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Gasoline Direct Injection

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This presentation covers some of the differences between GDI and FSI. More specifically, this article focuses on the issues facing the GDI systems.

Gasoline Direct Injection

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GDI

- GDI Highlights
- Mechanical & Electrical Differences
- Lexus
  - D-4
  - D-4S
- Volkswagen
  - FSI
  - TSI
- GDI Issues
  - Fuel System
  - Intake Valve

GDI Highlights

- Leaner Burn: **65-1**
- Higher compression Ratios: **12:1**
- Higher Power Output: **V6=312HP**
- Higher MPGs: **29 HWY**
- Reduced Emmissions
- Forced Induction Friendly

GDI Vehicles

- BMW
- Ford
  - EcoBoost
- General Motors
  - 2.0L Ecotec
- Hyundai
  - Theta
- Lexus
- Mazda Speed
  - Direct Injection Spark Ignition
- Mitsubishi
  - Gasoline Direct Injection
- Volkswagen
  - FSI Fuel Stratified Injection

Mechanical & Electrical Differences

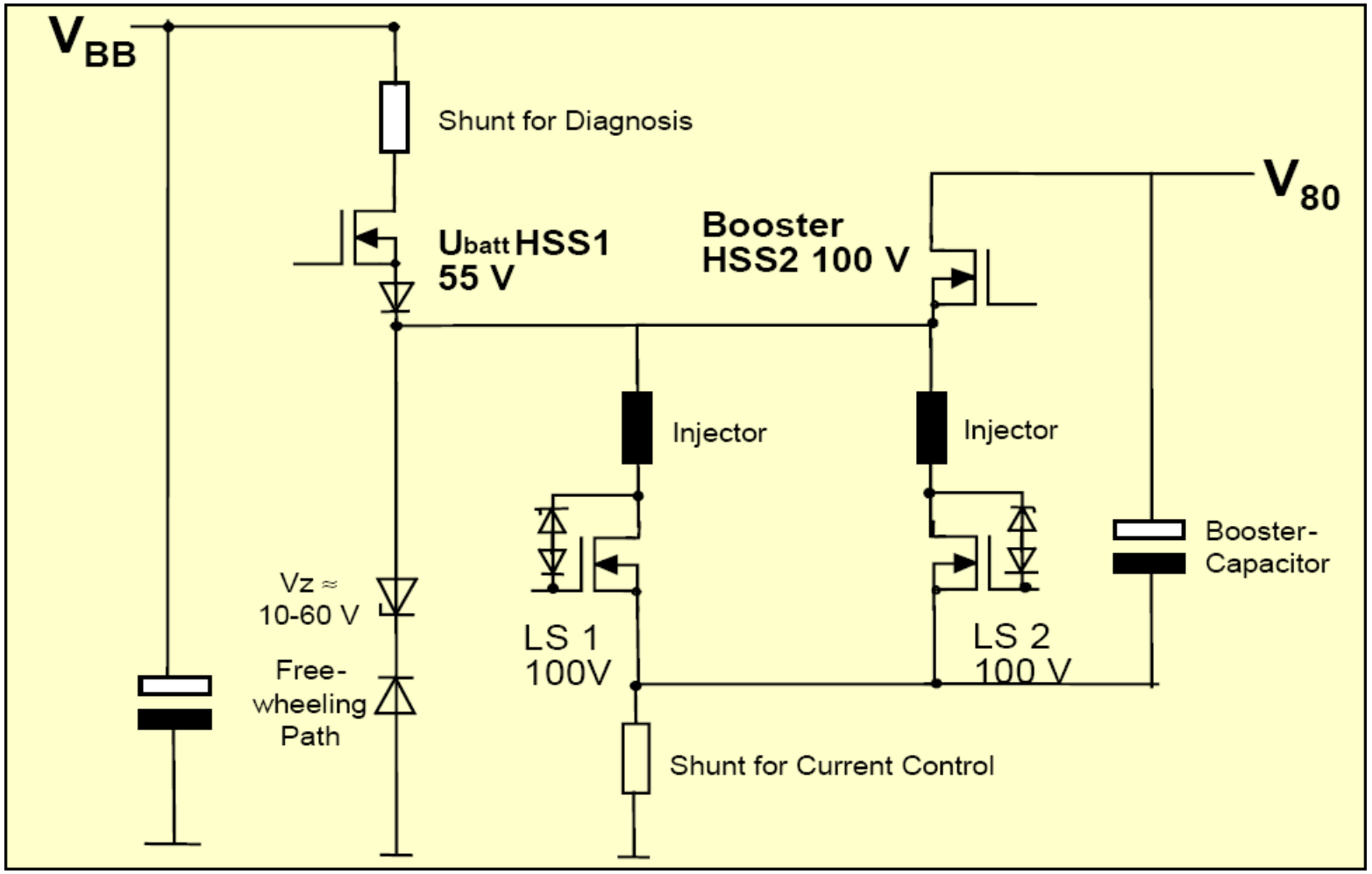
Mechanical

- Mechanical Fuel Pump
- Piston Shape
- Swirl Valve
- Higher Compression

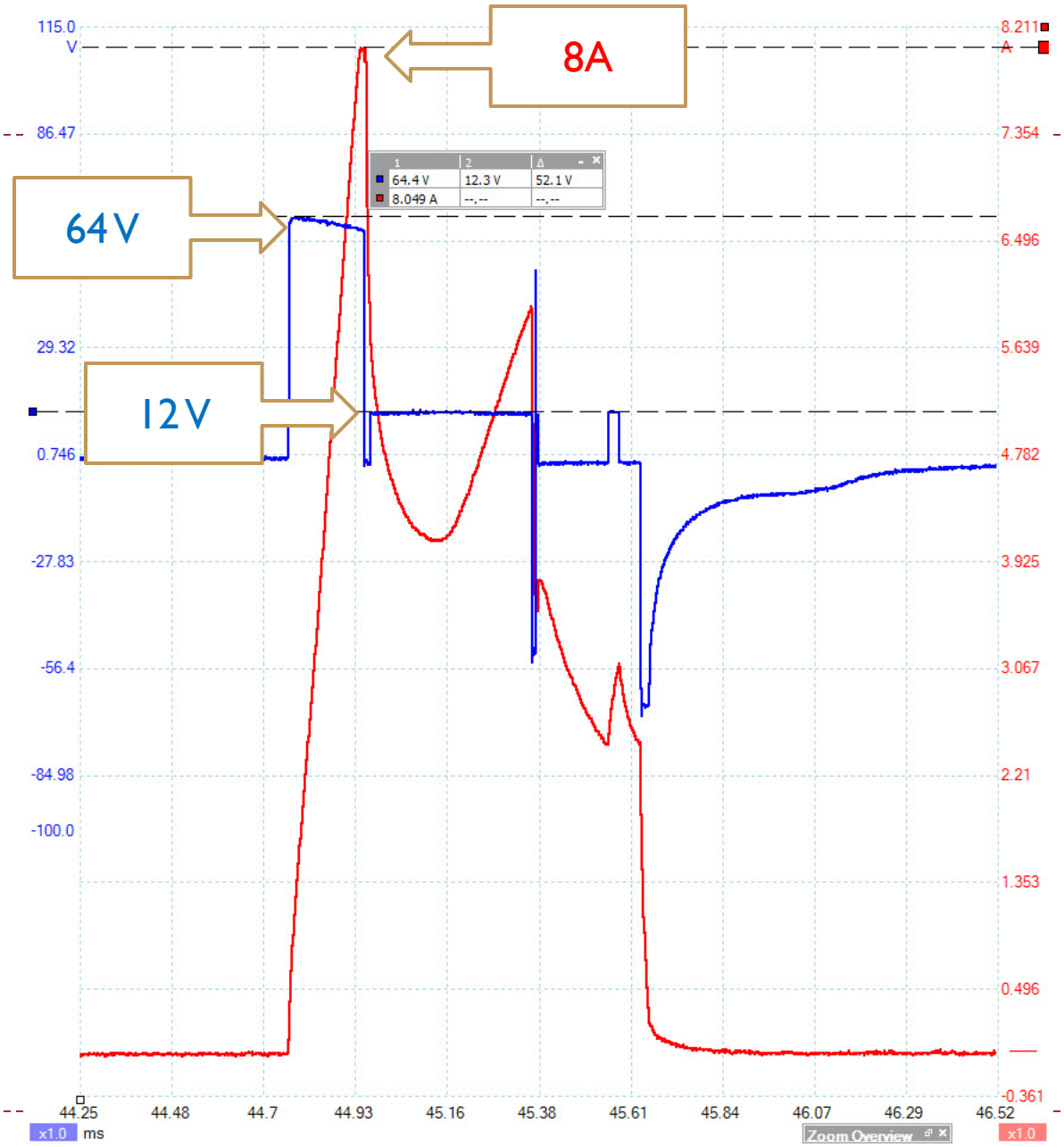
Electrical

- Voltage
  - Initial Pulse: 50-75 Volts
  - Duty cycled 12 V
- Paired cylinders
- Power and Ground controlled
- Multiple Injection

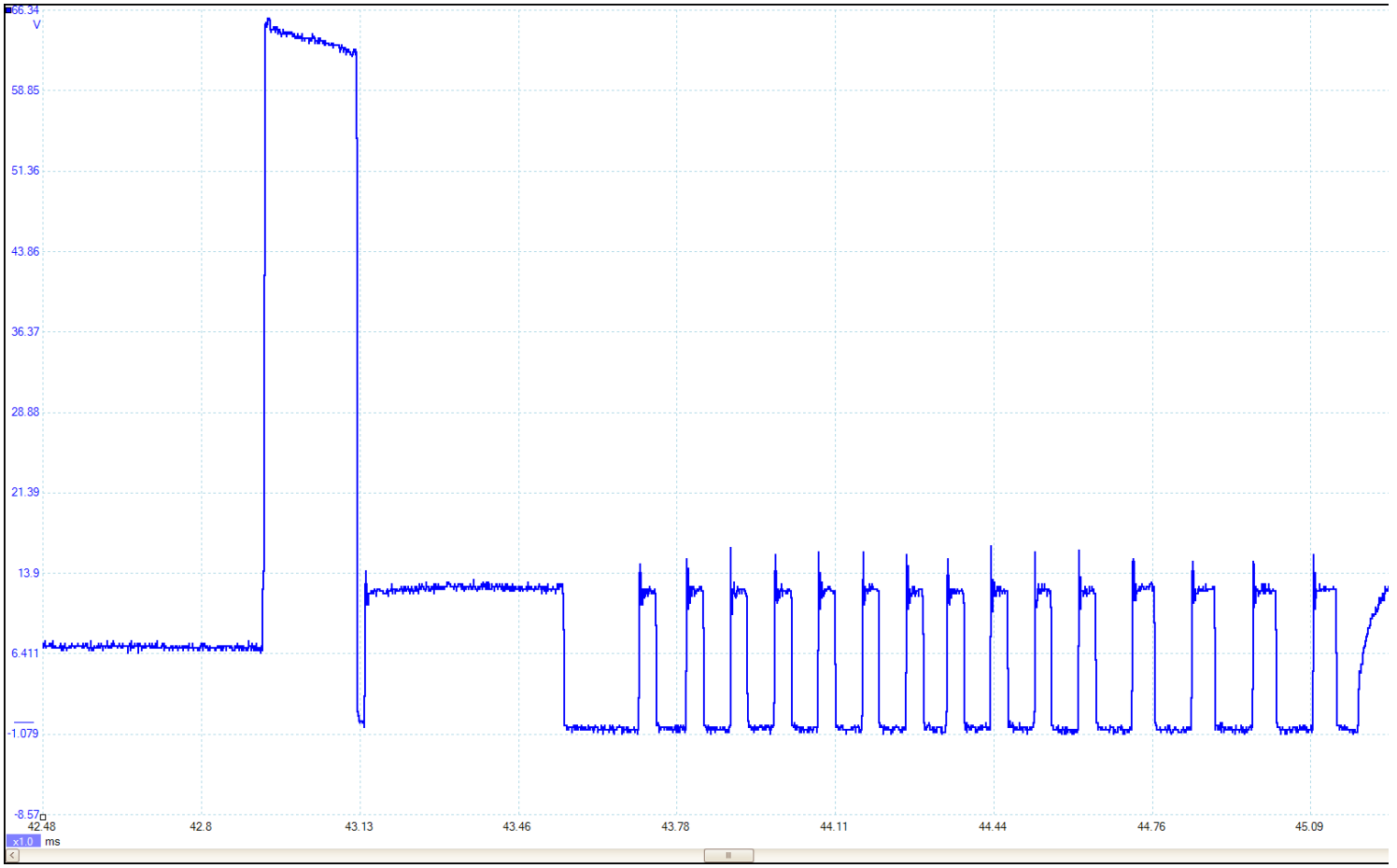
Controller Schematic



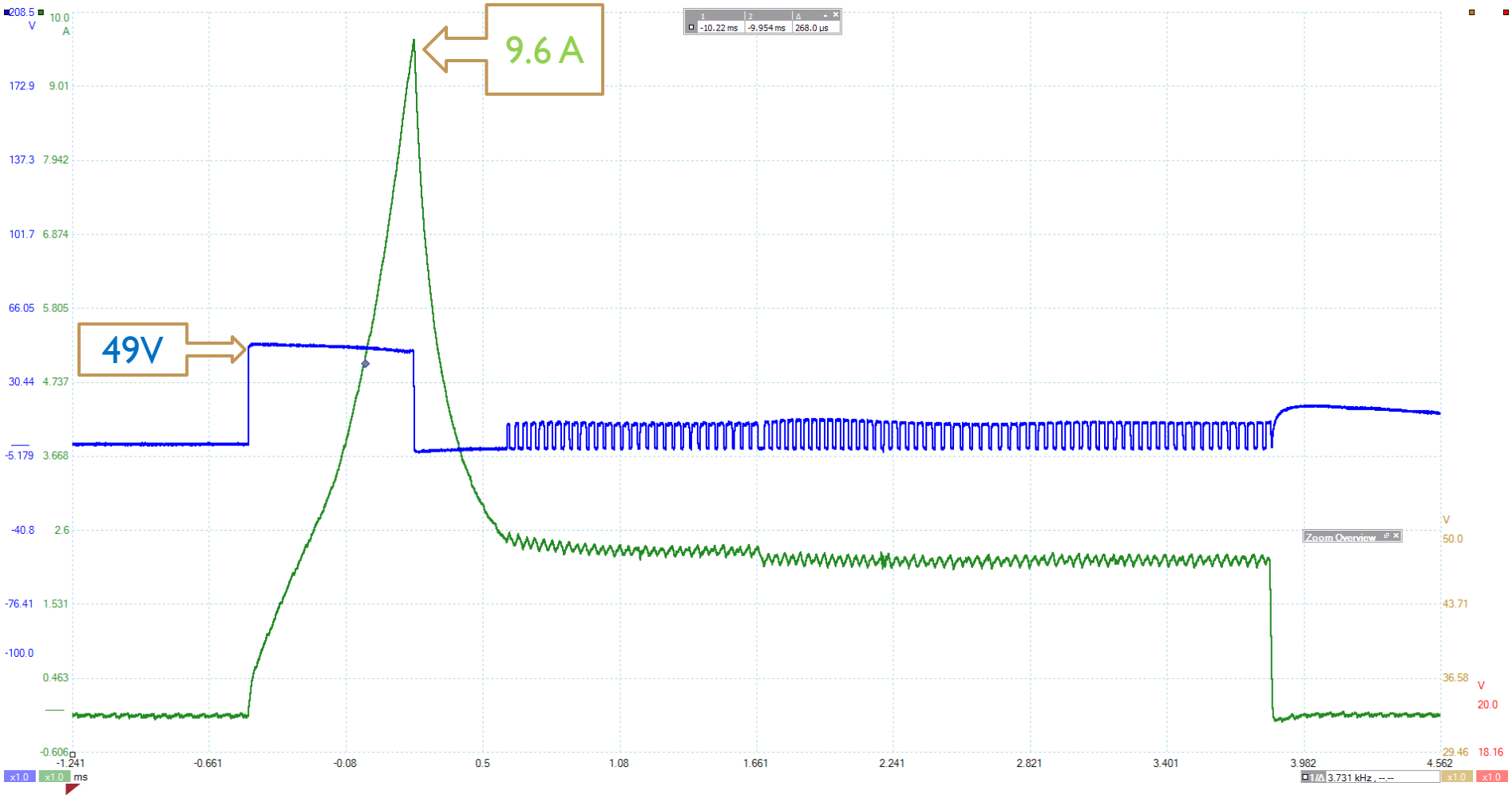
VW GTI


8A
64V
12V
115.0
V
86.47
29.32
0.746
-27.83
-56.4
-84.98
-100.0
8.211
A
7.354
6.496
5.639
4.782
3.925
3.067
2.21
1.353
0.496
-0.361
1 2 Δ
64.4 V 12.3 V 52.1 V
8.049 A --.-- --.--
44.25 44.48 44.7 44.93 45.16 45.38 45.61 45.84 46.07 46.29 46.52
x1.0 ms
Zoom Overview
x1.0

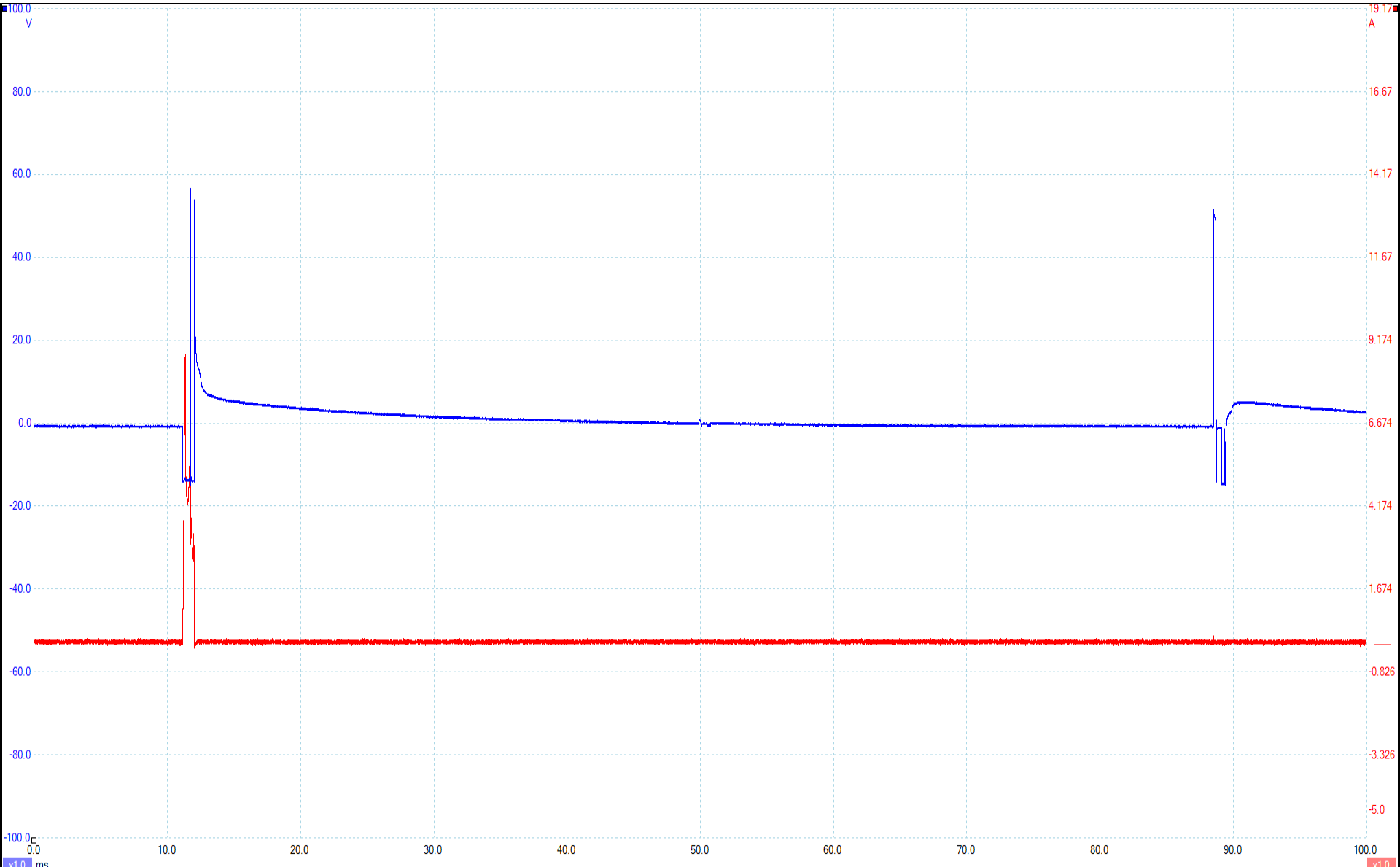
WOT


66.34
V
58.85
51.36
43.86
36.37
28.88
21.39
13.9
6.411
-1.079
-8.57
42.48
42.8
43.13
43.46
43.78
44.11
44.44
44.76
45.09
x1.0
ms

Lexus IS350


9.6 A
49V
208.5 V
10.0 A
172.9 9.01
137.3 7.942
101.7 6.874
66.05 5.805
30.44 4.737
-5.179 3.668
-40.8 2.6
-76.41 1.531
-100.0
0.463
-0.606
-1.241
-0.661
-0.08
0.5
1.08
1.661
2.241
2.821
3.401
3.982
4.562
ms
-10.22 ms
-9.954 ms
268.0 µs
Zoom Overview
V
50.0
43.71
36.58
29.46
20.0
18.16
3.731 kHz , --.--

Paired Cylinders



Multiple Injection

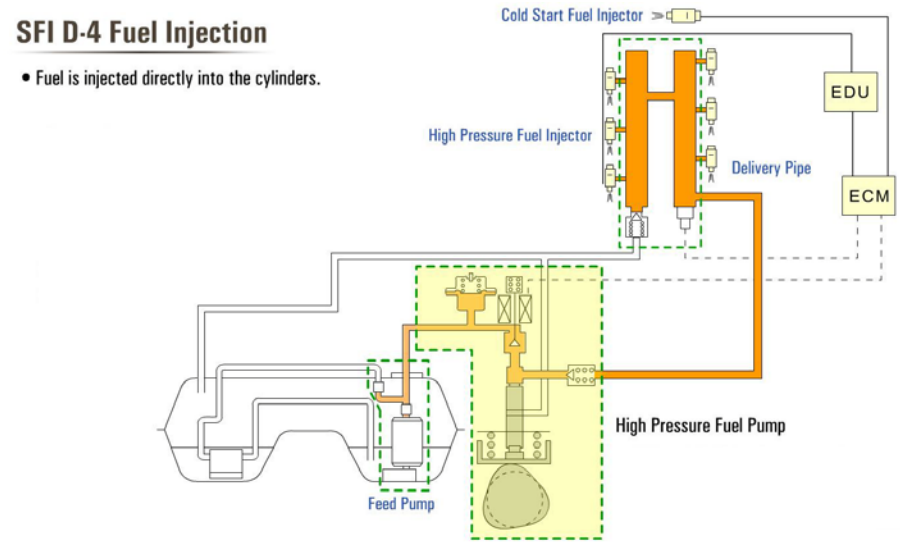
Lexus GDI Systems

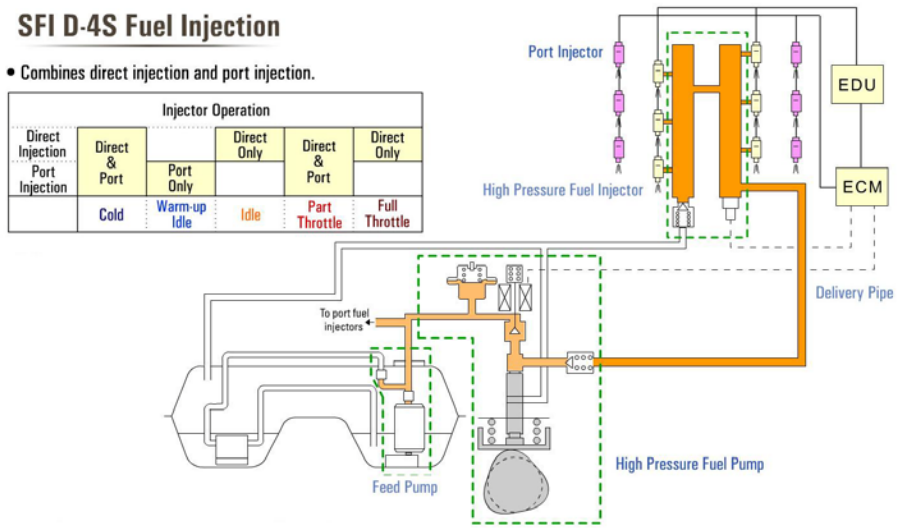
D-4 (4GR-FSE)

- IS250 (2005-Present)
  - Direct injectors
  - Cold Start Injector

D-4S (2GR-FSE)

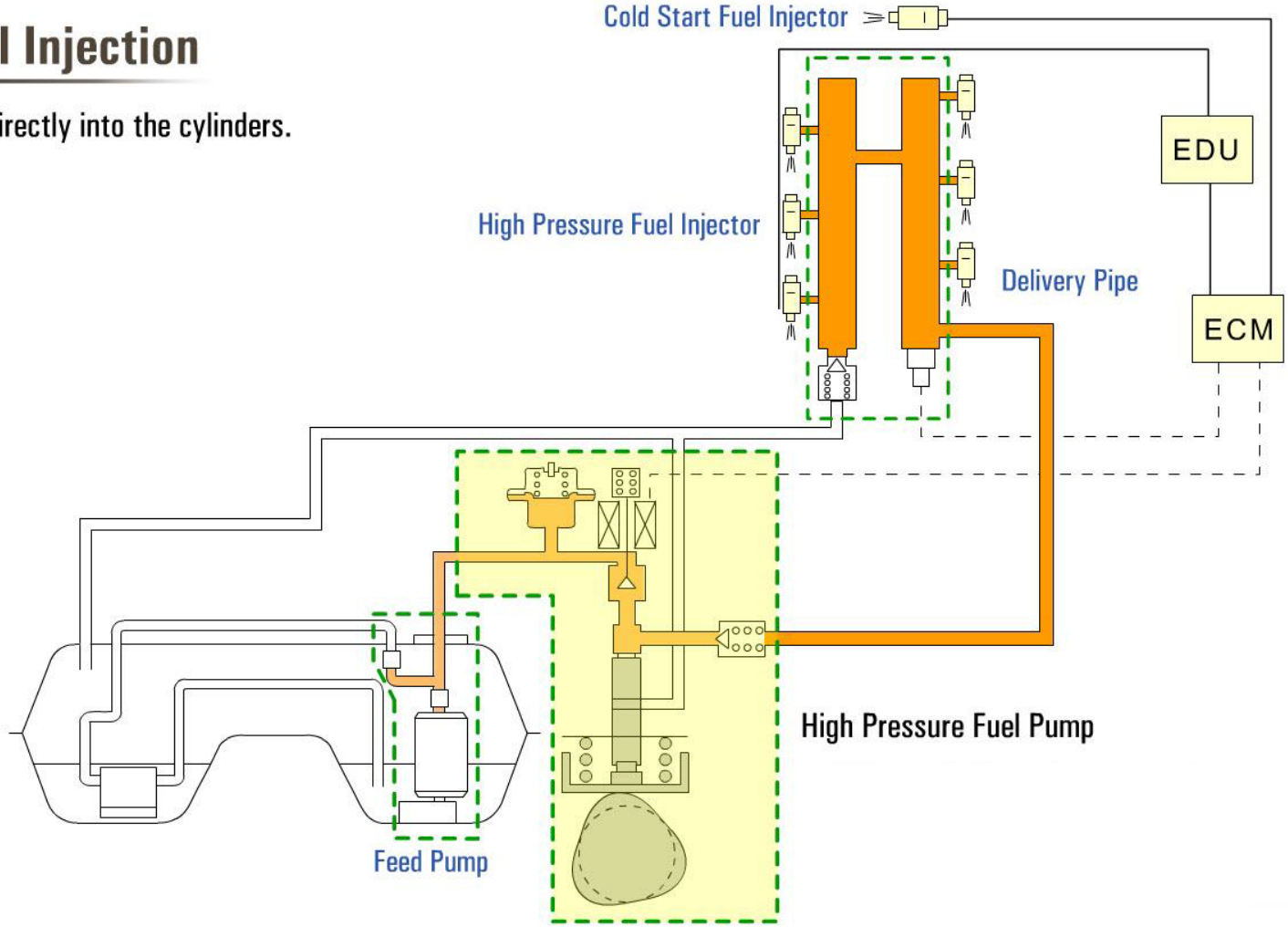
- IS350 (2005-Present)
  - Direct injectors
  - Port injectors



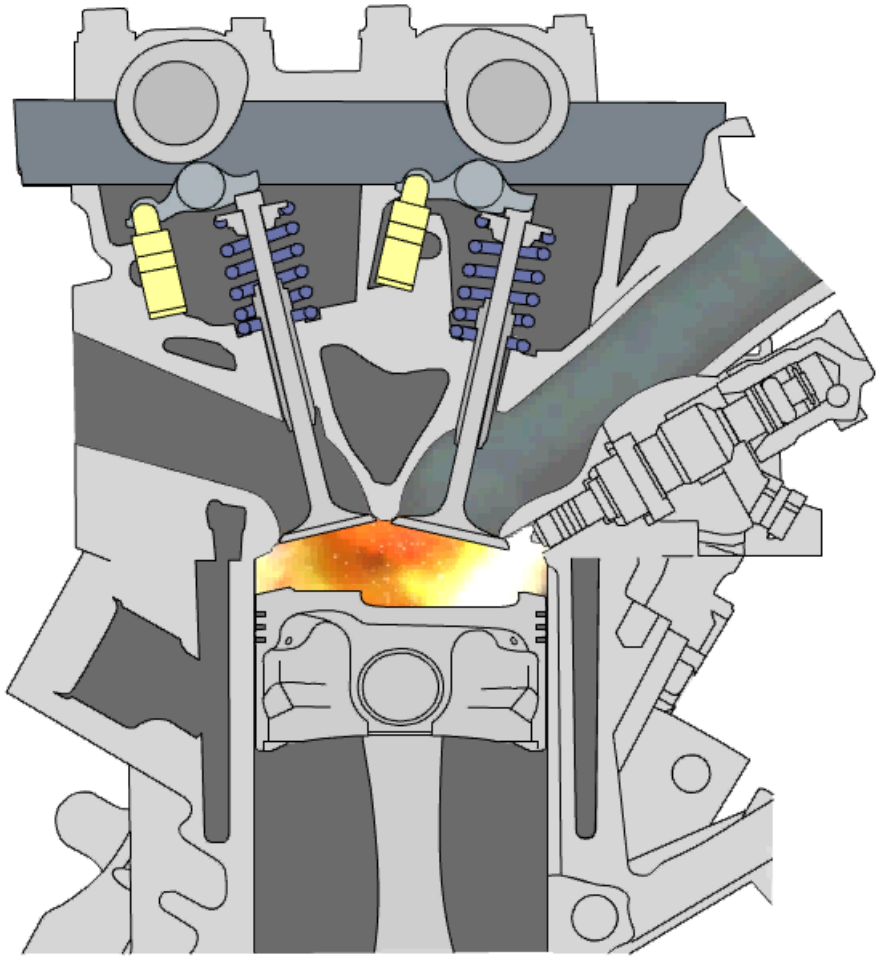


SFI D-4 Fuel Injection

- Fuel is injected directly into the cylinders.

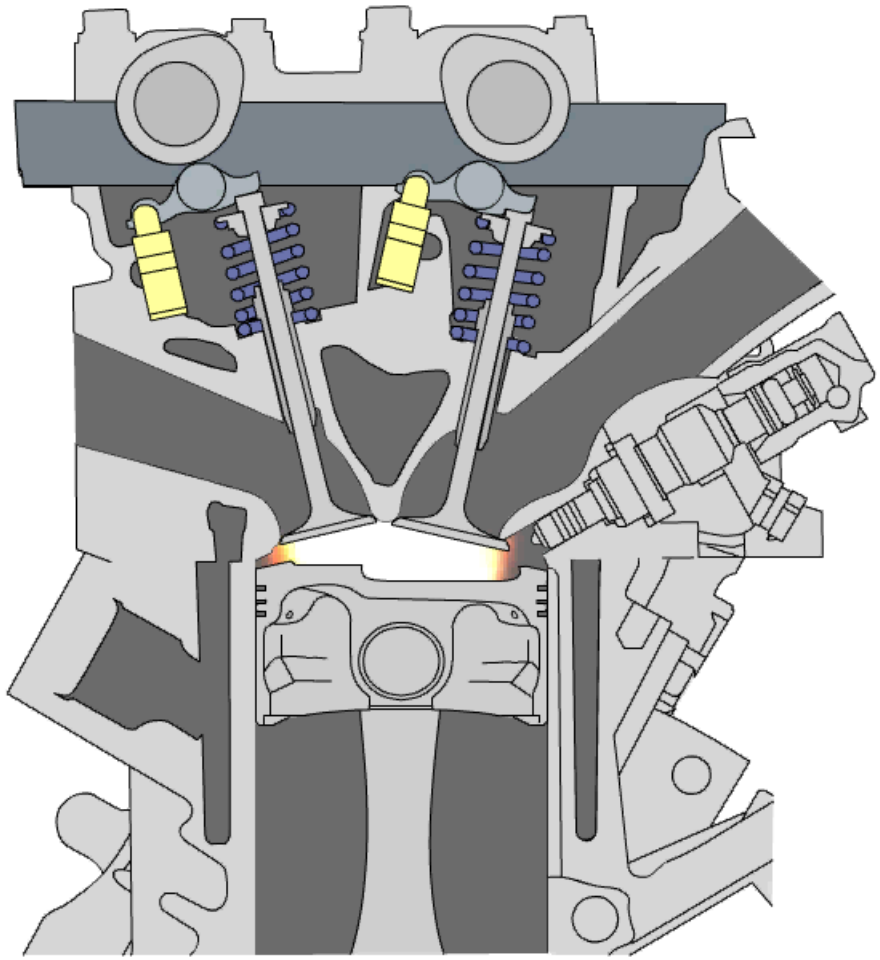


D-4 Stratified



- Injected after the intake stroke
- Lean Mixture
- Cleaner Burn
- More efficient

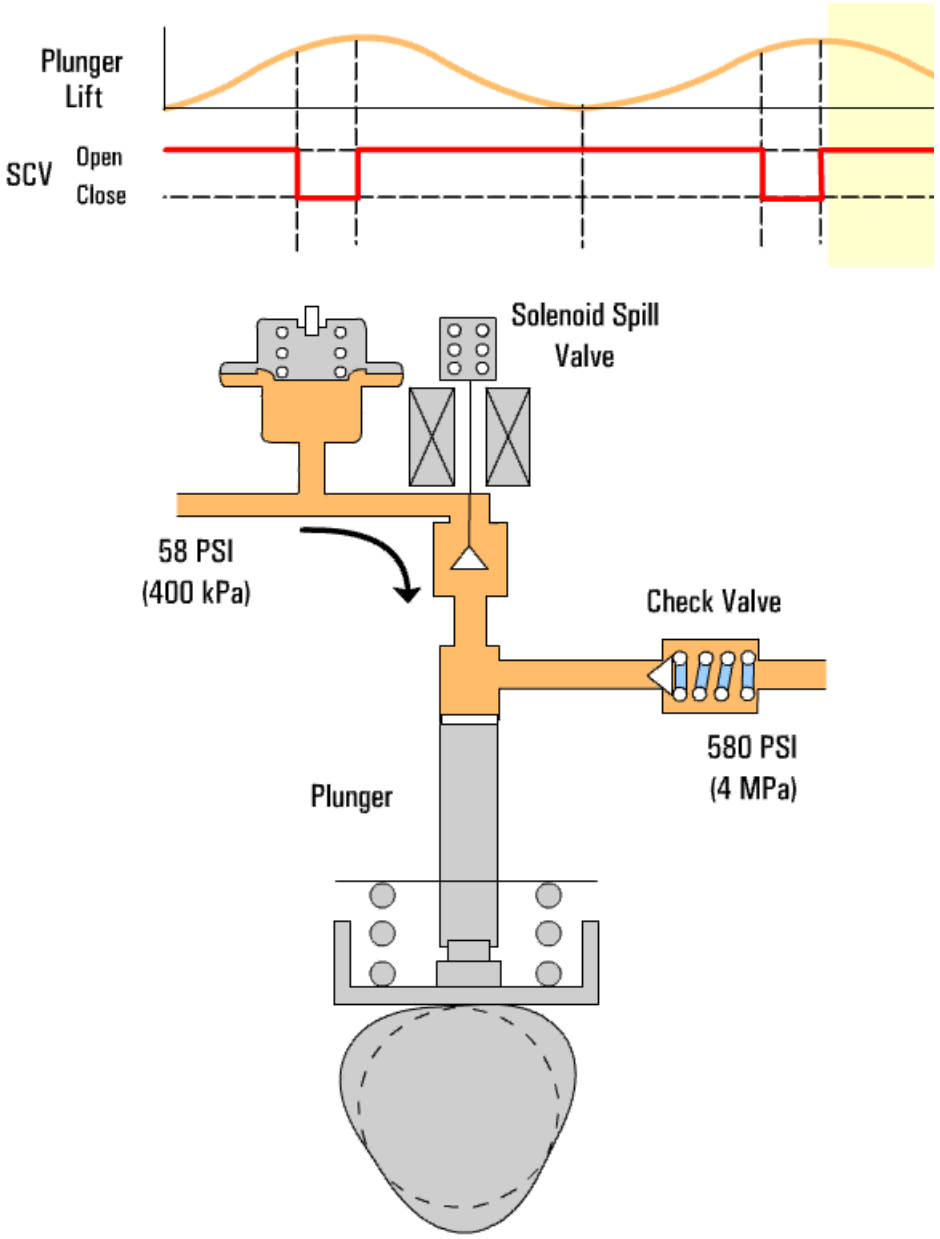
D-4 Homogenous



- Injected during the intake stroke
- Shorter catalyst light-up time
- More power
- Cold start conditions
  - With Cold start injector

Cold Start Injector

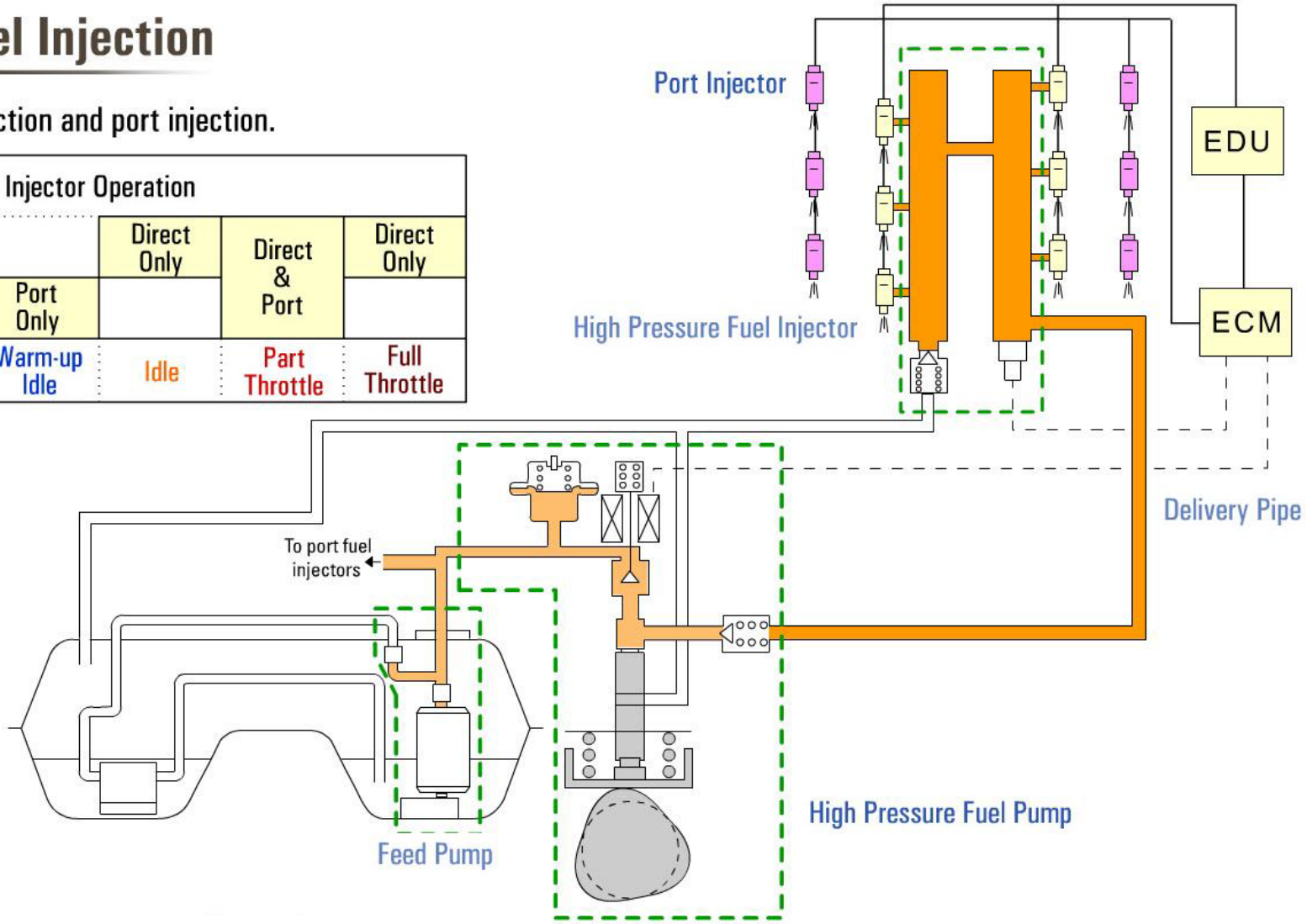
High Pressure Fuel



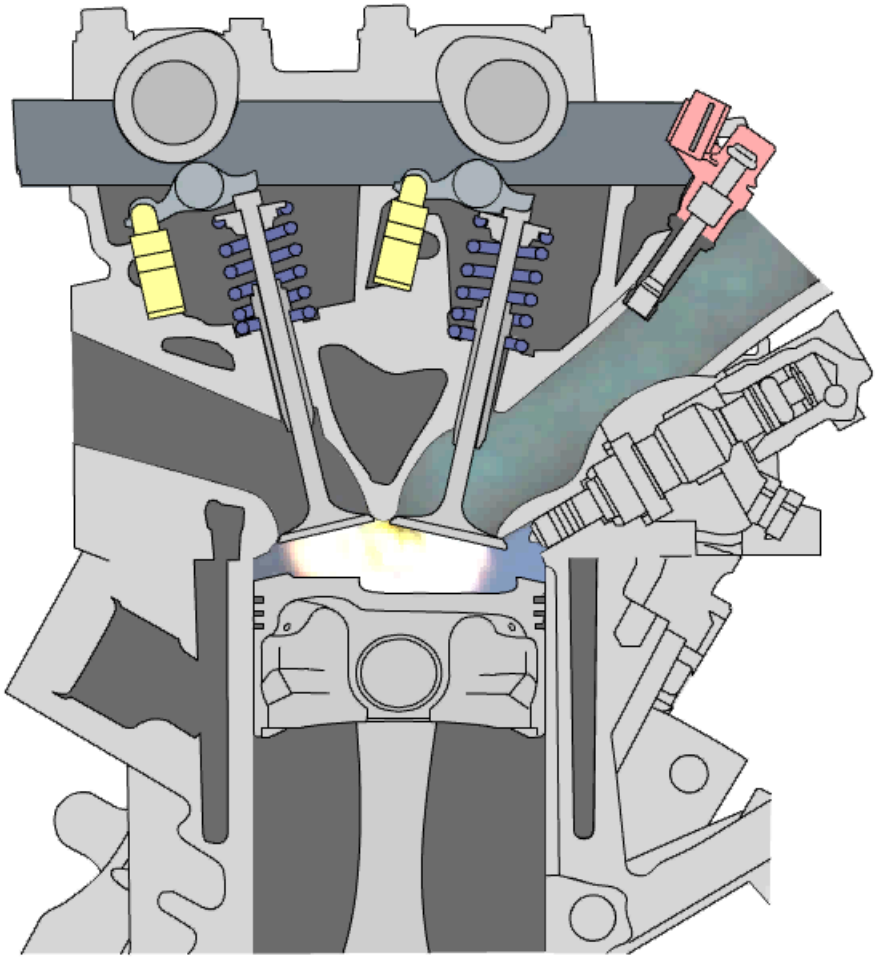
SFI D-4S Fuel Injection

- Combines direct injection and port injection.

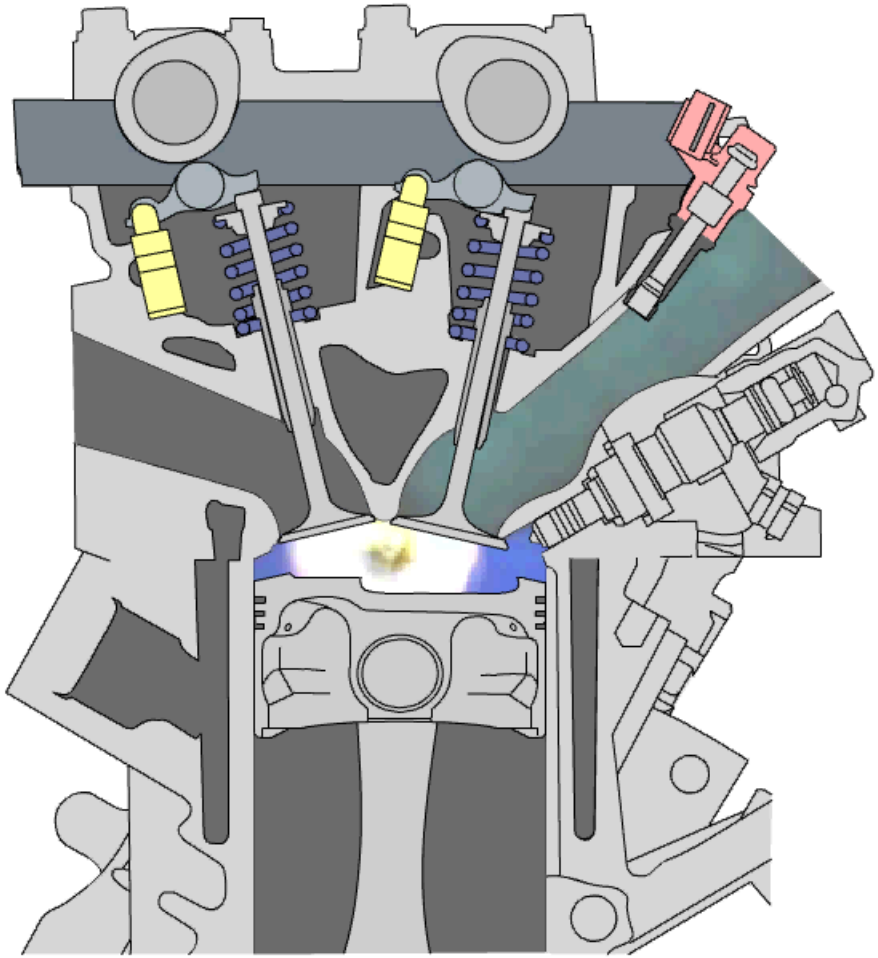
Injector Operation					
Direct Injection	Direct & Port		Direct Only	Direct & Port	Direct Only
Port Injection		Port Only			
	Cold	Warm-up Idle	Idle	Part Throttle	Full Throttle



D-4S Stratified



D-4S Homogenous



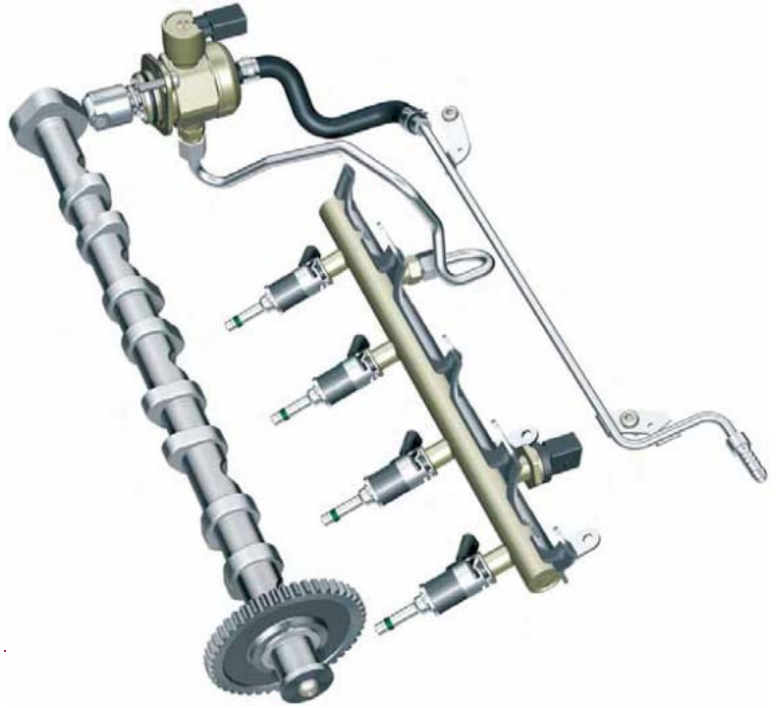
Volkswagen GDI Systems

FSI (Fuel Stratified Injection)

- 2006-2008.5 GTI/Passat
  - Tappet Type Mechanical Pump Follower
  - Three Cam Lobes

TSI (Turbo Stratified Injection)

- 2009-Present GTI/Passat
  - Roller Type Mechanical Fuel Pump Follower

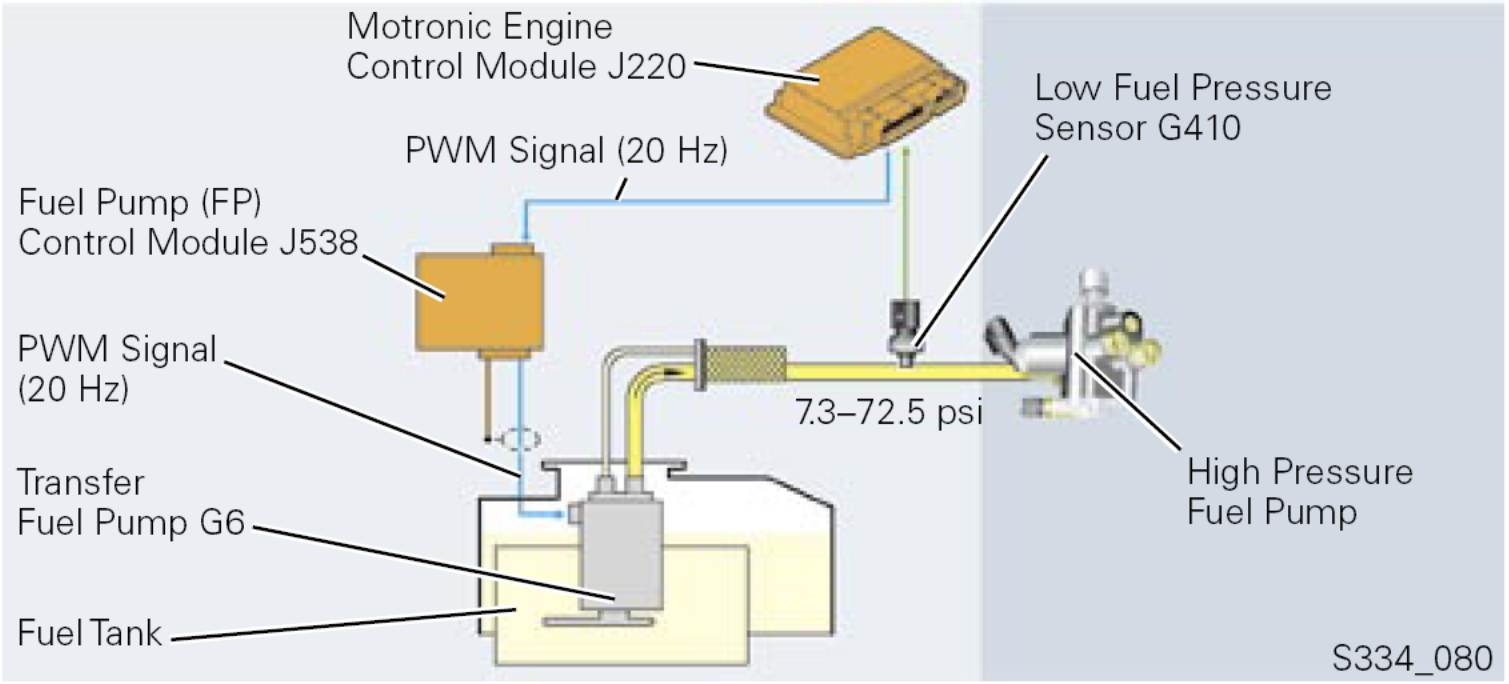


FSI System

FSI System

VW FSI Fuel Systems

Low Pressure System



GDI Issues

- Fuel System
  - Cam Follower
  - Fuel Pressure Sensor
- Intake Valve Deposits
  - Misfire
  - Lower MPG

FSI Cam Follower

9K   111 K   31K

Cam Lobe

Technical Bulletin

Model(s)	Year	Eng. Code	Trans. Code	VIN Range From	VIN Range To
Eos	**2006 - 2007**	**2.0L (BPY)**	**All**	**All**	**All**
GTI	**2006 - 2007**	**2.0L (BPY)**	**All**	**All**	**All**
Jetta (A5)	**2005 - 2007**	**2.0L (BPY)**	**All**	**All**	**All**
Passat, Passat Wagon	**2006 - 2007**	**2.0L (BPY)**	**All**	**All**	**All**

Condition

15 09 03 Dec. 16, 2009 **2015153** Supersedes T. B. Group 15 number 09-02 dated November 10, 2009 to revise technical diagnosis code in warranty table.

MIL ON, DTC P0087, P1093 or P2293 Stored in ECM Fault Memory

MIL ON with the following DTCs may be stored in ECM fault memory:

DTC	Description
P0087	Fuel Rail / System Pressure - Too Low
P1093	Fuel Trim 2, Bank 1 Malfunction
P2293	Fuel Pressure Regulator 2 Performance

Technical Background

Excessive wear of intake camshaft lobe that drives the high pressure fuel pump. The wear limits maximum pump piston lift, causing fuel rail pressure fluctuations.

The wear on the camshaft lobe can also lead to wear on the base of the high pressure fuel pump cam follower.

Note:

Please review with customer the importance of using proper engine oil. Use of engine oil that does not meet VW quality standards can cause premature wear to engine components. Refer to Technical Bulletin Instance 2012855 *Engine Oils Which Meet Volkswagen Oil Quality Standards VW 502 00, VW 505 01 and VW 504 00/507 00.*

Production Solution

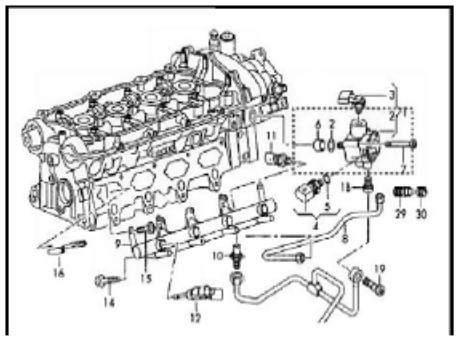
Increase surface hardening of camshaft lobe for the high pressure fuel pump. Improved intake camshafts have Part No. 06F109101B.

Service

If there are low pressure faults stored in the ECM like P310b or P129f, always diagnose low pressure faults first before diagnosing high pressure faults.

Note:

DO NOT REPLACE high pressure pump for low pressure faults.



Remove the high pressure fuel pump and visually inspect:

1. Base surface of the cam follower -6- in contact with the camshaft lobe.
2. Tip of the high pressure fuel pump plunger.
3. High pressure fuel pump camshaft lobe.

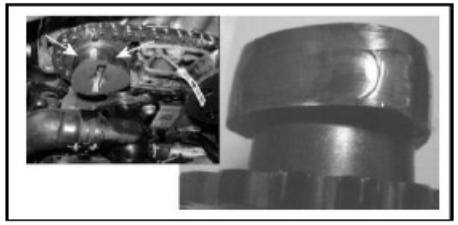
If the base of the cam shaft follower looks like -C- or -D-, **no excessive wear is present**.

Cam follower and camshaft should **NOT** be replaced.

Tip:

If excessive wear of the cam follower is found an oil change should be performed on the vehicle following the repair.

If the cam follower base surface is excessively worn so that its surface is concave -B- or missing -A-, inspect the intake cam shaft lobe for wear.



If the high pressure fuel pump camshaft lobe shows excessive wear, replace the intake camshaft with Part No. 06F109101B and the cam follower with Part No. 06D109309C, see Group 15 Engine - Cylinder head, Valvetrain in ElsaWeb.

TSI New Design

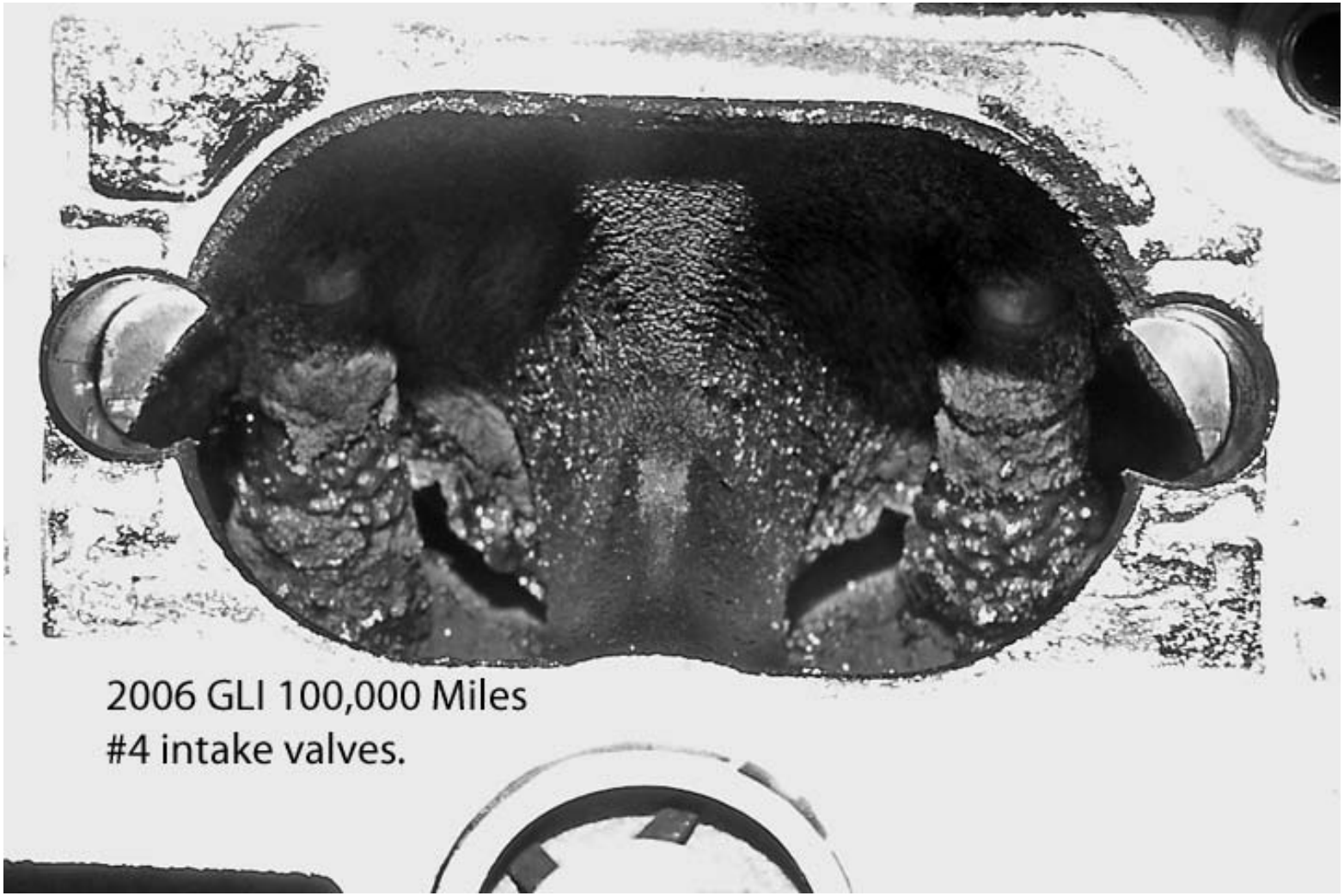
- Roller Type Follower
- Four Lobes

Fuel Pressure Sensor TSB

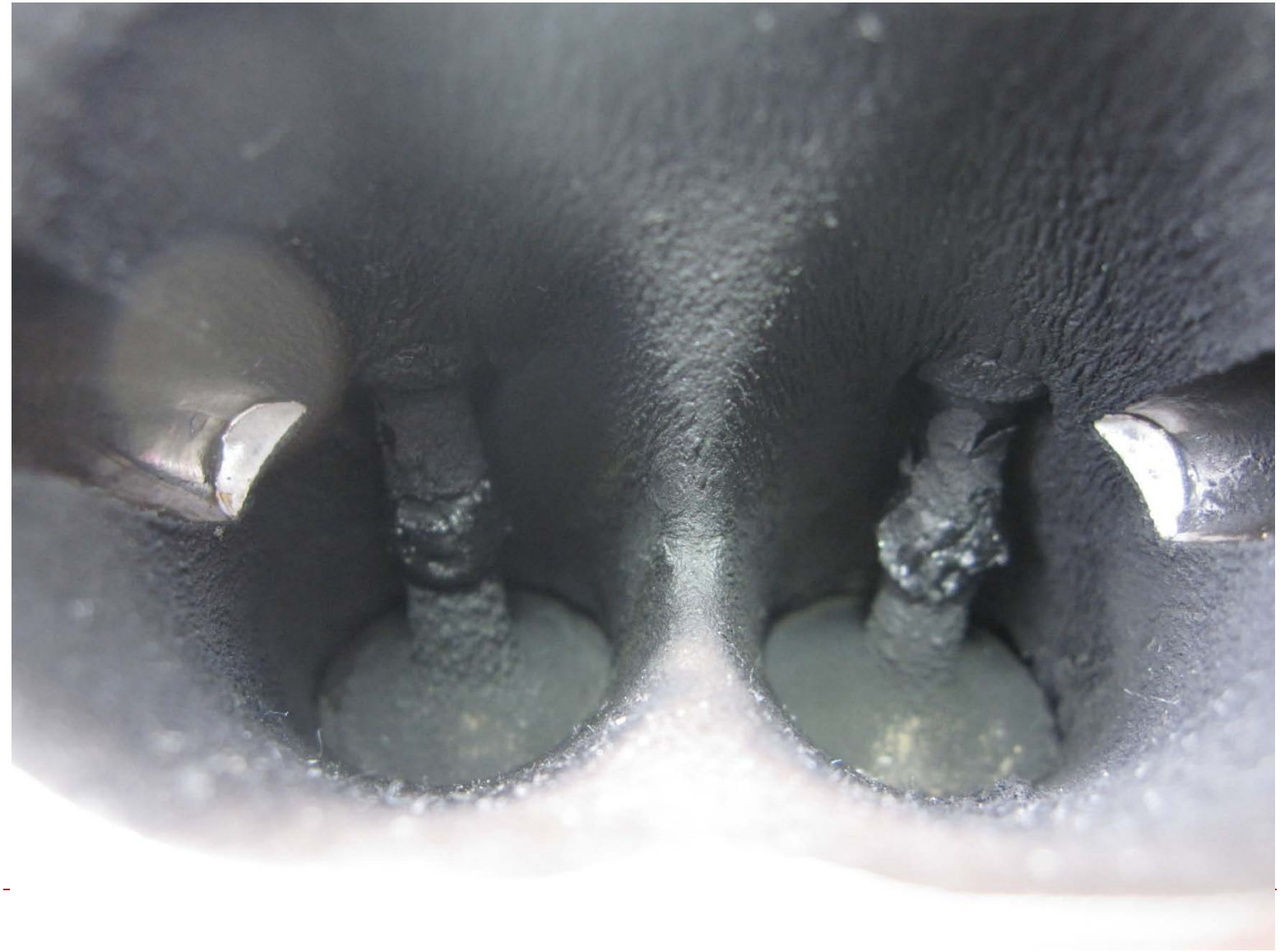
- June 7, 2010
- #2016182 Supersedes T.B. Group 01 number 07-69 dated Dec. 13, 2007 due to updated thrust sensor part number for the 2.0L T (BPY) engine.
- MIL ON, DTC P129F and or P310B Stored in ECM Fault Memory
- Due to fuel intrusion into the Low Pressure Side Fuel Pressure Sensor -G410-, a false signal may be sent to the ECM resulting in a reading that is out of tolerance. A false signal may result in illumination of the malfunction indicator lamp (MIL) and DTC P129F or DTC P310B being stored in fault memory.

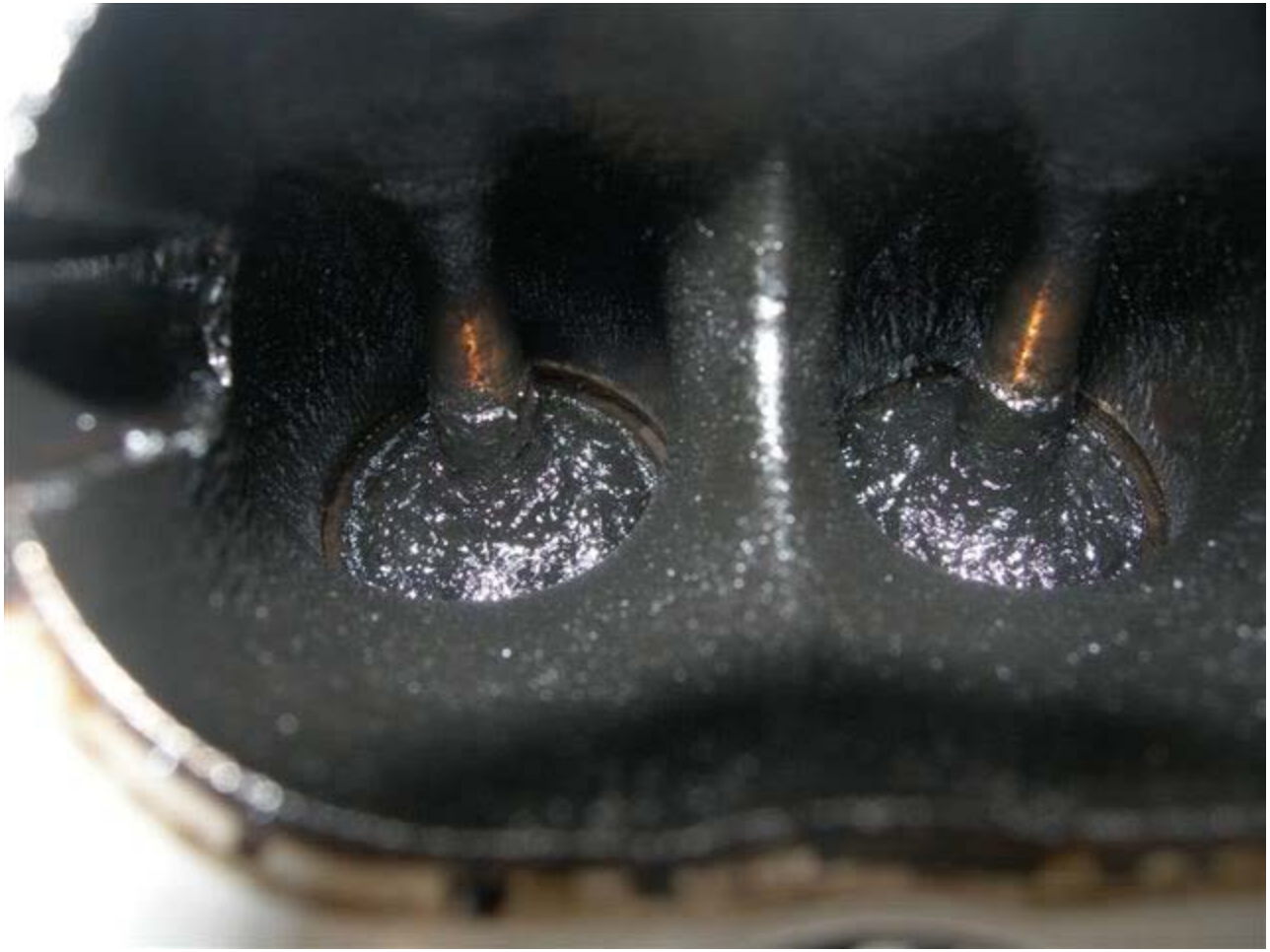
- Improved fuel pressure sensor -G410- to aid against fuel intrusion

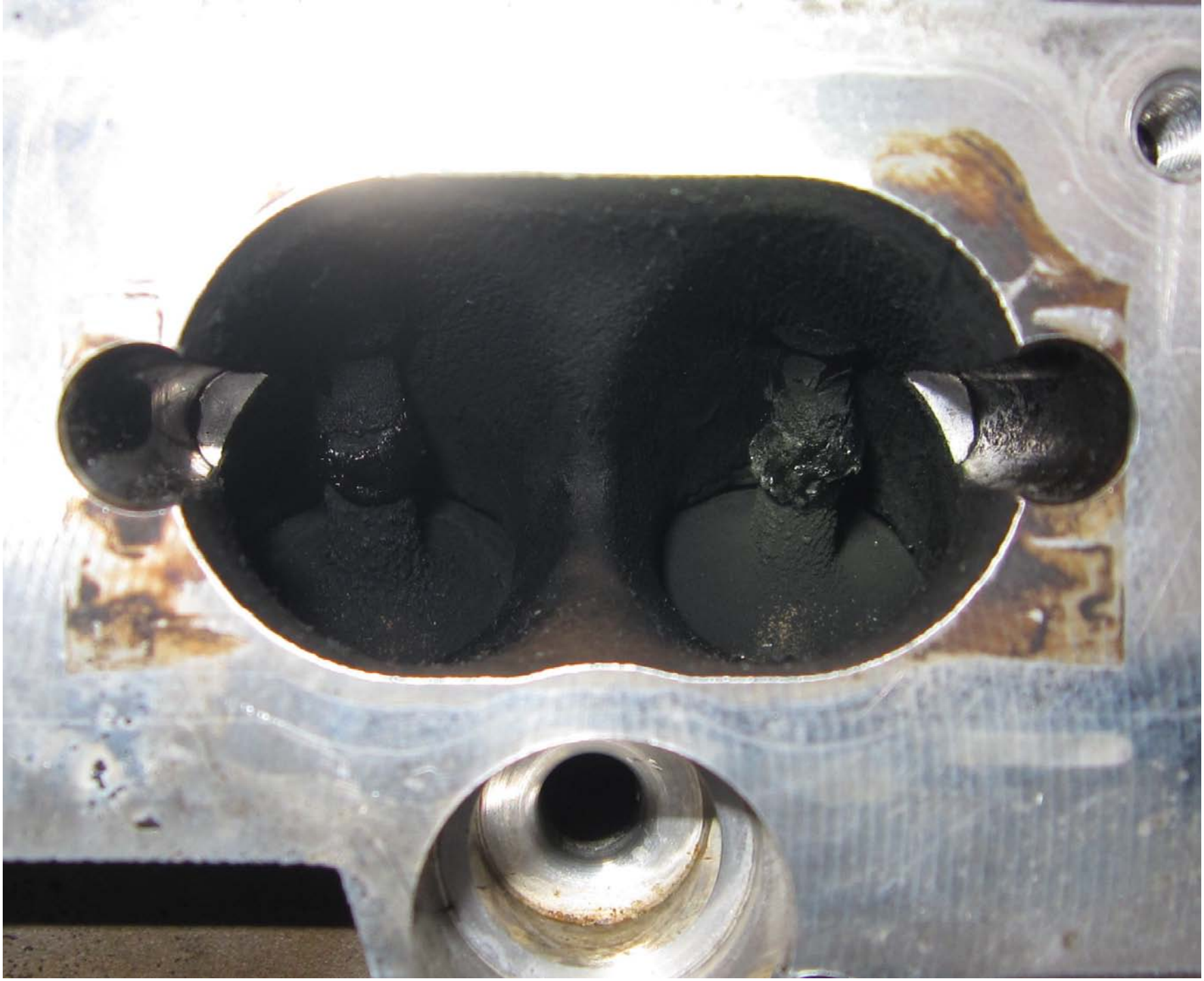
Intake Valve Deposits



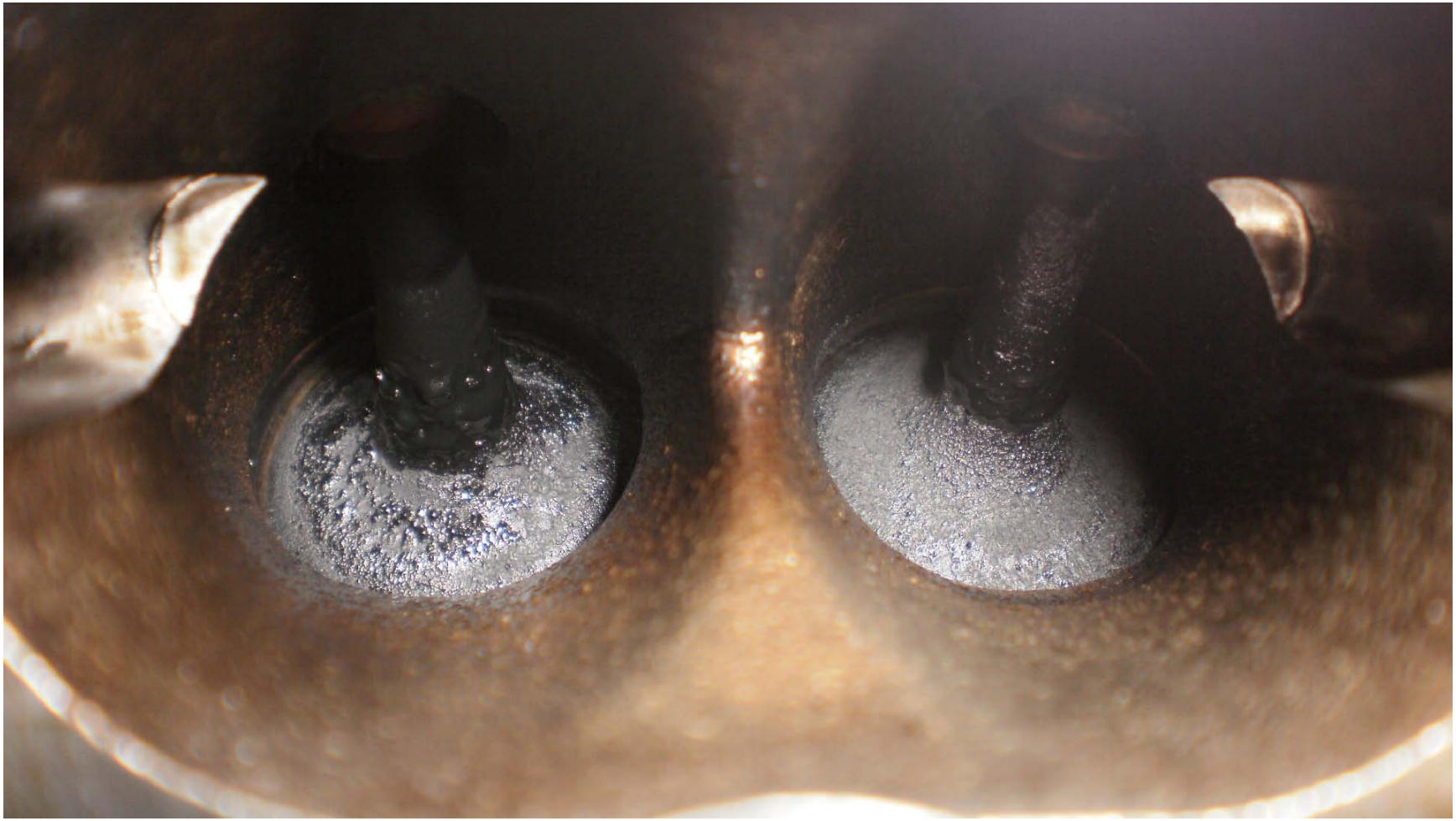
2006 VW GTI 45K Miles



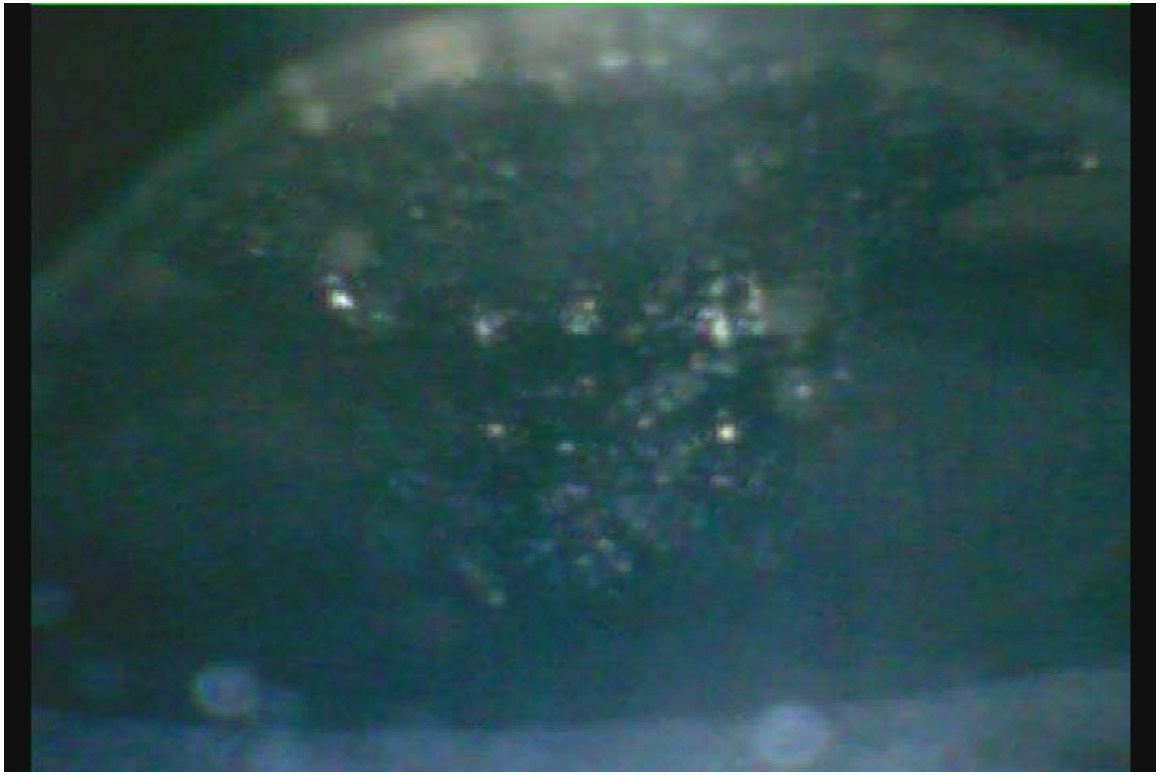




10K Miles After Cleaning



2006 Lexus IS250



2006 Lexus IS250 After Cleaning

2007 Cobalt SS 20K Miles

Lexus TSB

- **MIL "ON" DTC P030# and/or Intermittently Runs Rough**
- 2006 – 2010 IS250
- Conditions
  - MIL "ON" DTC P0300, P0301, P0302, P0303, P0304, P0305, and/or P0306.
  - Runs rough after coming to a stop with the engine at operating temperature.
  - Runs rough with engine misfires present after a cold soak startup.

MIL "ON" DTC P030# and/or Intermittently Runs Rough

Required Tools & Equipment (Continued)

TOOLS & MATERIAL	PART NUMBER	DRIVETRAIN	QUANTITY
Engine Oil	ILSAC GF-4 Multigrade SAE 5W-30	2WD	With Oil Filter Change: 6.7 U.S. quarts (6.3 liters)
			Without Oil Filter Change: 6.2 U.S. quarts (5.9 liters)
		4WD	With Oil Filter Change: 6.8 U.S. quarts (6.4 liters)
			Without Oil Filter Change: 6.3 U.S. quarts (6.0 liters)
GM - General Motors Vehicle Care Upper Engine and Fuel Injector Cleaner	GM# 88861802*	–	1

* This can be acquired from a GM dealer.

NOTE

Engine oil is changed twice per the Repair Procedure.

Inspection Procedure

1. Confirm that the condition is applicable per the Introduction.
2. Perform misfire diagnosis.

   Refer to the Technical Information System (TIS), applicable model year IS 250 Repair Manual:

   - 2006 / 2007 / 2008 / 2009 / 2010 IS 250:
     Engine/Hybrid System – Engine Control – "4GR-FSE Engine Control System: SFI System: P0300-P0306: Random / Multiple Cylinder Misfire Detected"

NOTE

Normal mechanical engine condition, engine control system, fuel supply/injection systems, and ignition system operation must be present or this TSIB does NOT apply.

3. If the concern is NOT resolved after following the Repair Manual misfire diagnosis, proceed with the repair procedure below.

NOTE FOR 2006 MY IS 250 ONLY:

BEFORE starting the repair procedure, the following MUST be confirmed:

Is the VIN applicable to TSIB No. L-SB-0088-08, *"M.I.L. 'ON' DTC P0300, P0301, P0302, P0303, P0304, P0305, or P0306"*? (Was the vehicle produced BEFORE the Production Change Effective VINs shown below?)

MODEL	DRIVETRAIN	PLANT	PRODUCTION CHANGE EFFECTIVE VIN
2006 IS 250	2WD	Kyushu	JTHBK262#62017120
	4WD		JTHCK262#62007184
	2WD	Tahara	JTHBK262#65020537
	4WD		JTHCK262#65006155

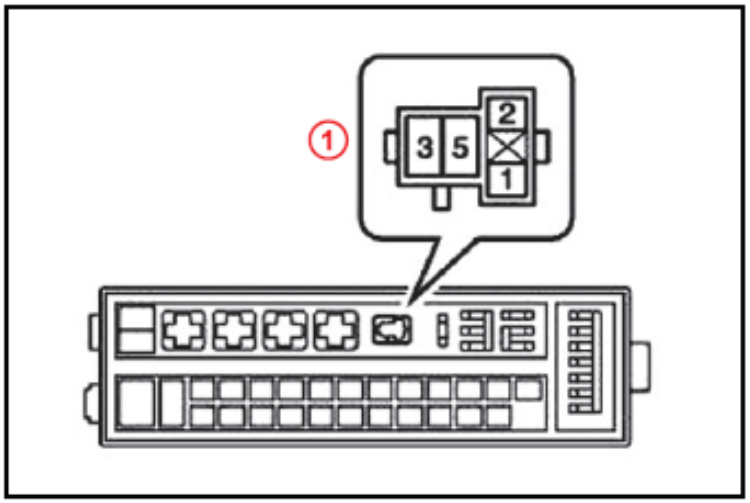
- **YES — Perform the repair outlined in TSIB No. L-SB-0088-08 *BEFORE* performing the repair noted in this Service Bulletin.**
- **NO — The VIN is NOT applicable or TSIB No. L-SB-0088-08 was already performed prior to this occurrence. Proceed to step 1 of the Repair Procedure in this bulletin.**

1. Run the engine and bring to operating temperature.
2. Remove the intake air surge tank assembly.
3. Remove all ignition coils and spark plugs.
4. Remove the starter relay.
5. Using a funnel as necessary, pour 1.0 oz of GM Upper Engine and Fuel Injector Cleaner (GM P/N 88861802) into each of the 6 cylinders via the spark plug holes.
6. Place and secure shop towels over all the spark plug tubes.
7. Crank the engine for 5 seconds using a jumper wire at the starter relay terminals 3 and 5.

NOTE

Cranking will assure even dispersal of top engine cleaner on the piston domes.

Figure 1. Engine Room No. 1 Relay Block



1	Starter Relay

8. Let the engine soak for 60 minutes.
9. Spray a generic lubricant into each bore.
10. Rotate the crank pulley clockwise 2 rotations by hand to disperse the bore lubricate.
11. Crank the engine 5 seconds to redistribute the top engine cleaner.
12. Allow 1 additional hour of soak time prior to starting the engine; proceed with reassembly during the remainder of the soak period.

13. Remove any remaining top engine clean from the combustion chamber and spark plug tubes.
14. Reinstall the spark plugs and ignition coils.
15. Reinstall the intake air surge tank assembly.
16. Drain and refill the engine oil.
17. Start the engine and immediately test drive the vehicle for 15 minutes minimum.

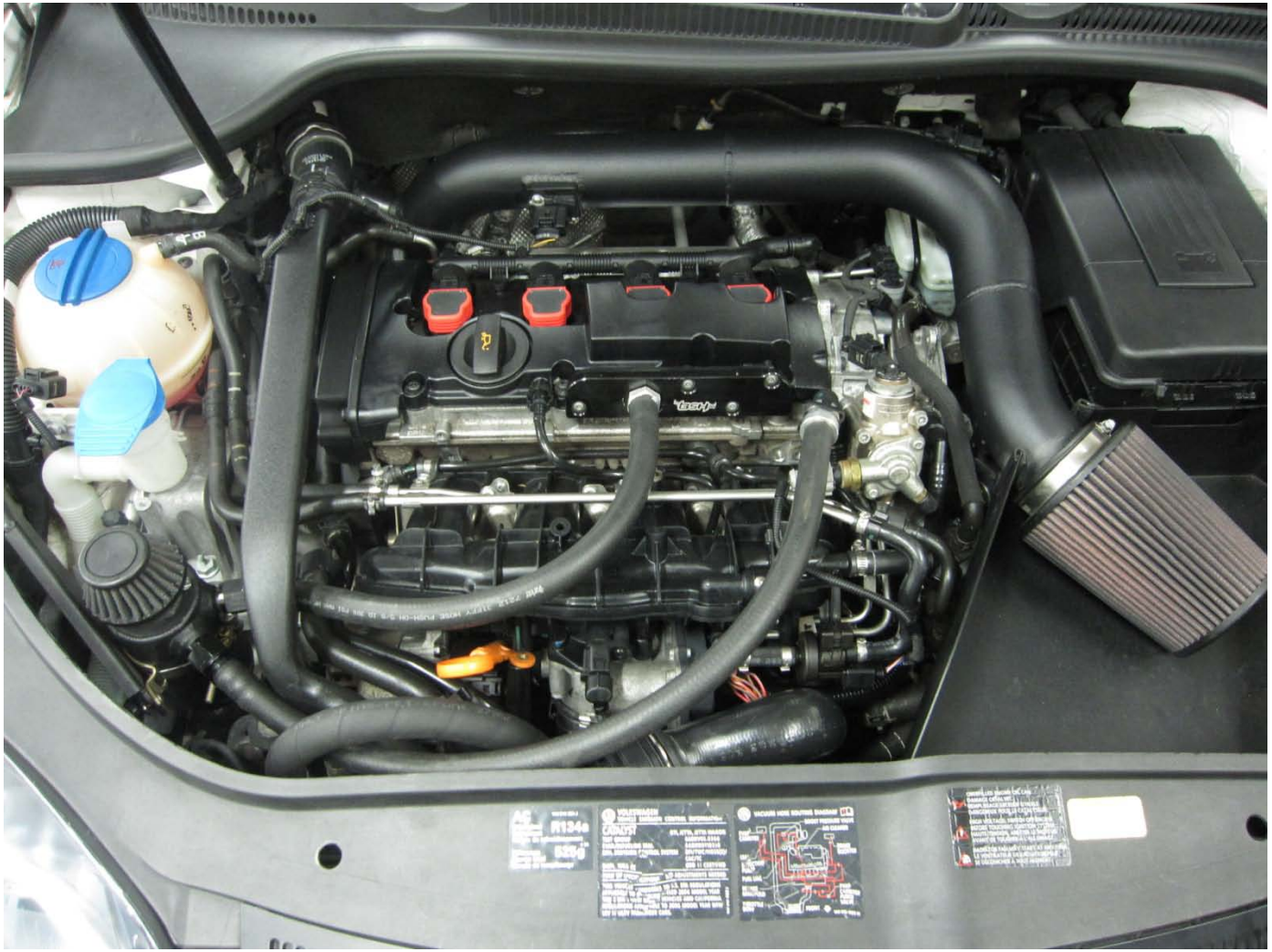
> **NOTE**
>
> **During the test drive, it is recommended to use lower gears and moderate throttle to operate the engine at an increased RPM. It is normal for smoke to be emitted from the exhaust during the first few minutes of operation.**

18. Change the engine oil and oil filter.
19. Using TIS Techstream, clear any DTCs that may have set.
20. Confirm normal vehicle operation.

Solutions

- Cleaners
  - BG's Gasoline Direct Injection Cleaner
  - Gasoline Direct Injection Service Tools, Part No. 9060
- PCV Catch Can
- Intake Valve Cleaning
  - Manifold Removal
- Cylinder Head Replacement

PCV Catch Can



*** Will Void Your Warranty***

PCV Catch Can (1 Week)

PCV Catch Can

Intake Valve Cleaning

Intake Valve Cleaning

Cylinder Head Replacement

Presentation Access

- http://opensiuc.lib.siu.edu/auto_pres/
- Google: Open SIUC