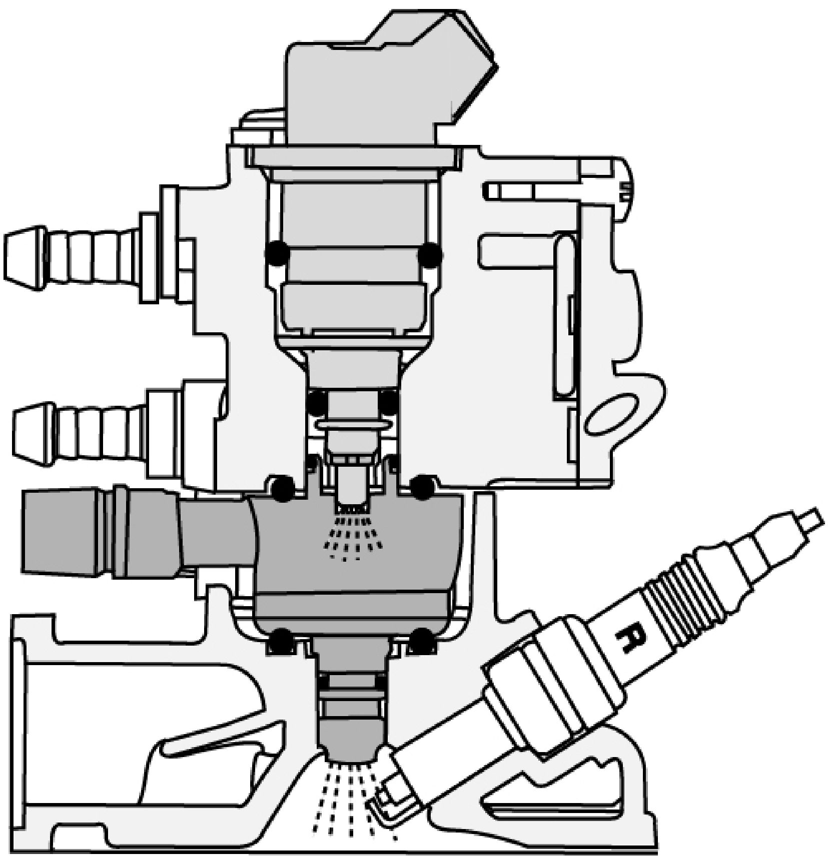
SALES DIVISION
NETWORK TECHNICAL INFORMATION

WORKSHOP MANUAL



TSDI INJECTION SYSTEM FUNCTIONING PRINCIPLE
(Two Stroke Direct Injection)

CONTENTS

Advantages of the injection system

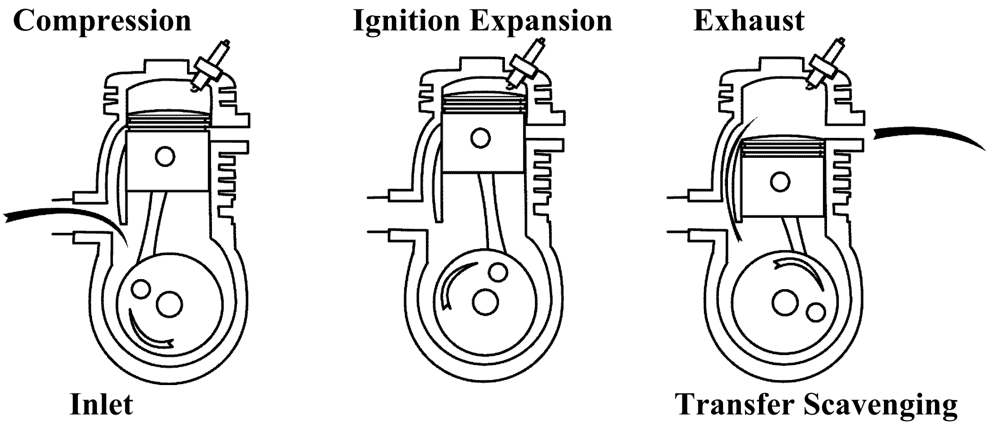
Peugeot Motocycles has built a new generation engine. Cleaner, more reliable, more economical, they will comply with the most stringent standards, whilst remaining very high performance. With the TSDI (Two Stroke Direct Injection) there are numerous advantages:
- up to 80 % reduction of polluting emissions
- up to 35% fuel savings
- up to 40% oil savings
- improved rider comfort
- reduced exhaust soot
- better starting

The injection system on the 2-stroke engine means it complies with increasingly stringent pollution control standards.
ECE 47 standard: CO <8.0g/km and HC <5g/km with a carburettor
Euro1 standard: CO <6.0g/km and HC + Nox <3.0g/km will be possible for an injection system used without a catalyser
Euro2 standard: CO <1.0g/km and HC + Nox <1.2g/km will be possible for an injection system used with a catalyser.
The two main pollutants on a 2-stroke engine are petrol and oil. To reduce pollution, we need to:
- ➯ Reduce the quantity of fuel and oil consumed.
- ➯ Obtain better combustion and therefore higher efficiency.

Fuel savings

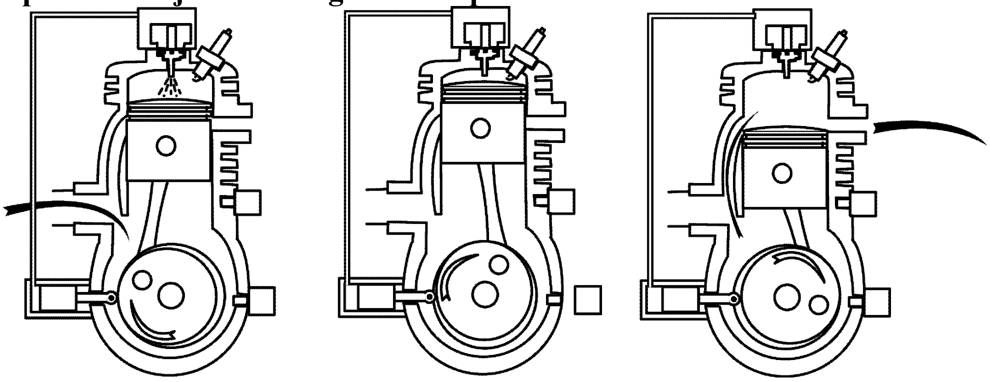
A. Engine functioning savings

1. Functioning of a carburettored 2-stroke engine:



In the inlet phase, a mixture of air + fuel enters the engine. This mixture is compressed by the piston and then fed to the combustion chamber through the transfer conduits. When the mixture reaches the combustion chamber it is used to expel the burned gases. This is scavenging. For complete and efficient scavenging, it must be prolonged until the new mixture (air + fuel) begins to exit through the exhaust. The mixture which exits through the exhaust is wasted.

2. *Functioning of the injection 2-stroke engine:*



In the inlet phase, only air enters the engine. The air is compressed under the piston then fed to the combustion chamber through the transfer conduits. Scavenging uses this air which contains no fuel and therefore there is no wastage. Fuel will only be injected on compression when the piston rises.

B. Fuel savings

In a carburettor, the fuel flow is proportional to the diameters of the jets. The richness curve is therefore fixed and proportional to the jets used. Combustion is almost never correct since the mixture is either too rich or too lean but very rarely correct. There is therefore loss of efficiency.
In an injection system, the electronic control unit (ECU) determines the quantity of fuel strictly necessary for correction functioning of the system on the basis of the actual engine functioning parameters (via its sensors). The mixture richness is always correct. Combustion is more complete and of better quality, therefore the engine is more efficient.

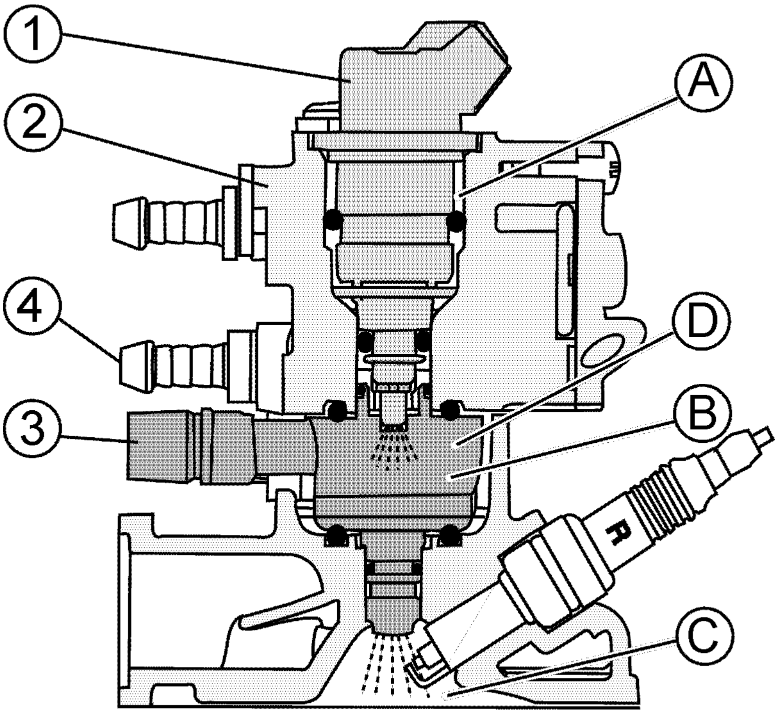
This system gives a fuel saving of up to 35 %.

Oil savings

The oil pump on a carburettored engine is driven by the crankshaft and its flow is directly proportional to the engine speed. In certain cases, a correction based on load is applied to “variable” flow pumps, but the flow remains proportional to engine speed.
Engine oil requirements are completely different, the maximum oil requirement of an engine is when it is under full load at low speed (machine heavily loaded, going uphill). On the other hand, it requires almost no oil when the engine is at high speed and no load (machine loaded, going downhill).
The injection system drives the oil pump which in this case is electric, and can therefore determine the quantity of oil injected for the engine actual requirements, in the same way it does for petrol.

This system gives an oil saving of up to 40%.

Functioning principle



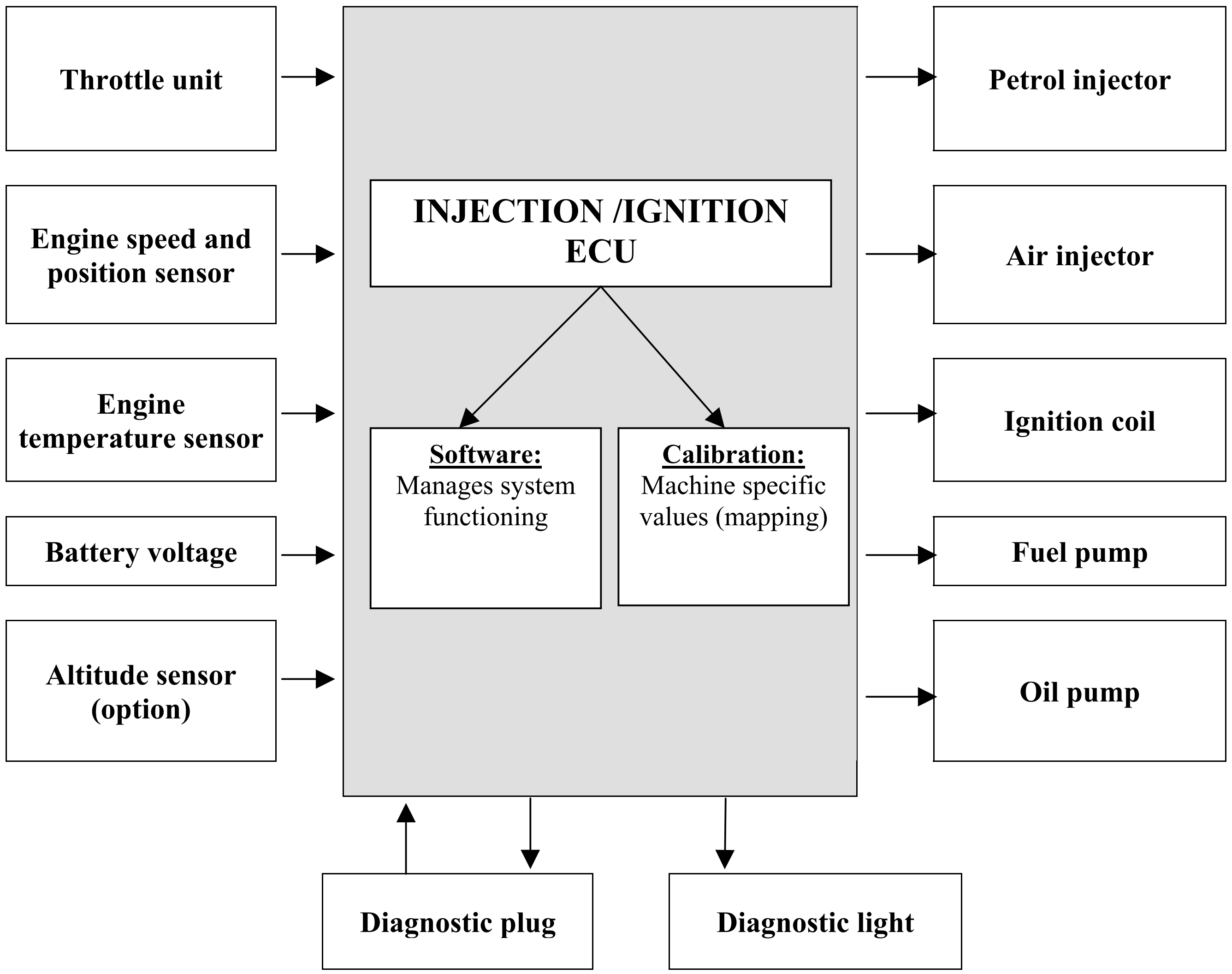
1. Fuel injector
2. Injection rail
3. Air injector
4. Pressurised air inlet

A	Pressurised fuel (8 bar)
B	Mixture chamber
C	Combustion chamber
D	Pressurised air (5 bar)

To convey the fuel, the system uses pressurised air (D). The air is pressurised by a compressor driven by the crankshaft. The pressurised fuel (A) is injected into the air injector mixture chamber (B).

The pressurised air (D) is fed into the air injector mixture chamber (B), and mixes with the fuel injected. The air-fuel mixture is then injected directly into the combustion chamber (C) as the piston rises.

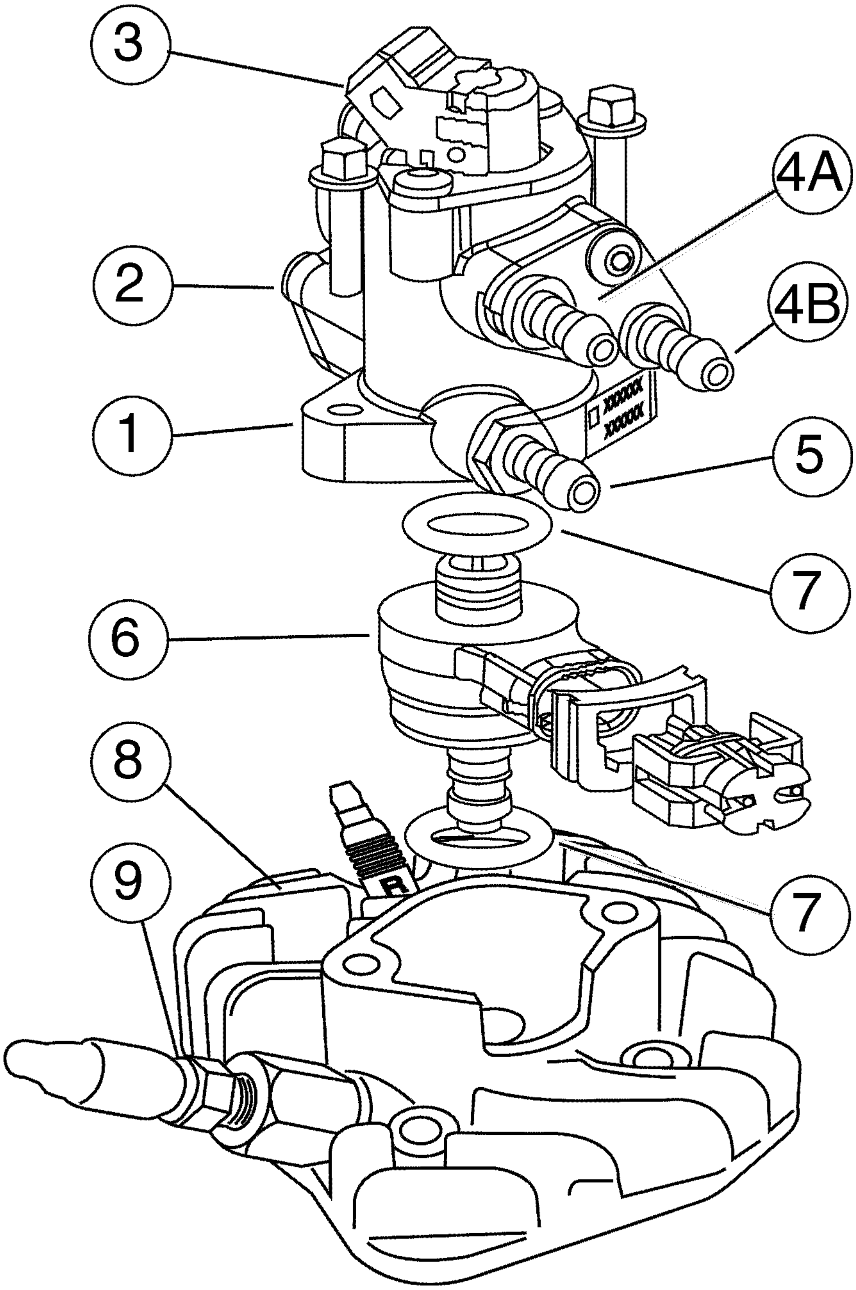
Synoptics



The system basic principle consists in measuring the engine speed and load (throttle valve opening) in order to determine the optimum quantity of fuel to be injected

Note:
In this system, the pressurised air from the compressor is used only to convey the fuel to the cylinder and not for turbocharging.

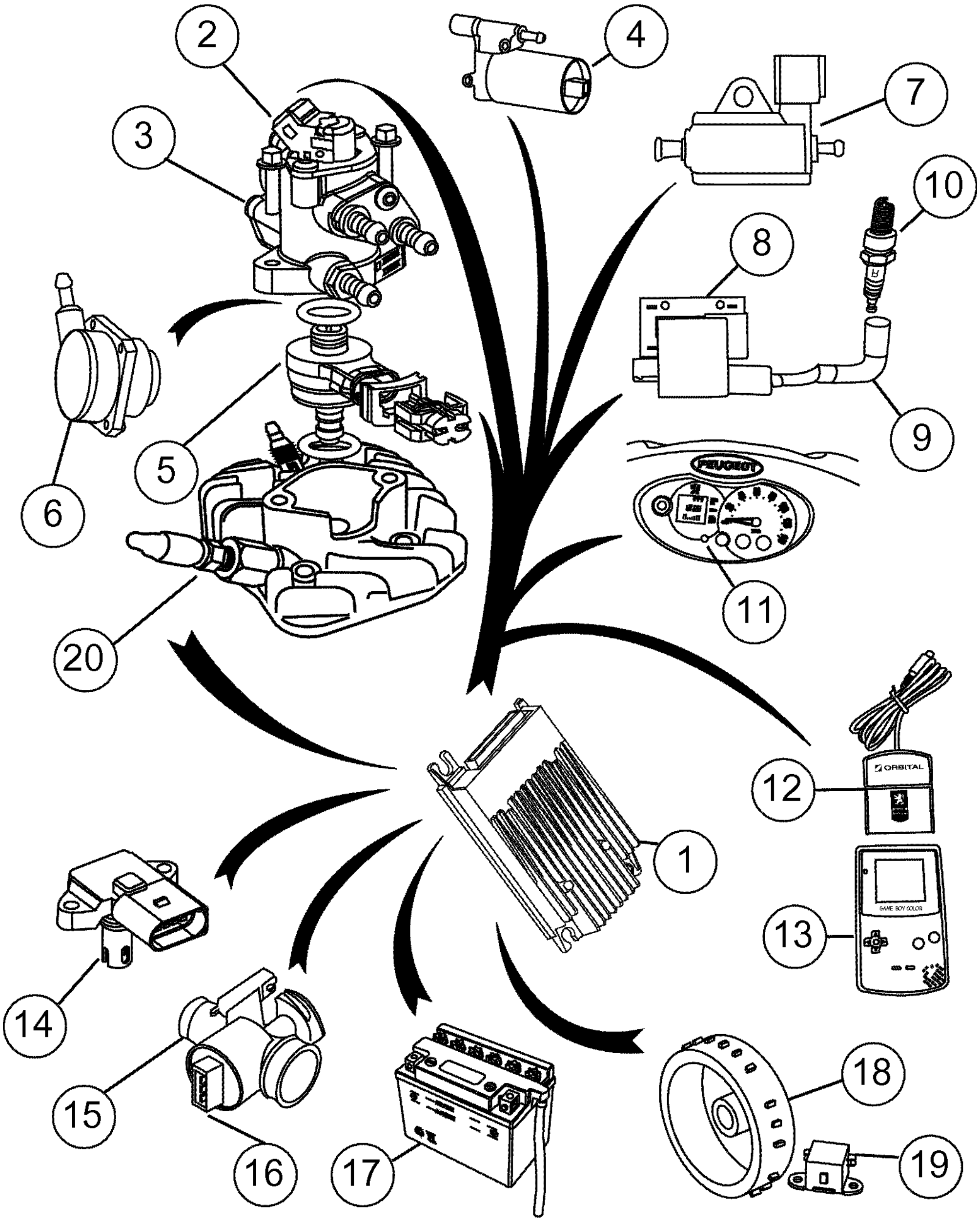
Injection rail composition



The assembly is composed of:

1. The injection manifold
2. The fuel pressure regulator
3. The fuel injector
4. Fuel system:
   A fuel inlet
   B fuel return
5. Compressed air circuit
6. Air injector
7. Seals
8. Cylinder head
9. Engine temperature sensor

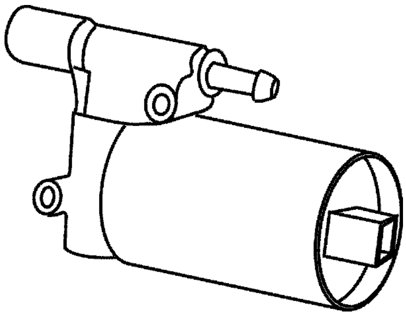
General view



1. Injection ECU
2. Fuel injector
3. Injection manifold and regulator
4. Fuel pump
5. Air injector
6. Air compressor
7. Oil pump
8. Ignition coil
9. Resistive suppressor
10. Resistive spark plug
11. Diagnostic light
12. Diagnostic cartridge
13. Diagnostic tool
14. Altitude sensor (optional)
15. Throttle unit
16. Throttle potentiometer
17. Battery
18. Magneto pulse flywheel
19. Engine position sensor
20. Engine temperature sensor

component details:

Fuel supply system



Pump output: 5.2 litres/hour

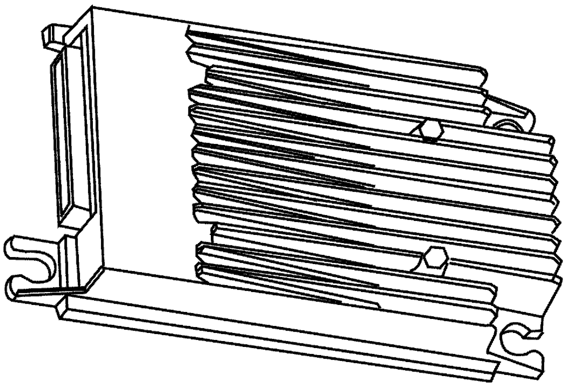
Connection:
Pin 1: to ECU pin 14
Pin 2: Battery +

Check: R= 5.5 $^{\pm 10\%}$ Ω

Strainer in fuel tank
(clean every 5000 km, and change every 15000 km)

An electric pump, controlled by the ECU, feeds fuel to the injection manifold. The fuel is then fed at a pressure of around 7.5 bar, limited and regulated by a pressure regulator. The regulator is slaved to the compressor air pressure to continually maintain a differential pressure of 2.5 bar between the air (at around 5 bar) and the fuel. This makes the fuel delivery proportional to the injector opening time.
The pump functions for 3 seconds when the ignition is turned on in order to pressurise the fuel system.

Fuel metering:



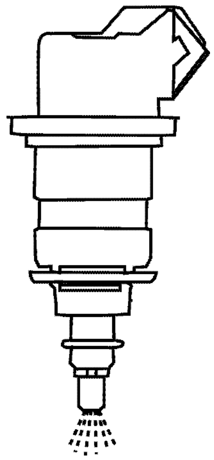
Connection:
22 pins

Overvoltage protection up to 18 volts

Note:
Never disconnect the ECU or a circuit component when the power is on. The ECU may be destroyed.

Fuel metering is provided by the ECU which, depending on the quantity of air inlet into the engine (measured by the throttle unit), the engine speed (measured by the speed sensor) and the necessary correction (cold starting, acceleration, idle, etc….), determines the fuel injector opening time (injection time). The fuel is injected into the mixture chamber which is filled with pressurised air. The air injector injects the very rich mixture composed directly into the combustion chamber just after the transfer phase when the piston rises.

Petrol injector



Delivery: 0.67 g/s at 2.5 bar

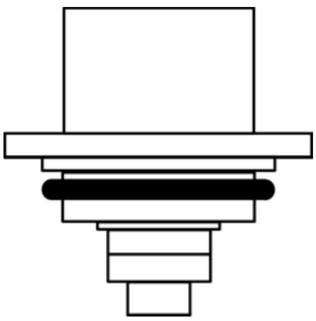
Connection:
Pin 1: to ECU pin 3
Pin 2: Battery +

Check: R= 2.0 $^{\pm 10\%}$ Ω

Identification: green

The fuel injector, controlled by the ECU, injects the fuel necessary for engine functioning, into the mixture chamber.
The injection time is corrected on the basis of the battery voltage

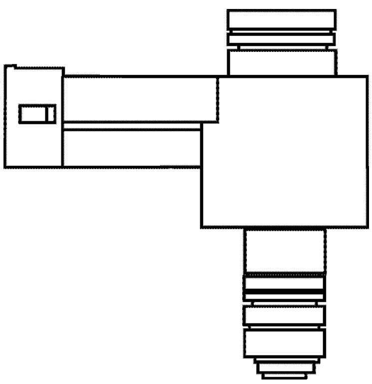
Petrol pressure regulator



Regulation pressure: 2.5 bar

Slaved to the air pressure

Air injector

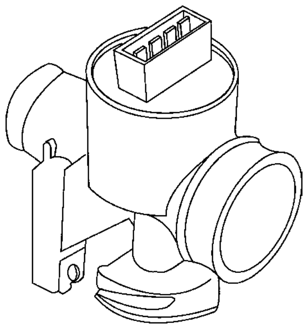


Connection:
Pin 1: to ECU pin 13
Pin 2: Battery +

Check: R= 1.5 $^{\pm 10\%}$ Ω

The injection time is corrected on the basis of the battery voltage

Throttle unit



Diameter 20 mm

Check between terminals:
1 and 2 R= 1000 $^{\pm 40\%}$ Ω
1 and 3 R= 2000 $^{\pm 40\%}$ Ω
1 and 4 R= 1000 $^{\pm 40\%}$ Ω

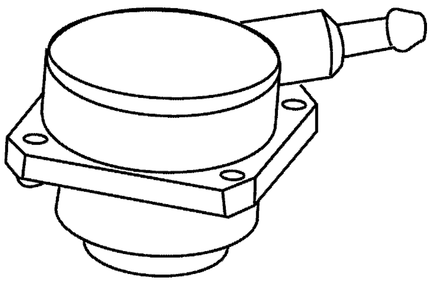
Connection:
pin 1: to ECU pin 15, potentiometer power return
pin 2: to ECU pin 7, N° 1 potentiometer information
pin 3: to ECU pin 10, N° 2 potentiometer information
pin 4: to ECU pin 18, ECU power supply to throttle unit

The air supply is through a throttle valve unit which measures the quantity of air taken in by the engine. The quantity of air is measured (throttle flap angle) by a potentiometer fixed to the throttle spindle. The air is fed into the engine bottom end the same as for a conventional two-stroke.

Throttle potentiometer

- This notifies the ECU of the engine load (idle, full load, partial load)
- It notifies the ECU of the rate of load change (acceleration, deceleration)

The compressor

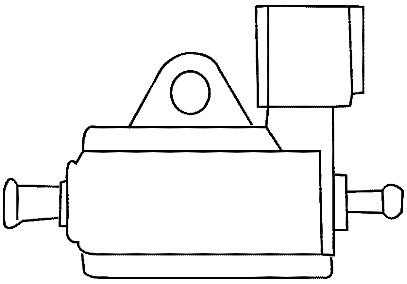


Output: 3cm^3/stroke

Lubricated by 2-stroke oil conveyed in the inlet air

The compressor takes in air from the engine bottom end (air measured by the throttle unit and pre-compressed by the piston downstroke) and compresses it up to a pressure of 5.5 bar. The compressed air is used by the system to convey the fuel through the mixture injector to the cylinder.

Oil supply



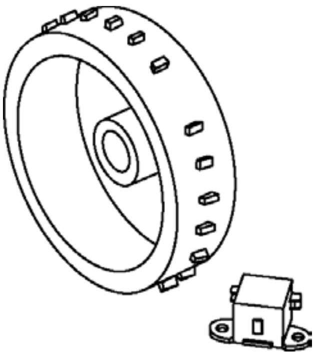
Output: 0.00664 ml/stroke

Connection:
Pin 1: to ECU pin 2
Pin 2: Battery +

Check that: R= 12.4 $^{\pm 10\%}$ Ω

An electric pump, controlled by the ECU, takes oil from the tank and injects it into the air flowing through the throttle unit. This oil is metered by the ECU which by controlled activation of the pump adapts the quantity of oil injected to the engine requirements, giving an oil saving of up to 40%. With injection, as the oil is not diluted by the fuel mixed with the inlet air, it must be better guided in order to properly lubricate the engine bottom end and must imperatively comply with the manufacturer's recommendations.

The engine speed sensor.



Pulse wheel fixed to the magneto flywheel

Connection:
Pin 1: to ECU pin 19
Pin 2: to ECU pin 20

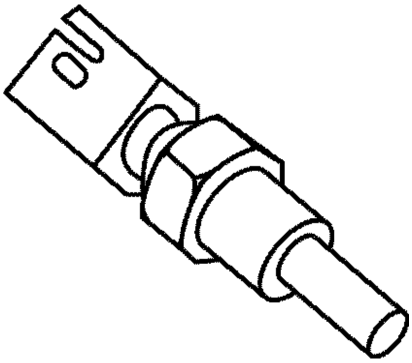
Sensor check: R= 105 $^{\pm 2\%}$ Ω

Signal voltage 0.9 to 75 volts depending on engine speed

It is fitted opposite a pulse wheel driven by the crankshaft. The pulse wheel has 24 teeth, one of which is removed to mark the position of the pulse wheel in relation to top dead centre. The missing tooth is positioned 293°30' before TDC.

- It gives the ECU the engine speed (counts the number of teeth per minute)
- It gives the ECU the engine position (missing tooth position)

The engine temperature sensor



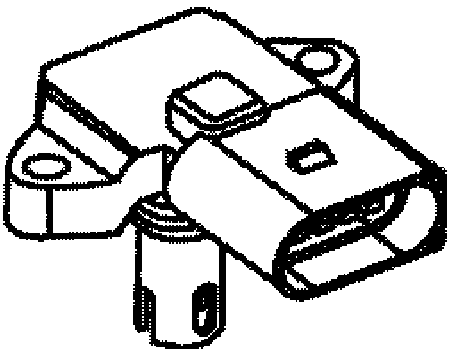
Negative temperature coefficient thermistor

Connection:
Pin 1: to ECU pin 16
Pin 2: to ECU pin 9

Sensor check:
at –10° R= 58036 to 70575 Ω
at +20° R= 12922 to 15091 Ω
at +25° R= 10319 to 11981 Ω
at +100° R= 683 to 738 Ω
at +150° R= 184.5 to 194.5 Ω

It notifies the ECU of the engine temperature. This enables the ECU to handle cold starting, cold functioning, etc.

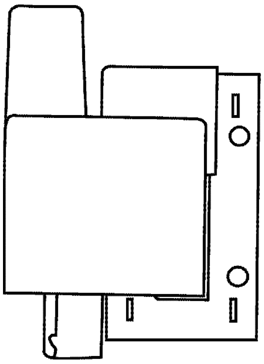
The atmospheric pressure sensor (optional)

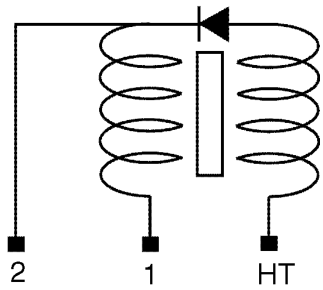


Connection:
Pin 1: to ECU pin 18
Pin 2: to ECU pin 16
Pin 3: to ECU pin 8

This is used to correct the quantity of fuel injected in relation to atmospheric pressure (the higher the atmospheric pressure, the greater the mass of air for a given volume, and therefore the better the intake). It is only necessary for a machine used at high altitudes (over 1500 metres).

Ignition coil





Connection:
Pin 1: to ECU pin 12
Pin 2: Battery +

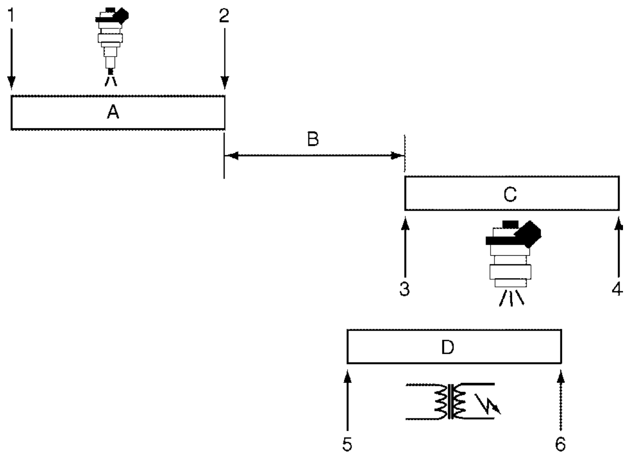
Check that:
1 and 2 R= 0.63 $^{\pm 0.03}$ Ω on coil primary winding
The coil secondary winding cannot be measured as it has a condenser and a diode in the circuit.

The ECU controls the ignition. It uses the speed sensor to determine the ignition point (on the basis of the missing tooth on the speed sensor pulse wheel). It calculates the ignition advance on the basis of the load, engine speed, engine temperature parameters, etc.
A dwell time (coil charging time) correction is applied based on the battery voltage.
The use of a resistive suppressor and resistive spark plug is essential.

The battery
The battery is essential for functioning of the system.
The minimum battery voltage necessary for the ECU to function is 8.5 volts.
The ECU continually needs to know the battery voltage to enable it to adapt the order signal time for the different systems.
The reaction time of an injector, for example, depends directly on its power supply voltage. The ECU will therefore modify the injector signal time to compensate for battery voltage variations. (A weak battery applies a retard to injector opening)

Functioning strategies

System control signal



1. Petrol injector open
2. Petrol injector closed
3. Air injector open
4. Air injector closed
5. Start of coil charging
6. Ignition advance

A. Petrol injector open time
B. Time between petrol injector closing and air injector opening
C. Air injector open time
D. Coil charging time

When the piston has sufficiently risen to have closed off the exhaust port, injection can begin. The petrol injector opens and injects, into the air injector, the quantity of petrol necessary for engine functioning. After a certain lapse the air injector opens to inject the mixture of compressed air and petrol into the cylinder. The spark is produced before the air injector closes.

ECU software

This is the program which manages functioning of the system using the data supplied to it.

ECU calibration

Adaptation of the system to the machine is by determining a certain number of machine specific values. These values are determined by bench testing, and entered into the calculation tables (maps) which the ECU uses to adapt the system to the machine.
For example: engine temperature map, fuel quantity map, speed map, throttle position map, etc.

Cut-off on deceleration

Under high deceleration and to save fuel, the system cuts off the injection. When the injection is cut off under deceleration, the petrol injector is closed, the spark is cut off, but the air injector continues to function to prevent overpressure in the air circuit (the compressor continues to compress the air in the injector). The quantity of oil injected is minimum.

Idle management

Idle is managed entirely by the ECU which determines the corrections and how it applies the corrections to continually obtain the correct idle speed when both cold and hot. No adjustment is necessary. To obtain a correct idle in all cases, the ECU adjusts: the petrol injection duration, the air injection duration, the ignition advance.

Diagnostic

Diagnostic led

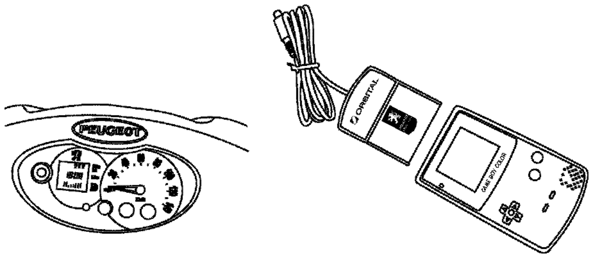
The led comes on when the ignition is turned on to check it is functioning and goes off when the engine starts if there are no faults.
In case of a fault, the led notifies the rider.
There are three fault levels on the machine:

1. Serious safety fault or one which may destroy the engine, **the machine must be stopped.** The light comes on and stays on.
2. Serious fault affecting the functioning or riding comfort.
   The light flashes.
3. Minor fault.
   The light stays off.

Faults codes and priorities

Fault code	description	Priority level
1	engine overheating	1
2	speed sensor circuit fault	2
3	potentiometer adaptation fault	2
4	potentiometer track 1 adaptation fault	3
5	potentiometer track 2 adaptation fault	3
6	potentiometer track 1 fault	2
7	potentiometer track 2 fault	2
8	potentiometer fault	1
9	battery voltage fault	1
10	oil pump fault	1
11	air injector fault	2
12	petrol injector fault	2
13	ignition fault	2
14	petrol pump fault	2
15	engine overspeed	3
16	faulty power supply to sensors	3
17	engine speed incoherent fault on start-up	2
18	engine temperature sensor circuit fault	3
19	not allocated	-
20	temperature gauge fault	3
21	control led fault	3
22	faulty power supply to sensors	2
23	altitude sensor circuit fault	3

Diagnostic resources



A diagnostic led notifies the rider of the presence of faults. The same led also enables the repairer to "read" a memory in which the codes identifying a functioning fault are stored.
A diagnostic tool may be connected to the ECU to read in its memory the fault codes, machine functioning parameters, etc.

System diagnostic is carried out by the ECU which checks all the components connected to it.
The ECU memorises all faults detected and puts them into three categories depending on their importance or effect on machine functioning.
There are two ways of carrying out diagnostic of the system:

- Manually via the test led
- Automatically with the diagnostic tool.

Manual diagnostic procedures

Fault reading procedure

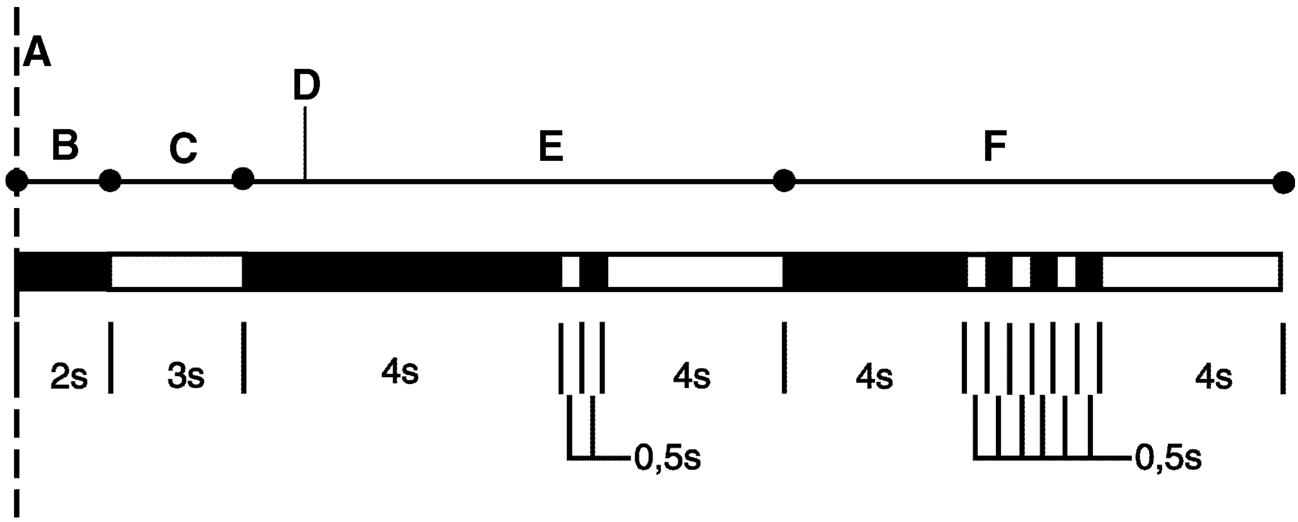
Fault reading is by "reading" the diagnostic led flashes. The number of flashes represents a code enabling reference to the workshop manual to identify the problem.

Note: This procedure cannot function if the throttle unit is disconnected or its harness is cut.

Procedure:

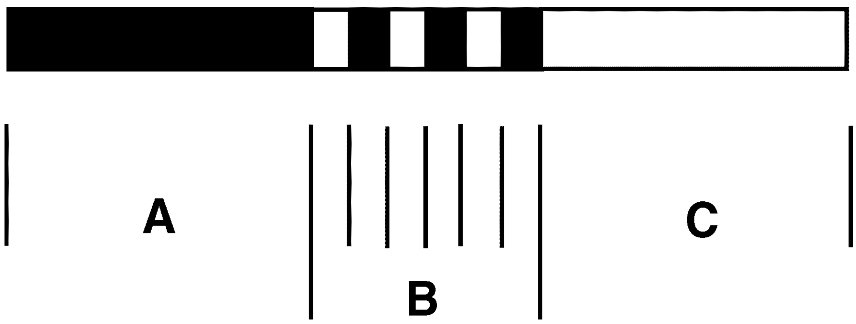
1. Turn off the ignition
2. Fully open the throttle (accelerator cable properly adjusted)
3. Hold the throttle fully open
4. Turn on the ignition holding the throttle open
5. The led comes on for 2 seconds, goes off for 3 seconds, then comes on
6. Close the throttle **as soon as the led lights**
7. Diagnostic begins each code (x flashes of 0.5 seconds) is precede by the led lighting for 4 seconds and ends with the led going off for 4 seconds. All the codes are sent one after the other and all of the codes are repeated 4 times after which the codes are cleared automatically. If you do not wish to clear the codes, turn off the ignition before the procedure is repeated 3 times.
8. Note the fault codes obtained
9. Repair the faults
10. Then clear the fault codes.
11. Then test the vehicle and check that the codes do not re-appear.

Diagnostic frame



A- ignition on
B- led test
C- led goes off
D- throttle unit closed
E- 1st code
F- 2nd code

Code detail



A- start of code (led lights for 4 seconds)
B- code (number of flashes for the code)
C- end of code (led goes off for 4 seconds)

<u>Note:</u>
If the machine is started during diagnostic, the procedure is interrupted and the machine functions normally.

Clearing fault codes

The codes are cleared after the fault frame has been read 4 times consecutively without cutting off the ignition, on condition there are no more faults on the machine.

Procedure:
1. Start a fault code reading procedure
2. After reading the fault codes 4 times without cutting off the ignition the memory is cleared automatically
3. The light stays off
4. Turn off the ignition

Throttle unit initialisation

Initialisation is necessary in the following cases:
1. If the ECU is changed
2. If the throttle unit is changed

Procedure:
Note:
The engine must not be started during the procedure, if it is, the procedure is void.
This procedure cannot function if the throttle unit is disconnected or its harness is cut.

1. Turn on the ignition and disconnect the throttle unit
2. Wait for at least 5 seconds
3. Turn off the ignition
4. Reconnect the throttle unit
5. Turn the ignition on again.
6. Fully open the throttle (accelerator cable properly adjusted) and return to the idle position (throttle full travel is learned by the ECU)
7. Turn off the ignition
8. Clear the fault codes

Engine fuel clearing procedure

Note: This procedure cannot function if the throttle unit is disconnected or its harness is cut.

1. Turn on the ignition
2. Fully open the throttle (accelerator cable properly adjusted)
3. Hold the throttle fully open, crank the starter motor (this action cuts off the injection and ventilates the cylinder with air only). In a few seconds the cylinder is ventilated with the fresh air clearing the excess fuel.
4. Close the throttle and start the engine without accelerating.

Oil circuit bleed procedure

Bleeding is necessary in the following cases:
1. If the oil pump has been changed
2. If an oil union has been disconnected
3. After circuit stalling due to an empty tank

Important: when bleeding the oil circuit the fuel pump is operated at the same time therefore ensure that the fuel system is not leaking before bleeding the oil circuit

Note: This procedure cannot function if the throttle unit is disconnected or its harness is cut.

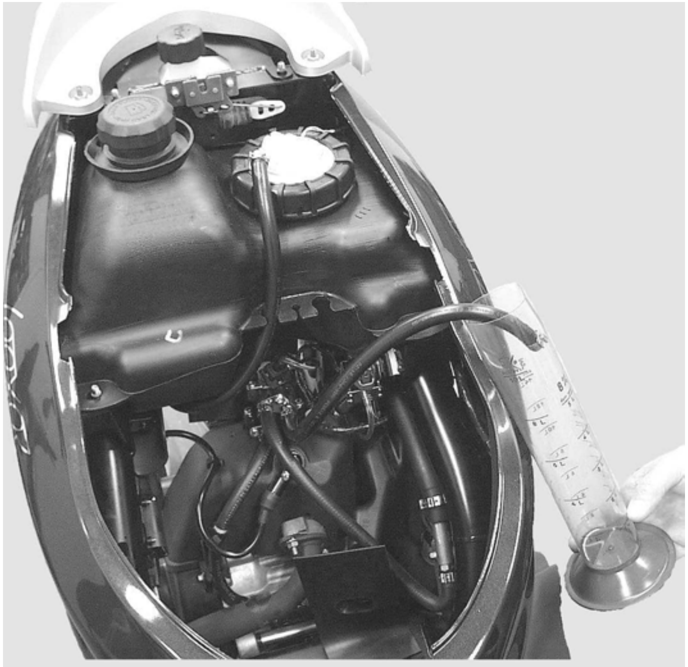
Procedure:
1. Disconnect the oil union from the inlet pipe
2. Fully open the throttle (accelerator cable properly adjusted)
3. Turn on the ignition
4. Hold the throttle open for at least 10 seconds
5. Close the throttle
6. The oil pump is activated for a pre-defined time which fills up the unions and bleeds the air from the circuit. Check that the oil runs out drop by drop from the lubrication union. If it does not, repeat the procedure.

Fuel pump bleed procedure

The fuel pump operates as soon as the engine is running
It also functions for a short instant (3 seconds) when the ignition is turned on in order fill and pressurise the fuel system.

Procedure:
1. Turn on the ignition
2. The pump operates for a short instant
3. Repeat the operation until the circuit is bled completely.

Fuel pump delivery check procedure



Disconnect the union of the fuel tank return line and put it in a graduated glass. Turn on the ignition to run the fuel pump and measure the output quantity. The fuel quantity obtained must be 4.3 ml minimum for 3 seconds (when the ignition is turned on the pump functions for 3 seconds).

Diagnostic procedure with the diagnostic tool

Refer to the "Using the injection system diagnostic tool" workshop manual.

Various

Emergency strategies

In case of a faulty component, an emergency strategy is applied, whenever possible, so that the rider can reach the nearest dealer.

E.g.: in case of a faulty engine temperature sensor, a standard temperature of 160°C is applied (the machine will not start when cold, but in case of a fault when on the move, the customer will not break down).

Precautions

Never accelerate to start the engine whether it is hot or cold.

Never run the machine with a petrol-oil mixture, the fuel pump and injectors are not designed to function with oil.

Use only 95 or 98 unleaded petrol.

For the separate lubrication system, the oil approved by the manufacturer must be used: Esso 2T special oil.

After working on the oil circuit, it must be bled. To do so, operate the oil pump with the diagnostic tool until there is no more air in the circuit.

RECOMMENDS

CERTIFICATION
SYSTEMES QUALITE
ISO 9001
Certificat n° SQ/766

REF: 756007

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