D-Jetronic Fuel Injection for the Porsche 914

(Care and Feeding for the Owner-Mechanic)

by

Kjell Nelin

Introduction -

The "D-Jetronic" or "MPC" (manifold pressure control) fuel injection system was developed by Bosch in the late sixties. It was used by a variety of automobile manufactures (including Mercedes, Volvo, Volkswagen and others). Our interest encompasses the Volkswagen-Porsche 914 1.7L (1970- 1973) and the 2.0L (1973-1976). This article does not cover the "L- Jetronic" system used on the 1.8L 914s. I will discuss the theory of operation, common problems, and then recommend a procedure for renewing the system as a whole and ensuring proper functioning and increased reliability. I will also discuss how the system may be adjusted and modified (as for a 1.9L rebuild for example). As with any fuel system, frequent filter changes and fresh gas (in other words - drive the sucker!) will help longevity.

Many problems believed to be caused by the fuel injection are actually caused by some other malfunction, often the ignition, electrical system or a mechanical fault (low compression, etc.). Therefore, you must insure proper functioning of these basic systems before beginning to troubleshoot your fuel injection!!

I hope this guide will be of use to the owner-mechanic. I can not cover everything in detail, but this article should set you on the road to understanding you fuel injection. For more information, I recommend the following books ; "How To Tune & Modify Bosch Fuel Injection" by Ben Watson, and "Bosch Fuel Injection Handbook and Engine Management" by Charles Probst. If you are a serious, long term 914 owner, I suggest that you purchase a set of factory Workshop-Manuals. Also, many of the parts catalogs have a short troubleshooting guide as part of the fuel injection section, tear out that page or Xerox it, it's handy to have in the glove box.

Theory -

Fuel is delivered to the injectors via a high pressure roller type pump. Pressure is regulated by an adjustable regulator. A simple analog computer (ECU) processes a number of inputs and opens each injector as necessary to ensure proper mixture. The main determinant of mixture is the intake manifold pressure as measured by the pressure sensor. The mixture is fine tuned by the head temp sensor and an air temp sensor. The FI points located in the bottom of the distributer provides the ECU timing and speed data. A throttle switch functions as an "accelerator pump". Cold starting is facilitated by a fifth injector which sprays gas into the air-box when the starter cranks and the engine is cold. This injector is controlled by the thermo-time switch and operates independently of the ECU. Here's a rundown of each component and common problems:

Fuel Pump -

The fuel pump on the 914 is very reliable. You should be able to determine if your pump works by turning on the ignition and listening for a buzzing noise lasting for 1 - 2 seconds. If no buzzing is heard, most likely the pump is not getting power. If a voltmeter at the pump wires shows voltage when the ignition is again turned on, then indeed the pump has a problem. If no voltage is present, you may have a wiring fault, a bad relay or a blown fuse.
It is possible for the pump to run while hooked up incorrectly. There are three hose connections. They are "D" (pressure - to engine), "S" (intake - from fuel tank, large outlet), "R" (return - to fuel tank, small tube). If

"S" and "R" are reversed the pump will suck unfiltered fuel and rust or other material can easily contaminate the injectors or even jam the close tolerance pump!
If care is taken, the pump can be opened and cleared out, be careful not to damage the O-ring and keep work area etc. clean. The fuel pump also incorporates a check valve which maintains pressure to the injectors for some time after the engine is stopped. The purpose is to facilitate restarting. Failure of the check-valve is not a serious problem.
Speaking of fuel pumps, do you have trouble starting your car when it' s warm? Is your pump (prė 75 models) still located in the engine compartment? If so you have vapor lock. Do yourself and your car a big favor, move your pump to the front trunk, near the gas tank.

Pressure Regulator -

The pressure regulator, located at the rear of the engine on the drivers side is very reliable. Testing and adjustment will be covered later.

Injectors -

The solenoid operated injectors are driven by short pulses which are generated by the ECU.
The 1.7L injectors are yellow, 2.0L injectors have a slightly larger hole (for more flow) and are green in color.
The electrical resistance of the injectors is about 2.4 ohms.
The injectors are very reliable if given clean filtered gas.
I will cover flow testing and cleaning in a later section.

Trigger points -

Located in the base of the distributor, the trigger points synchronize the injector pulses with the crank shaft. Because they pass very little current (unlike the ignition points) they can last for up to 100,000 mi. There are two sets of points, one set controls cyl #1 and #4. The other set controls cyl #2 and #3. So, if only two injectors are firing in the pairs described, the most likely suspect is the trigger points. To replace, remove the distributor from the engine (this is the easiest way to replace the ignition points and condenser, also) and pull the trigger points out after removing the two retaining screws. You may be able to simply clean the points with a little emery paper. I use a tiny amount of distributor grease on the parts that rub on the cam. When reinstalling, note that there is some variability in the range setting of the points, try to get them near the middle of the range. You can now test them by using a voltmeter set to the ohms scale. Measure first between the middle connection and one of the outside connections. Spin the distributer shaft and you should see the points make and break connection. Now measure between the middle and the other side and repeat for the second set of points. Replace distributor and don' t forget to plug in the trigger points.

Temperature Sensor I -

This temp sensor, mounted on the air intake distributor, is used to fine tune the mixture. Even if faulty, it has little effect on the running of the system. The resistance of this thermistor is about 400 - 500 ohms at 50 deg. F, it is about 150 - 200 ohms at 100 deg. F.

Temperature Sensor II -

Temp sensor II is located in the head near the #3 spark plug. This signal is an important parameter for determining mixture. You can measure its resistance with an ohm meter, it should be about 2,000 - 3,000 ohms cold. After the engine has reached operating temp the resistance will be less than 1,000 ohms.

Throttle Switch -

The throttle switch can be found mounted underneath the throttle body. To test, turn on the ignition and open the throttle with your hand. You should be able to hear the injectors firing, a sort of "brrrrrrp" noise. If working correctly, the injectors will fire 20 times for the full range of movement. One very mysterious intermittent fault

caused by the throttle switch is an occasional "bucking" while driving at constant speed. This is caused by the switch cutting of the fuel and then turning it back on. Test by disconnecting the switch (it is amazing how well the car will run without it, actually), you will notice that acceleration will be a little sluggish as the "accelerator pump" action will be missing.

Pressure Sensor -

Located at a bracket near the battery, the pressure sensor is the single most important sensor in the fuel injection system. Consisting of an iron core surrounded by a pair of coils, mechanically connected to a thin metal diaphragm, this sensor measures the pressure at the intake air distributor relative to the ambient pressure (that is, it can correct for changes in altitude).
It can fail in several ways. The coils can develop an electrical fault, or the diaphragm can leak. A defective sensor will often result in a very rich running condition. However, I have seen one fault resulting in the mixture becoming so lean that the engine wouldn't run. The coils can be tested by measuring the resistance between terminals #7 & # 15 (should be about 90 ohms) and between #8 & #10 (should be about 350 ohms). You can try blowing into the sensor to test the diaphragm.
Although they carry different part numbers, the only difference between the 1.7L and 2.0L pressure sensors is calibration. I will describe how you can change this yourself later on.

Electronic Control Unit (ECU) -

The ECU, mounted to the battery tray, is one of the most reliable components of the FI system components although it is often accused in error of causing problems. Some of these units have been damaged by battery acid however (a visual inspection will quickly determine if this is the case). The knob located on the top of the unit (after '71) is used to adjust the idle mixture. Here's a breakdown of all the connections from the wiring harness to the ECU (#1 is at the top):

1. Temp Sensor I
2. Not used
3. #1 Injector
4. #4 Injector
5. #2 Injector
6. #3 Injector
7. Pressure sensor, primary winding
8. Pressure sensor, secondary winding
9. Throttle switch (full load signal)
10. Pressure sensor, secondary winding
11. Ground, engine
12. Trigger points, common
13. Temp sensor I
14. Not used
15. Pressure sensor, primary winding
16. 12V power (from relay board)
17. Throttle switch
18. Starter motor (terminal 50)
19. Fuel pump relay
20. Throttle switch
21. Trigger points
22. Trigger points
23. Temp sensor II
24. 12V power

Deceleration Mixture Control Valve -

Located at the pressure sensor bracket, this valve leans out the mixture when the throttle is closed. This is

purely an emissions control device. If it is removed and its associated air lines plugged, no performance change will result. However, this may cause you to fail smog certification in some states. A leaking decel valve will cause a high idle condition (test by pinching off the air lines).

Auxiliary Air Regulator -

Located next to the airbox (front, drivers side), the Aux. Air Regulator supplies extra air to the engine during warm-up. A bi-metallic spring closes the valve as it warms up.There is also a built in heater powered by 12V from the fuel pump relay . Failure of the valve to close results in a very high idle after warm-up! Test by connecting to a 12V source (I use a battery charger). The valve should close within 5 minutes. The valve will still close without the electric heater, it just takes longer. You can test the valve for mechanical functioning by placing it in a stove at 200 - 300 degrees F. If it doesn't close, you should try to fix it as new ones are no longer available.
To fix the valve you'll need to open it by prying up the formed flange of the housing (I place it in a vise and then carefully tap it up with a chisel and hammer), pull the valve out and clean the rust out, then reassemble. Sometimes the valve is too far gone and a used one must be found.

Cold Start Injector/Thermo-time Switch -

Located at the front of the air box on the 1.7L and at the rear (drivers side) on the 2.0L, the cold start injector will spray fuel when the starter is cranked if the engine is cold.
If your motor is hard to start when cold you may have a problem with the cold start valve. If it starts with the use of cold starting fluid then short out the thermo-time switch, it it now starts, the switch is at fault, if it still won't start, it's the injector. The injector can also fail by leaking, thus causing a rich running condition.

Air Filter Housing -

The early 1.7L cars used an oil bath air filter (yeeechhh!). Fortunately the dry element filter housing used in 1973 is a direct bolt on replacement. The 2.0L cars have a very nice square air filter housing with an efficient filter.

Relay Board -

Although this is not really a part of the fuel injection, it is often a cause of trouble. A common problem is due to voltage drop caused by the fact that the connections thru the board are riveted, not soldered. These boards are now 20+ years old and moisture has begun to effect most of them. You can remove them easily, then strip of the rubber coating by soaking overnight in solvent if needed and then properly solder the thru the board connections. Rebuilt boards can also be purchased.
This board, located in the engine compartment has places for four relays starting from the front, they are for the rear window defogger (missing on most cars), the power supply relay (12V for the ECU), the fuel pump, and the heater blower. There are two fuses on the board the one toward the rear is a 25A fuse which provides power to the fuel pump. If the fuel pump is not working, try replacing the relay with a known good one (there are two in the front trunk for the headlight motors for example), check the fuse, corrosion often forms in the holder it can be cleaned off with a piece of emery paper (fuse also).

Procedure for Renewing and Testing the Fuel Injection -

Here's the procedure I've used on three different cars in the last year or so. In each case, I started with a poorly running (or not running) engine and ended up with a strong, reliable motor which easily passed California smog testing.

WARNING Please exercise caution when working on fuel systems! It doesn't take a lot of gas fumes to cause lots of damage. I recommend doing the following procedures outside. Always have a fire extinguisher nearby.

Before proceeding with the FI overhaul, I recommend that you perform the following; check all components of the ignition system including proper functioning of the mechanical and vacuum advance (I also test each spark plug for good spark), set the timing, adjust the valves and check compression. Leave the spark plugs out after the compression test (you'll see why later). I will not discuss these systems in this article, if you are unfamiliar with them, learn about them before tearing into your fuel injection.

If you have recently replaced the gas lines, intake runner boots, and vacuum lines, you can skip some of the following. If your hoses are more than 4 years old or are of unknown age, please, change them all! OK, here's my recommendations -

1)

Renew all the fuel lines, use good quality German hose if possible. Otherwise, make sure you get high pressure fuel injection hose. You will need 7mm and 9mm fuel line, also replace any suspect clamps. This will require removal of the gas tank, so run the tank down before you start (if your car runs) and drain the rest. I drain the tank at the back of the car by pulling one of the lines coming from the plastic lines that run through the passenger compartment, clamping with a pair of small lock grip pliers and draining into a gas can. If its good gas, just pour it into your other car, otherwise dispose of carefully. This is a good time to take a look inside you gas tank, so pull off the filler assembly once it is drained (there's also less chance of scratching the inside of your trunk lid when you pull the tank if this is removed) and pull your tank. You may have to cut the fuel lines going into the tank (I use a large pair of wire cutters) in order to get it out. Inspect the inside of the tank carefully, if there's a good amount of rust, deal with it now or replace the tank.
If your car is a '74 or earlier, the fuel pump may still be located back in the engine compartment. Move it to the front trunk area to avoid vapor lock problems (you'll need the gas tank out to do this so this is a good time).
Once you are happy with the condition of the gas tank replace it using new fuel lines. Do yourself a favor and use long pieces of line so you can lift the tank out far enough to disconnect them the next time you pull it. Also replace your fuel filter at this time.
Next, at the engine compartment replace all the pieces of fuel line. Be sure to inspect the plastic line and replace with copper or stainless steel if necessary (I've only replaced the lines that run through the car when the engine has been out). You may wish to remove the engine cover at this time for a little extra access. I also recommend removing the battery for safety reasons. Boy, there sure are a lot of fuel hoses, aren't there! While you are at it, pull the injectors and inspect the hoses. Unless there fairly new, you'll want to replace these also. Yes, they are most likely the original clamped hoses. I use a grinder to cut way the clamps. Don't replace the injector hoses yet, because the next step is to:

2)

Deal with the injectors. First clean them up. I use some spray type carburetor cleaner and give them a good squirt into the fuel intake then a gentle blast of compressed air (you would be amazed at what might come out). Now install a short piece of fuel line with a hose clamp. Don't forget to clean the cold start injector. Place in a plastic bag and set them aside. Before we reinstall the injectors it time to

3)

Replace the intake runner boots and vacuum lines. In order to replace the intake runner boots, unbolt the intake runners from the heads, pull off (you may wish to remove your pressure sensor and decel valve to make extra room for the passenger side runner). Most likely you will want to replace the intake to head plastic blocks also. After removing the old runner boots and cleaning off the intake air distributer and the runners, seat the new runners on the intake air distributer. Make sure they are pushed on as far as possible or they will leak, then push on the intake runners and install the nuts (4 on each side for 1.7L, 3 on 2.0L). I use a little high temp gasket compound to seal the boots. Don't over-tighten the runner nuts.
Next, replace the vacuum lines. Do them one at a time and you won't get them mixed up. Of course, someone else might have mis-connected them in the past so it can't hurt to check the routing if you have a manual which shows the hose arrangement. Don't forget the hoses for the distributer advance/retard. These hoses should all be available at your nearest German Car parts supplier.

4)

Inspect the engine wiring harness, and replace the boots (if needed). Check out you harness and look carefully

for loose wires. Bad grounds are a very common cause of fuel injection problems. Look for the grounds on the top of the engine, under the back of the air distributer on the passenger side. I pull them off, clean up the terminals on the engine with some fine emery paper, give the connectors on the harness a blast of contact cleaner and a little squeeze with a pair of pliers (so they'll make good contact) and reconnect. If the injector boots on the wiring harness are worn out, they can be replaced. To replace, you must dismantle the connectors. I got a wire terminal tool at a local auto parts place, its a Lisle #56500 (about $12). If you are not experienced working with wiring, you may want to get someone else to do this for you.

5)

Back to the injectors. Check the injector seals and replace them if they are cracked. Install the injectors on the fuel rails and plug them into the harness. Do not install into the intake runners yet. For the next part you will need the following: A pressure gauge (compatible with fuel) 0 - 50 psi, and 4 small clear vials (I use 20cc graduated cylinders, available at Camera stores or chemical supply houses).

6)

Set the fuel system supply pressure. Connect the pressure gauge at the "T" connection on the top of the drivers side fuel rail (disconnect the hose going to the cold start valve on the 2.0L) with a piece of 7mm fuel line and 2 hose clamps. Go over all the connections for all the fuel hoses that you just replaced! Now, put a gallon or so of fuel in the gas tank. Next, place each injector in one of the clear vials. Supply 12V to your fuel pump (I use a couple of push on style connectors crimped to two pieces of wire and connect to a battery charger (remember, the battery is still out of the car). Once the pump is running, check EVERYWHERE for fuel leaks. Take your time. If no fuel leaks are found (and don't forget the hoses under the tank, that's why I recommended only 1 gal, so you could easily pull the tank if needed), go look at your fuel pressure gauge. It should at least 28 psi (I set mine to 30 psi). If not, adjust the fuel pressure regulator (first loosen the locking nut on the adjusting screw). After the system has been up to pressure for awhile, turn off the power to the pump. Check the vials at the injectors. If there is any fuel in the vials then the injector (or injectors) are leaking and must be replaced. Check the pressure gauge again, is it holding pressure? If not, the check valve in the fuel pump is not working, or one or more of the injectors are leaking.

7)

OK, time for the Injector Flow Test. Be very careful, as you will now have four "fuel leaks" in your engine compartment (that is, if everything is working). Reinstall your battery. Disconnect the wire from the distributer to the coil (Important - you don't want any sparks flying around!). With each injector in its cylinder or vial, floor your accelerator and crank the engine for 15 - 20 sec. Now, carefully remove the vials and line them up on a level surface. The exact amount is not important (I get about 7 - 8 cc in 15 sec for a 1.7L) at this point. What we want to see is the same amount for each injector (ideally, up to 10 percent variation is all right unless you are racing in which case....optimize). If they look good, you are done, however, my experience has been that one or more injectors are faulty! Most common is low flow or no flow (though occasionally there will be too much). Warning, if there is no flow the problem may be elsewhere in the system. I switch injectors (or just switch wires) and rerun the test, if the problem stays with the injector, replace it. You may also wish to inspect the spray pattern of each injector (certainly if you are building that auto-cross winner). The pattern should be cone shaped. My experience has been that flow rate is the most important parameter.

8)

Once you have verified that you have all four injectors present and accounted for, install them in the intake runners, remove the pressure gauge (be careful if the system is still under pressure), install the plugs and reconnect the coil wire. Cross your fingers and start the car. Does it run? It should, but I'll bet the idle is now too low (when warm). Why, you ask, it's because you have most likely fixed a good number of vacuum leaks. Just readjust the idle screw on the throttle body.

9)

Want some free horsepower? OK, with the engine turned off, place a heavy object on the accelerator pedal (or get someone to floor it for you) and look at the position of the throttle butterfly. Is it all the way open? If not adjust the stop under the throttle pedal and that's free horsepower! (make sure that the cable is not being stretched or it will wear out prematurely).

Adjustment and Modifications -

There are several mixture adjustments possible with this system. The easiest is to simple adjust the knob on the top of the ECU (' 72 and later). This will fine tune the idle mixture only. Here' s how you can make major changes in the mixture (if the engine is getting worn or if you have changed cams, or displacement during a rebuild). Some people recommend changing to the 2.0L injectors if a 1.7L is bumped up to 1.9L, however I have found this to be unnecessary if the stock cam is retained.

First, remove the pressure sensor. You will notice a large plug with a slot in it sealed with epoxy on the end of the unit. Heat the epoxy (I use a heat shrink gun but a powerful hair drier should work) and scrap it away with a screwdriver. Once the slot is clear, turn the plug in a bit and remove the epoxy from the threads. Continue turning the plug out then in and scrape the epoxy away until you can remove the plug. Allow the unit to cool. You will see an adjusting screw inside the pressure sensor.

Mount the sensor in the car with the access hole pointing up so that you can see the adjusting screw. Turning the screw clockwise will lean out the mixture, counterclockwise will make it richer. Ideally, use a CO meter or an O2 (lambda) sensor to set the mixture. Set the mixture to 2.0 - 2.5 % CO at 2,500 RPM. I use a single wire O2 sensor mounted on the exhaust system on my 1.9L which gives me the instantaneous air/fuel ratio at all times, even while driving the car.

You can set the mixture "by ear" if you must. Make sure the engine is up to normal operating temperature. Run it up to 2,500 RPM and hold it there, adjust mixture for the smoothest sounding running. This will set the overall mixture. Turn off the engine, install the plug and mount the pressure sensor as normal. Now, to set the idle mixture, try turning the adjustment on the top of the ECU, clockwise enriches in this case.

If the idle "hunts" when turned up all the way it is too lean. Do the following, get a 2,000 ohm variable resistor ("pot") and install it in series with the Temp Sensor II (in the head). Set the ECU idle adjustment at the middle of its range. Starting at zero ohms adjust the pot with the engine running (again, at full operating temp) until the idle smoothes out or the CO reads about 1.5 - 2.0 %. Shut off the engine, remove the pot and measure the resistance. Get a fixed resistor near this value and install permanently.

Finally, adjust the idle mixture with the ECU adjustment and set the idle speed with the air bypass screw at the throttle body. Lastly, drive and enjoy your rejuvenated 914 for many years to come!

Comments or questions are always welcome, Kjell *kn@bigbear.caltech.edu*