Aug 2014

Technical Newsletter

Automotive Electronic Control Systems

AECS

Training, Equipment and Data for Automotive Diagnostic Specialists

# Closed Loop Common Rail.

***This article is a true description of an AECS technical help desk call.***

Problem presented to the help desk a **2008 Nissan Vanette CR diesel** with a misfire at about 1300-1500 RPM. This article is complex and needs detailed reading for full understanding, enjoy!

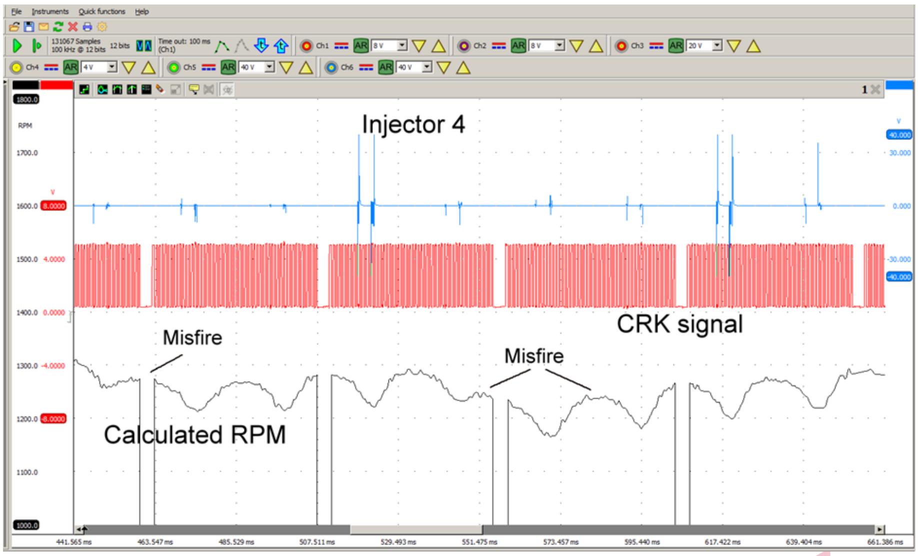


*Figure 1: ATS scope recording of crank vs injection showing misfires.*

Peter, will run through all the data that was presented explaining the diagnostic steps that we take when running through a complicated problem like this seemingly simple issue.

**Where to start?**

When presented with a missing engine we want to distinguish between two different scenarios.

1. Fixed miss fire on one (or more) cylinders
2. Random misfire

Firstly, we want to see an ATS scope recording of crankshaft sensor signal and an injection signal. The injection signal gives us a reference as to which cylinder is having an issue or if the issue is across multiple cylinders. Recording the crankshaft sensor signal also shows the quality of the signal i.e. is it corrupted with noise etc.

Zooming in on the crankshaft pattern showed that there is no noise on the pattern so this will not be the cause of the misfire.

The recording of crank vs. injection with the calculated RPM line shows that there are multiple misfires occurring which seem to be linked to two cylinders. Based on the firing order we can see that cylinders 1 and 2 are missing.

**EGR?**

Random misfires are usually caused by air flow issues i.e. an EGR valve that is not functioning properly. We blocked off the EGR valve but this made no difference to the misfiring of the engine. It must be noted that blocking the EGR valve also disrupts swirl in the engine. The ignition dampening effect of the CO2 in the exhaust gasses has been removed, so as a result the engine sounded more rattily.

We can now safely say that the EGR is not the cause for the misfiring engine and that we are happy with the gas flow through the engine. Just to be doubly sure a relative compression test was also performed which showed that all four cylinders were within two percent of each other, a perfect result.

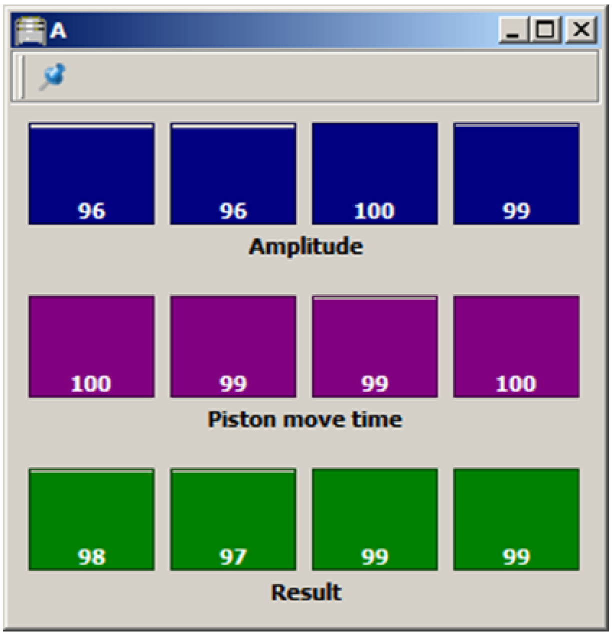


***Figure 2: relative compression test***

**Compensation values.**

Having eliminated the crankshaft sensor, EGR valve and compressions, it is time to look at the injectors. This Nissan Vannette (RF-T engine) is the result of a joint operation between Mazda and Nissan. As a result, we had with the scan tool access to the injector compensation valves, which is something the designers at Nissan do not give you access to on for example their Navara.

The injectors are compensated at four different pressure set points to ensure that the engine is running smoothly under different conditions. The graph below shows these set-points and the compensation values of each cylinder. These adaption values were recorded with a Launch Scantool and sent to AECS for analysis with our own software.

**Please note:** this level of support, and being able to share data is something that is unique to the AECS help desk.

# Did you Know?

- *That our **refrigerant identifiers** also detects air in the AC system.*
- *We have now Paul, Peter and Herbert training, and we still can't satisfy demand.*
- *That our **Truck scantool (Jaltest)** also has a huge data base with wiring diagrams and measurement data as part of the package.*
- *That you can **click on the pictures** in the news letter **to enlarge**, for more detail.*

Click on the icon to view our Facebook page

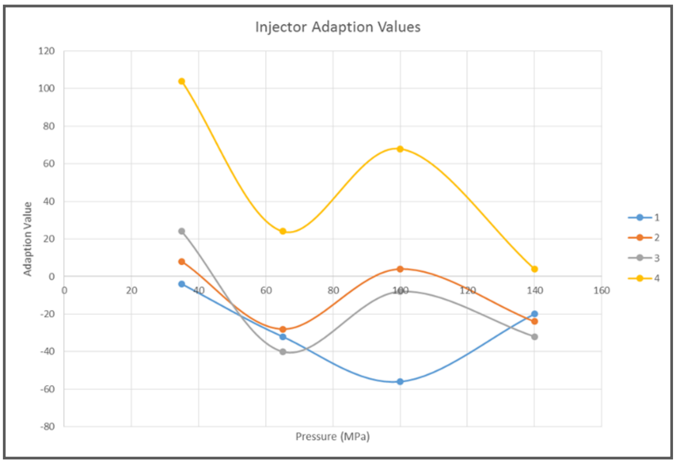


*Figure 3: injector set-points and adaption values.*

Figure 3 shows the four set-points at 35, 65, 100 and 140 MPa rail pressure. This graph instantly shows that there is an issue with injector number four because its adaption values lie so much higher than the other three injectors. However, our crankshaft speed measurement did not identify #4 as a missing cylinder.

## Closing the loop

I regard the automotive sector in New Zealand as being 'highly skilled' and not 'simple parts swappers' so let us look further. Please put your thinking cap on, brew another coffee and step into our world!

All four injectors were removed and tested by a local diesel specialist who shared their data with us, thank you.

A scanned copy of the results was sent to us and the data was a real eye-opener! The tables below presents the results.



| Inj #1 | Actua-tion Time | Pres-sure | Measure-ment Time | Injected quantity | | Return Quantity | | Evalua-tion |
|---|---|---|---|---|---|---|---|---|
| | (us) | (MPa) | (s) | Set ($mm^3$/H) | Actual ($mm^3$/H) | Set ($mm^3$/H) | Actual ($mm^3$/H) | |
| Leak Test | 0 | 170 | 90 | -- | -- | 38+/-38 | 19.09 | ok |
| Full Load | 860 | 160 | 120 | 55+/-3.8 | 52.86 | 43+/-43 | 41.12 | ok |
| Idle Fuel | 760 | 25 | 60 | 3.5+/-2.4 | 3.26 | -- | -- | ok |
| Pilot Inj | 330 | 80 | 40 | 2.4+/-1.6 | 2.62 | -- | -- | ok |

| Inj #2 | Actua-tion Time | Pres-sure | Measure-ment Time | Injected quantity | | Return Quantity | | Evalua-tion |
|---|---|---|---|---|---|---|---|---|
| | (us) | (MPa) | (s) | Set ($mm^3$/H) | Actual ($mm^3$/H) | Set ($mm^3$/H) | Actual ($mm^3$/H) | |
| Leak Test | 0 | 170 | 90 | -- | -- | 38+/-38 | 43.48 | ok |
| Full Load | 860 | 160 | 120 | 55+/-3.8 | 51.84 | 43+/-43 | 73 | ok |
| Idle Fuel | 760 | 25 | 60 | 3.5+/-2.4 | 3 | -- | -- | ok |
| Pilot Inj | 330 | 80 | 40 | 2.4+/-1.6 | 1.69 | -- | -- | ok |

| Inj #3 | Actua-tion Time | Pres-sure | Measure-ment Time | Injected quantity | | Return Quantity | | Evalua-tion |
|---|---|---|---|---|---|---|---|---|
| | (us) | (MPa) | (s) | Set ($mm^3$/H) | Actual ($mm^3$/H) | Set ($mm^3$/H) | Actual ($mm^3$/H) | |
| Leak Test | 0 | 170 | 90 | -- | -- | 38+/-38 | 28.37 | ok |
| Full Load | 860 | 160 | 120 | 55+/-3.8 | 53.79 | 43+/-43 | 54.87 | ok |
| Idle Fuel | 760 | 25 | 60 | 3.5+/-2.4 | 2.97 | -- | -- | ok |
| Pilot Inj | 330 | 80 | 40 | 2.4+/-1.6 | 2.11 | -- | -- | ok |

| Inj #4 | Actua-tion Time | Pres-sure | Measure-ment Time | Injected quantity | | Return Quantity | | Evalua-tion |
|---|---|---|---|---|---|---|---|---|
| | (us) | (MPa) | (s) | Set ($mm^3$/H) | Actual ($mm^3$/H) | Set ($mm^3$/H) | Actual ($mm^3$/H) | |
| Leak Test | 0 | 170 | 90 | -- | -- | 38+/-38 | 88.11 | Not ok |
| Full Load | 860 | 160 | 120 | 55+/-3.8 | 47.67 | 43+/-43 | 112.09 | Not ok |
| Idle Fuel | 760 | 25 | 60 | 3.5+/-2.4 | 0.88 | -- | -- | Not ok |
| Pilot Inj | 330 | 80 | 40 | 2.4+/-1.6 | 0 | -- | -- | Not ok |

The tables need some explaining. The actuation time, pressure, measurement time, set injected quantity and set return quantity are all specified by the manufacturer. For example if these injectors are tested for a full load test they need to be activated for 860us at a pressure of 160 MPa for 120 seconds and the actual injected quantity should be between 51.8 and 58.8 $mm^3$/H (cc's per stroke) with a fuel return quantity between 0 and 86 $mm^3$/H.

These tests have confirmed what the adaption values have already told us. Injector number four is faulty. As a result, the diagnostician replaced just injector number four.

Based on the scope patterns it is needless to say that **replacing just injector #4 did NOT improve the running of the vehicle.**

**What is injector compensation?**

To answer this question we need some more data from the vehicle. The recording shows RPM, Inj4 and suction control valve duty-cycle.

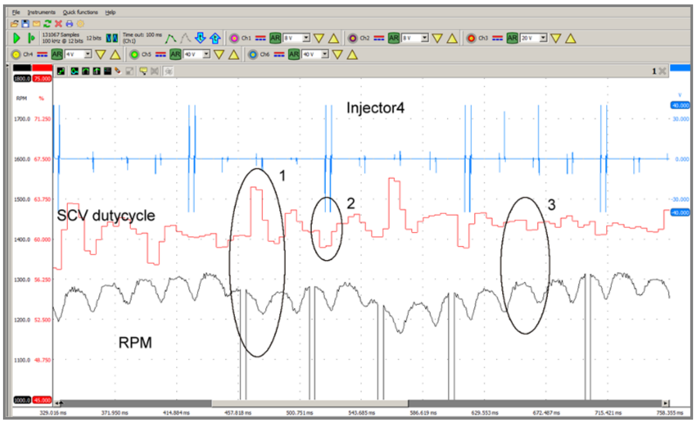


***Figure 4: ATS 5004d scope recording of inj, SCV duty cycle and RPM.***

When the suction control valve duty-cycle increases, more fuel enters the rail, when the control valve duty-cycle decreases less fuel enters the rail. Figure 4 highlights three important areas.

**#1.** The duty-cycle increases after a misfire has occurred. The ECU sees that the crankshaft has slowed down and now wants to speed up the crankshaft again. This is done by injecting more fuel in the following cylinder.

**#2.** The duty-cycle decreases after injector four injects. This is because injector four has higher than normal leakage rate (see test sheet table).

**#3**. this is the same cylinder as in #1 but now we don't see the increase in duty-cycle. This is because the cylinder beforehand fired properly so there is no need to speed up the crankshaft with additional fuel.

In this duty-cycle pattern, we can see two mechanisms at work. We can see the ECU compensating for a sudden decrease in crankshaft speed and we can see the ECU compensating for an injector with high return flow (rail pressure decrease).

**Conclusion**

Looking back at the injector tables we can see that the return flow of injector #2 under the leak test is more than twice that of injector #1 but further from the set-point. Similar conclusions can also be drawn with the other injectors.

As a result, **we replaced all four injectors**. The car was returned to the customer who took it for a 1000km drive and then bought it back into the workshop to have the injector compensation values re-checked. Figure 5 below shows the before and after results. We can see that Injector one did not need replacing because the compensation values did not move as far as the other three injectors.

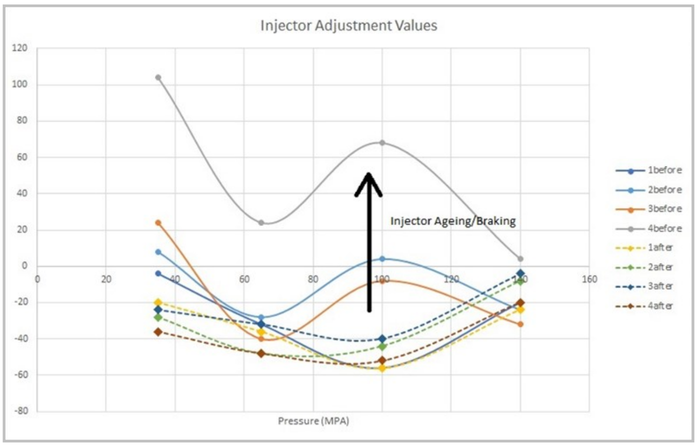


***Figure 5: before and after replacement injector compensation results.***

It also needs stating that we get more and more customers who purchased other brands of scopes, asking for our technical support. We try to help as much as we possibly can, but this usually ends up in a DNF (racing terms for 'did not finish') job. This is most frustrating for us and our customers.

Please make sure you choose your knowledge and equipment partner wisely.

Both you and AECS are dealing with more complex problems daily. AECS has the ability and resources to simplify these complex problems in an easy to understand manner for your benefit.

For ***AECS*** Ltd.
Peter Leijen, BE(Hons)
Application Engineer
P: +64 6 8749077
F: +64 6 8749078
E: peter@aecs.net
W: www.aecs.net