfire Range, Maximum Load

This value is the recorded maximum engine load when a misfire has occurred. These values are only valid if misfires have been recorded.
Note: Values used to determine the area at which misfires have occurred. This aids in diagnosis of misfires by knowing the range for complaint reproduction.

Retardation Cylinder 1-6

The retardation cylinder value is the measurement of the retarded ignition angle due to the combustion knock of a cylinder. Ignition timing is retarded in steps of 0.75° crankshaft up to a maximum of 15° crankshaft.

Air-Mass (HFM)

The Air-Mass (HFM) value is the total air measured per time unit by the mass air flow sensor (without tank ventilation) that enters the intake.

Warm-up Cycle Condition

The warm-up cycle condition value counts the predefined warm-up cycles. To fulfill the condition "warm-up cycle", the engine starting temperature may not exceed a specified value (currently 111° F./44° C.). The engine-operating phase has to be long enough to produce a certain temperature increase (currently 70° F./21° C., but the temperature reached must be at least 129° F./54° C.). The "warm-up cycle condition" is needed to count down or reduce the erase counter for faults that have been recognized as corrected.

Loss Adaptation, Idle

The loss adaptation, idle compensates for light / heavy running conditions of the engine or accessories in comparison to a standard engine. E.g., this value considers the increased friction loss of brand new engines or the loss tolerances of different components (alternator, coolant pump, etc.). Accessories, which can be activated (e.g. Drive position engaged, A/C), are adapted separately (not shown in the PIWIS Tester) and are not reflected in this actual value.

Dealership Distribution Routing	Service Manager	______	Shop Foreman	______	Service Technician	______	______	______	______
	Asst. Manager	______	Warranty Admin.	______	Service Technician	______	______	______	______