Driveability Corner

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Scan data is a convenient source of useful diagnostic information. Additional information can also be inferred by combining this data.

In the late '80s and early '90s, I worked on a fleet of fuel-injected Toyota trucks. The injector pulse width (IPW) warmed up, at idle, was generally around 2.5 milliseconds (mS). As these trucks aged, the IPW would approach 5.0mS. At this point, the PCM would no longer add fuel to compensate for the lean O_2 sensor reading, and the engine would go lean and idle poorly. The PCM had allowed for doubling of the fuel to compensate for injector restriction. What more could you ask for?

I asked the shop that cleaned my injectors to flow-test them before and after cleaning, and to give me a report. Generally, the injectors were flowing 50% of the fuel before cleaning as compared to after. That makes sense, with the doubling (100% increase) of fuel delivery to compensate for the injector restriction. Reinstalling the injectors fixed the problem and the IPW would return to normal (2.5mS).

Okay, times change, injector design changes, fuel changes and injectors don't restrict as much anymore. Also, along comes OBD II with short-term fuel trim (STFT) and long-term fuel trim (LTFT). STFT is a pretty quick average of fuel trim generally following the O_2 sensor as it switches. STFT is always looking to get back to zero. LTFT is a longer average of adaptation, and while it would like to be at zero, it has to compensate for situations like restricted injectors, which calls for longer injector on-times to

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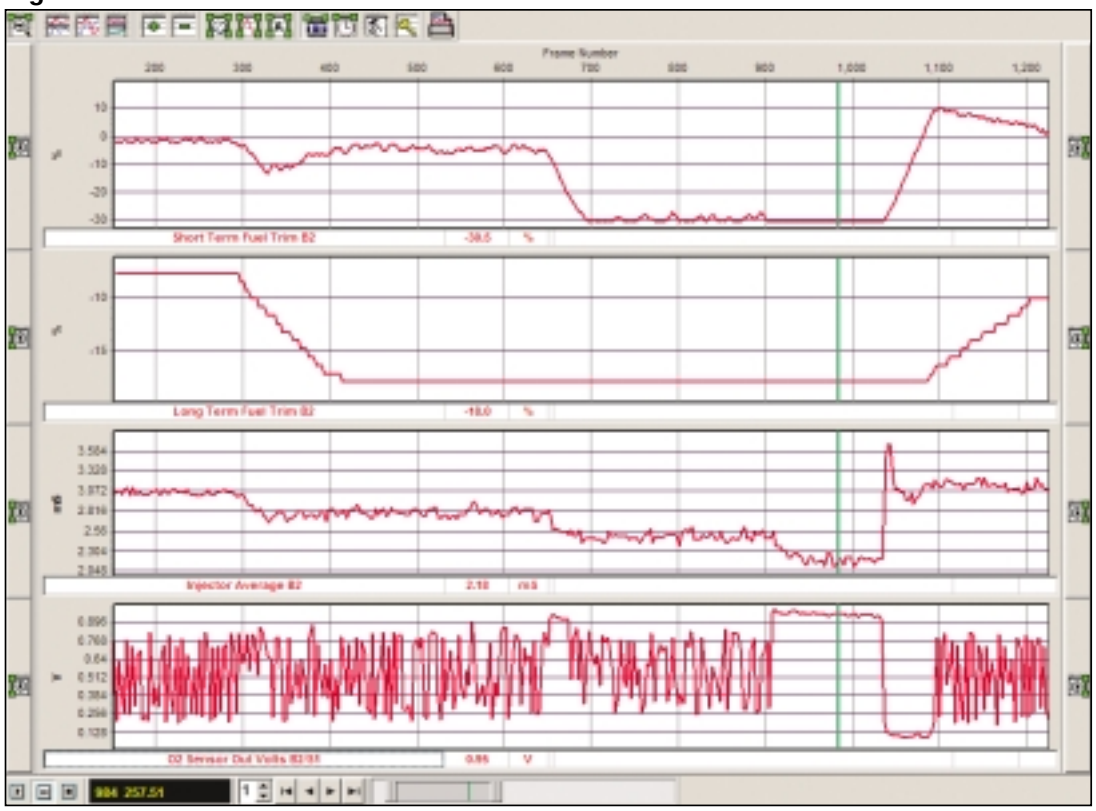
Fig. 1



Scan data graph: Mark Warren

keep the fuel mixture constant.

I've watched STFT and LTFT on a number of vehicles. Generally, LTFT will rail (go no further) at about 25%. On some vehicles, STFT will then also rail (as it can no longer hold zero) between zero to 30% (depending on the vehicle).

Now come the questions:

•Do injectors no longer restrict as much as before, calling for less compensation?

•Does 25% LTFT equal a 25% longer IPW?

•Can you add STFT and LTFT to get a total fuel trim adaptation percentage?

•Does the percentage make sense?

•Is the adjustment linear?

•Does the scan tool IPW correlate to the actual measured IPW?

Fig. 2

Adding fuel- Fuel Trim going negative					
Frame	STFT %	LTFT %	Total FT %	Actual IPW	Total FT % times base FT
Calculated	0	0	0	3.35	
200	-1.6	-7.8	-9.4	3.06	3.04
305	-3.9	-9.4	-13.3	2.98	2.90
315	-7.0	-10.2	-17.2	2.81	2.77
325	-12.5	-10.9	-23.4	2.76	2.57
345	-12.5	-12.5	-25.0	2.76	2.51
365	-10.2	-14.1	-24.3	2.81	2.54
385	-6.3	-16.4	-22.7	2.72	2.59
405	-3.9	-17.2	-21.1	2.52	2.64
425	-6.3	-18.0	-24.3	2.72	2.54
650	-5.5	-18.0	-23.5	2.78	2.56
660	-10.2	-18.0	-28.2	2.56	2.41
670	-18.2	-18.0	-36.2	2.55	2.14
680	-25.0	-18.0	-43.0	2.49	1.91
700	-30.5	-18.0	-48.5	2.46	1.73
983	-30.5	-18.0	-48.5	2.11	1.73

•If fuel pressure is good and all sensors report good values, at what fuel trim values should you consider cleaning injectors?

To answer the first question I called the expert, Doug Garriott, at Linder Technical Services. Doug said that most of the injectors sent in for cleaning and

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rebuilding test out at a 15% restriction. Occasionally, he'll see one restricted to a 25% reduction in flow. Injectors over 25% reduction generally are defective and not rebuildable. So it does appear that injectors do restrict less than in my previous experience, and LTFT percentages may make sense.

While it would appear that injectors plugged 15% may be able to be compensated for by the fuel system (LTFT), often the restriction differences between injectors (injector balance) is too great for smooth running. Also, injectors restricted 15% may not be able to deliver adequate fuel at the top end.

Making too many generalizations here is dangerous, so we'll dissect this issue a little at a time and make by make. We'll start with a 1999 Chevy Blazer with a 5.7L engine. In Fig. 1 on page 14, the graph begins with the engine warmed up, at idle, with the a/c off. Then we slowly added propane to drive the engine rich, causing the fuel management system to subtract fuel to attempt to retain closed-loop fuel control.

Frames 150-295 (at the top of the chart) record stable idle, with no fuel added (baseline). At frame 295, we started adding fuel, and you can see STFT start to react and then LTFT come in right behind to re-zero STFT. LTFT railed at –18%; is this the limit of compensation? We let the system run for a while in closed loop. At frame 650, we added more propane. LTFT is still railed at –18%. You can see STFT appear to add on top of LTFT until it rails at –30.5%. You can also see that the O_2 sensor is pegged high, showing low exhaust O_2 content. This indicates that we're pegged rich, at the PCM's preprogrammed limit of adaptation.

If total fuel trim (LTFT+STFT) applies, then it looks like the total fuel adaptation is –48.5% (–18.0% + –30.5%). Do the numbers make sense as applied to fuel trim? On this vehicle, I did not measure actual IPW, but I did record the scan data IPW. Look at the matrix in Fig. 2 on page 16. The first column is the frame number from the recording in Fig. 1, the second column is STFT, the next column is LTFT, the next is total FT (STFT+LTFT), the next column is scan tool-measured IPW. The final column is calculated IPW, taken from the base IPW with total FT adaptation applied to it.

It looks like the total FT applied to IPW is similar but not a perfect correlation to scan tool-reported IPW. We're in the process of running more vehicles, driving them rich and lean, and gathering actual IPW for comparison. I'll have more next time. If you'd like to see the results presented live, come to Linder's "Fuelish Thoughts" conference in September. Check *www.PWRtraining.com* or *www.lindertech.com* for information. Hope to see you there!