



# Tech Tip

FUEL SYSTEM 164

## GASOLINE DIRECT INJECTION Dealing with Intake Valve Deposits

**W**ith the introduction of a new vehicle or powertrain, the vehicle manufacturers will log hundreds of thousands of test miles in an effort to identify any potential problem with a system, prior to the vehicle being put into production. Considering that, it is difficult to understand why a system may experience a major unforeseen problem once the vehicle is placed into service. One such system that has given major challenges has been the fuel injection system. Often, injector related problems do not show up during the vehicle manufacturers' test miles, which may reach 500K miles, then suddenly appear once the vehicle is put into service. The reason is that the test vehicles are driven around the clock, never shut off, and never treated to the same conditions that a vehicle would encounter during daily driving. This would include stops and starts, short trips, heat soaks, poor fuel quality, etc.

Consider the port fuel injectors introduced in the 1980s that incorporated a pintle valve in the tips of the injectors. Extended testing and thousands of test miles by the vehicle manufacturer proved this to be a reliable system. Once these systems were put into service, injector plugging and intake valve deposits became a major challenge. During heat soak, the olefins and diolefins in the fuel would bake onto the injector tips, forming a crusty deposit, resulting in a restricted fuel spray from the fuel injectors. Fuel injector cleaning became a common requirement to restore engine performance and remove the intake valve deposits, which led to lean fuel conditions during cold starts. Once the carbon became saturated with fuel, engine performance was restored. With some of the newer injection systems, we are encountering similar contamination conditions with intake valve deposits. There is a bigger challenge this time, as conventional cleaning methods and fuel tank additives will not sufficiently clean these systems.

Often, in our diagnostics we identify intake valve deposits as the cause of engine performance related symptoms. In our discussion with the vehicle owner, they may assure us that they only purchase Top Tier fuel and they supplement with fuel system additives. In their defense, they can do these things and their engine may still encounter intake valve deposits and related performance symptoms. With some of the new systems, there is a good reason for this encounter and it will be explained in this article.

The first step in the diagnostics is determining the type of fuel injection system the vehicle is equipped with. It does

make a difference in how we treat the system and remove the deposits.

### PORT FUEL INJECTION VS. GASOLINE DIRECT INJECTION

The formation of the deposits is in relation to how the fuel is delivered to the combustion chamber. There is a major difference in the fuel delivery when comparing a Port Fuel Injection (PFI) to Gasoline Direct Injection (GDI). Let's consider those differences and you will appreciate the contamination concerns:

**Port Fuel Injection...**On a PFI system the fuel is injected into the intake manifold upstream of the intake valves. The fuel spray, at approximately 60 psi, has a cleansing effect on the intake valves, minimizing the formation of deposits. Fuel detergents and supplements added to the fuel tank can be beneficial in eliminating or removing the deposits on this type fuel injection system.

**Gasoline Direct Injection...**On a GDI system the fuel is injected directly into the combustion chamber at pressures that can exceed 2000 psi. Fuel under high pressure can inflict personal injury. Be certain to eliminate any residual pressure prior to replacing components. The injectors require higher operating voltages due to higher fuel pressure at the injectors. Be careful, as control voltages to the injectors can range from 60–120 volts depending on the application. On a typical GM system the ECM supplies a separate high voltage supply circuit and a high voltage control circuit for each fuel injector. Both circuits are controlled by the ECM. The ECM energizes each fuel injector by grounding the control circuit. The ECM controls each fuel injector with 65 volts, which is controlled by a boost capacitor in the ECM. During the 65 volt boost phase, the capacitor is discharged through an injector, which allows the initial opening. The injector is then held open with 12 volts. The injectors are positioned in the cylinder head where they spray fuel directly into the combustion chambers through six metered orifices, producing a cone shaped pattern. The GDI system offers improved fuel economy, increased engine performance and lower emission output, especially during cold start-up. With this injection arrangement, fuel never sprays directly on the intake valves and this can result in the formation of deposits due to the absence of the fuel wash, which includes detergents. Detergents and chemicals added to the fuel tank can help clean the combustion chambers, but

they offer no benefit to the intake valves on a GDI system, as only air passes across the intake valve.

## **INTAKE VALVE CONTAMINATION**

The crankcase is purged via a positive crankcase ventilation (PCV) valve and the vapors are routed through the intake manifold and intake valves where they are consumed in the combustion process. During this purging process the intake valves are subjected to oil vapors, which get baked onto the valves. Further, oil seeping past the intake valve guides and seals contributes to the same. Higher mileage engines with greater wear promote a faster accumulation of the mentioned deposits. Exhaust gas recirculation (EGR) is another source of contamination. Unlike a PFI system, the GDI system does not provide fuel washing of the intake valves. Once formed, these deposits can create hard starts, misfiring, surging, stumbling and random misfire codes. The deposits can create turbulence in the airflow and restrict airflow to the cylinders.

## **IDENTIFYING VALVE DEPOSITS**

The process of examining an engine for excessive intake valve deposits can be labor intensive, as it may require the removal of the intake manifold or cylinder head/heads. Another option could be to use a bore scope to get a visual of the condition. Unfortunately, most shops do not have a bore scope in their arsenal of tools and equipment. That method can be labor intensive, especially considering the difficult access to some cylinders. Rather than investing labor hours in identifying intake valve contamination, as it is certainly present, we recommend cleaning the intake system. This will save the customer some unnecessary expense and improve the performance of the vehicle.

## **THE CLEAN-UP**

Some vehicle manufacturers recommend removing the intake manifold for cleaning with the use of chemicals, and some recommend blasting the deposits with walnut shells. Others may recommend removing the cylinder heads and disassembling the valves for cleaning with a wire brush. These methods can be labor intensive and expensive. There is a less expensive way to clean the system and it is less invasive. Ask your Mighty Rep about his complete line of intake manifold and valve cleaning chemicals. They do an excellent job of cleaning the system.

## **PREVENTIVE MAINTENANCE**

The best course of action is to prevent the contamination from getting to the level that the valves are totally encrusted, making a clean-up difficult. Why not recommend an intake cleaning annually or every 15K miles to prevent the formation of major carbon deposits. It is imperative that we

minimize the formation of the carbon deposits before they become a major issue. Once heavy deposits accumulate, cleaning can result in large fragments breaking loose, causing piston or cylinder wall damage. Further, they can damage the oxygen sensors and catalytic converter. The cleaning process is non-invasive and only requires chemicals introduced into the intake manifold downstream of the mass airflow sensor. It is a simple procedure that can save the customer much expense and frustration. Your Mighty Rep will gladly demonstrate the necessary chemicals and cleaning procedures.

With the increase in the ethanol content of the fuel, the corrosion rate of the fuel system components are a major concern. Make certain the customer is aware of these challenges. Recommend annual intake and combustion chamber cleanings to reduce the formation of carbon deposits, purchase quality fuel, and keep the fuel filter changed at the recommended service interval.

## **TICKING AND CLICKING NOISES**

Another common complaint on vehicles equipped with the GDI system involves ticking or clicking noises. Be prepared to explain the following to your customer, as it can save the both of you much grief:

The GDI system operates at very high fuel pressures. The fuel injectors produce a rapid clicking or ticking sound that can be heard from the engine compartment. The noises are more evident when standing outside the vehicle with the hood raised. The clicking noise is more pronounced during idle speed and a cold start. Once the engine reaches the normal operating temperature the noise level lowers, but it is still evident. A rapid ticking noise emanates from the fuel pump located on the rear of the cylinder head on a GM application. The noise is the result of the fuel pump building up high pressure. The pump will continue to produce this noise at a rate of one tick per second during idle, once the engine reaches normal operating temperature. Some technicians misdiagnose the noises as a valve lifter related condition. The noises are a normal characteristic for the GDI system, and no attempt should be made to correct the symptoms.

With any new system you can expect to encounter new challenges. The GDI system offers many advantages that far exceed the intake valve contamination concerns. With some routine maintenance and a few chemicals administered on a scheduled basis, the formation of the deposits can be controlled.

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