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Sensing a commercial issue

An Isuzu N series fleet vehicle was giving trouble while being driven. The Isuzu 3 litre four-cylinder common rail engine was fitted with a 24V electrical system, which proves no problem to either G-Scan or G-Scan 2. Blue Print Technical Consultant Jim Gilmour explains how he diagnosed and fixed the problem with the N Series truck..

The complaint was that when driven, the engine would run for only a short time before losing power and coming to a halt – at idle the engine would sometimes surge then stall. Because the company did not have any suitable serial diagnostics, they had someone come in to read any stored codes. They retrieved codes relating to EGR (exhaust gas recirculation) faults.

The vehicle was driven into the workshop and the engine tone was rather odd. The G-Scan2 was plugged in and the codes were read. Sure enough, the G-Scan2 picked up codes relating to EGR. I then noticed that the exhaust brake was switched on. This would explain the strange engine tone and possibly the EGR related codes.

EGR is monitored in a number of ways, one of which is by using an air mass meter. Diesel engines do not use a throttle to reduce the pressure in the manifold, so the intake air mass is a function of engine capacity, intake air temperature, air pressure and engine speed. The engine control module (ECM) calculates the air mass reading based on this information. EGR fills the cylinder with as much as 60% exhaust gas, which by-passes the air mass meter, so increasing EGR will show as a reduction in air mass intake. The codes P0400 and P0402 were present, indicating excessive EGR. This would likely be a consequence of reduced air flow caused driving with the exhaust brake on.

There are 48 parameters on this engine, so to quickly get a picture of what was going on, the G-Scan 2 was set to record all parameters, then the engine was restarted. Fortunately, I did not have to wait too long to see a problem - after about 30 seconds of normal idle, the engine began to surge, then faltered and stalled.

Here's what I found: (figure 1): By sliding the bottom cursor on the G-Scan2, I navigated to when the engine started to falter and the flurry of data changes drew my attention to the fuel rail pressure. I selected the data that I wanted to look at in graph form (Figure 1). There were some very obvious discrepancies in actual and desired rail pressure values.

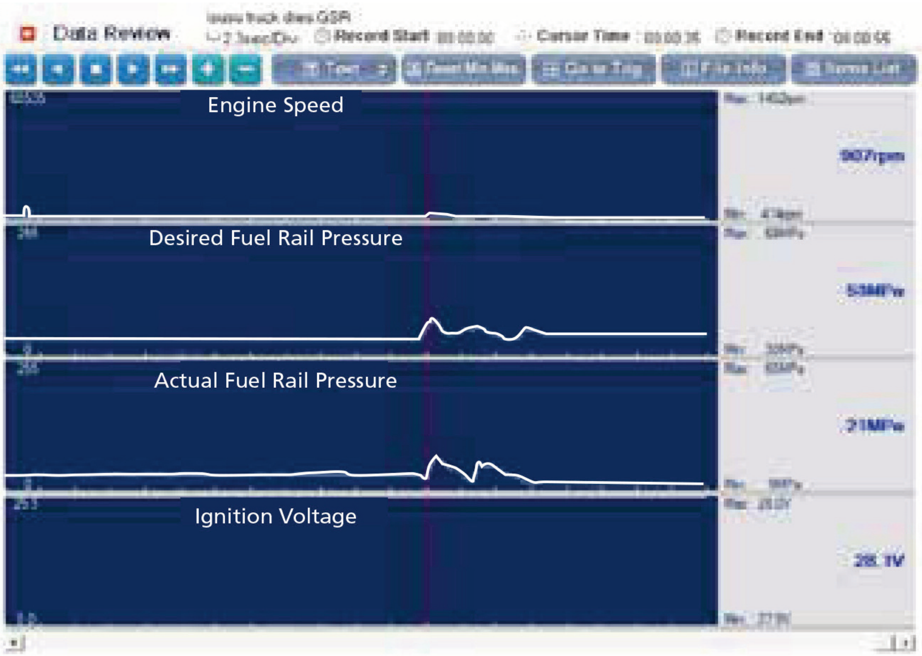

Figure 1 - Discrepancies between desired and actual fuel rail pressures provided the first clue to solving the problem.

When rail pressure falls below the value required by the system, a number of possibilities arise:

Delivery pressure

A reduced or restricted delivery to the pump would cause a drop in rail pressure; the metering system would try to compensate by opening the fuel rail pressure regulator (also known as the Suction Control Valve).

Suction Control Valve (SCV)

The SCV Is fitted in the high pressure pump and is a linear solenoid valve controlled by Pulse Width Modulation (PWM). Any interruption in the electrical control of the valve would cause changes in rail pressure.

Sticking or unresponsive SCV solenoid

Just like any other solenoid device, the electrical windings can short or open circuit, or

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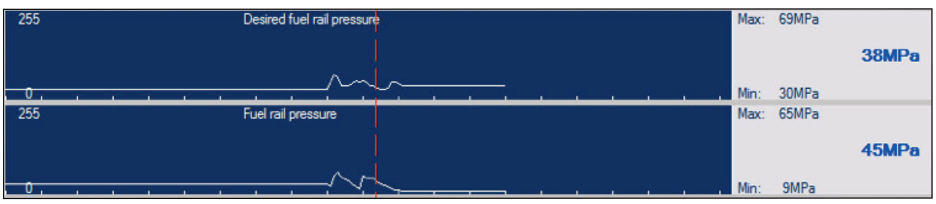

Figure 2 - The actual fuel pressure sometimes exceeded the desired fuel pressure

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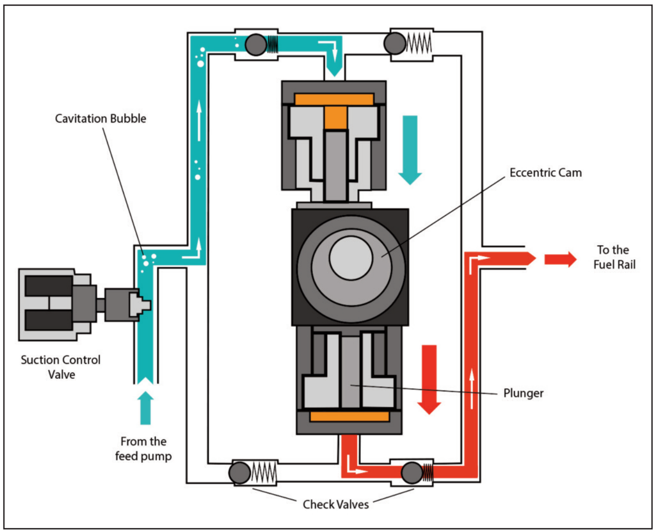

Figure 3 - The actual fuel pressure sometimes exceeded the desired fuel pressure

have a high resistance. Additionally, the mechanical movement of the device can become erratic, due to wear or contamination from debris.

Fuel rail pressure sensor fault

If the pressure sensor provides incorrect values, the SCV will respond accordingly.

The fuel system

The Isuzu is fitted with the Denso HP3 system, that uses fuel inlet metering to control the pressure in the rail. The high pressure pump, driven by the engine, has two plungers on opposite strokes driven by an eccentric cam. A low pressure feed pump in the high pressure pump draws fuel from the tank, at below atmospheric pressure, to provide a delivery pressure to the plunger chambers. The SCV controls the flow of fuel to the plungers, so that the chambers are not completely filled during the induction stroke. This causes cavitation (creation of a vacuum) in the plunger chamber, causing the fuel delivery to the rail to become a function of SCV control and pump/engine speed. A fuel rail pressure sensor fitted to the fuel rail provides information to the ECM, which then controls the rail pressure via the SCV. The benefit of this system, over high pressure regulation, is that the drive load of the pump is reduced.

The Diagnosis

Measuring delivery pressure requires installing a pressure gauge, which is intrusive and time consuming. To try and avoid this, I analysed the data in more detail.

Looking at the relationship between desired and actual fuel rail pressure, I noticed that at times the actual pressure exceeded the desired pressure (Figure 2).

This data is unlikely to be caused by a reduced low pressure delivery volume, so my next step was to repeat the test and monitor the control of the SCV.

The G-Scan 2 has an excellent and easy to use built in oscilloscope and multi-meter, so I back probed the SCV solenoid. There are only two wires on the SCV, one is a 24V supply and the other is the ground controlled by the ECM. One wire was green the other green and red and a quick look at the other sensors in the engine bay showed that the green wire was common to all and likely to be the supply voltage, so I chose the red and green. It's not exactly of bomb disposal importance, but when working in such a confined area, the fewer frustrations, the better.

The engine was started and sure enough, after a short while the engine surged, faltered and stalled.

The engine control module controls the SCV by varying the duty ratio ('on time' as a percentage of the period) the SCV is a normally open type, meaning that when disconnected it is fully open and maximum delivery is achieved and pressure is increased. The on time of the duty cycle controls the closing of the valve, so the longer the on time the lower the fuel pressure. The scope was connected to the switched ground wire; consequently the on time is when the solenoid is switched to ground. Figure 4 shows the duty ratio when the rail pressure was maintained at a normal idle pressure of 300 bars. Figure 5 shows the duty ratio commanded to increase to try and compensate for loss of fuel pressure, causing the engine to die. The two images also show the SCV control signal and the ground to be good. The SCV windings were checked for resistance and insulation and were within specification.

Things seem to be pointing to a sticking SCV which is not an uncommon problem; but what about the fuel rail pressure sensor?

If the fuel rail pressure sensor gives a lower signal than normal, the SCV would be commanded to increase rail pressure; consequently injection pressure would increase which, would cause the engine speed to rise, the ECM would control engine speed by reducing the injection duration; this would be accompanied by increased diesel knock and plausibility codes relating to rail pressure being stored - but the engine never knocked.

Based on the information I had, I concluded that the SCV was sticking, which caused the erratic fuel pressures recorded by the G-Scan.

A new SCV was ordered and fitted, which cured the problem completely.

Figure 4 - The SCV duty cycle with the engine at idle

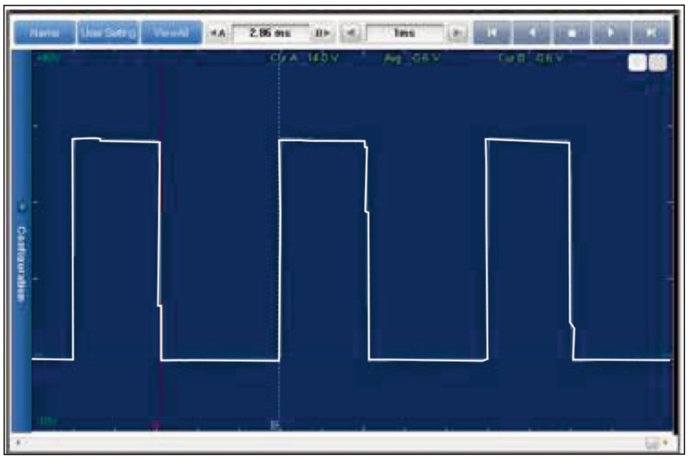

Figure 5 - The SCV duty cycle increased, to try and compensate for loss of fuel pressure, causing the engine to die.