Scan Tool Data Analysis:
How to Maximize Your Scan Tools Abilities for Drivability Diagnostics

Presented by: EZ Diagnostic Solutions

Instructor Eric Ziegler

TST Seminars BIG EVENT 2025
March 29, 2025

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Scan Tools have come a long way!!

Snap on Zeus

Fast-Track® Intelligent Diagnostics Available*

Model: EEMS342 MSRP: $11,695.00

Featuring Snap-on® Intelligent Diagnostics software, ZEUS provides all the functions and repair tips you need to diagnose, repair and manage any issue.

But unlike any tool before, it practically anticipates your next move by guiding you through every step you need to find the solution, while avoiding the steps you don't.

It displays only the information that's relevant to the specific vehicle and fault code.

From Technical Service Bulletins and scanner Smart Data to SureTrack® Expert Information, ZEUS is the most sophisticated, intuitive shop management tool we've ever created.

* Access to Fast-Track Intelligent Diagnostics software requires an applicable software agreement.

I AM INTERESTED

https://www.snapon.com/display/1060/Zeus/EEMS342_v3_ZEUS.jpg

Some Scan Tool Features:

- Scan Tools are one of the best diagnostic weapons in your arsenal!
- They allow one to glean the most amount of information with least amount of effort!
- They allow us to retrieve, review and store:

1. Codes, Freeze Frames, Failure Records and Snapshots
2. Calibration and Mode 6 Data (some vehicles)
3. Data PIDS and Bidirectional Control, System Tests.
4. Networks tests and Topology
5. Allow us make movies and graph scan data!!

The Diagnostic Process

- The diagnostic process should start by asking the questions: who, what, where, when and how?
- Our job is to figure out….**Why.**
- Modern automotive systems are complex and require a logical or deductive path to diagnose.
- You need a sound game plan to guide you!

Game Plan

- The key to resolving any problem is having a game plan ready and established.
- Get as much info as possible with the least amount of effort.
- Make your strategy repeatable on the majority of the vehicles you service.

"If you fail to plan, you are planning to fail!"
— Benjamin Franklin

1. Verify the complaint or conditions
2. Understand System
   - Research: Description and Operation
     Wiring Diagrams
     Flowcharts and any code criteria
     TSBs and Pattern Failures
3. Diagnostic Starting Point
   -Check base electrical system
     Battery load test and SOC
     Connections
   Scan Tool- (preferable one that graphs)
   - Is communication possible?
   - Codes- Status: Current, History, Pending or 1 Trip?
   - FF's and Monitors
   - Check Calibration IDs and Mode 6 info (if applicable)
   - Look at data PIDs before Starting
   - Set up and be prepared to make snapshot or movie

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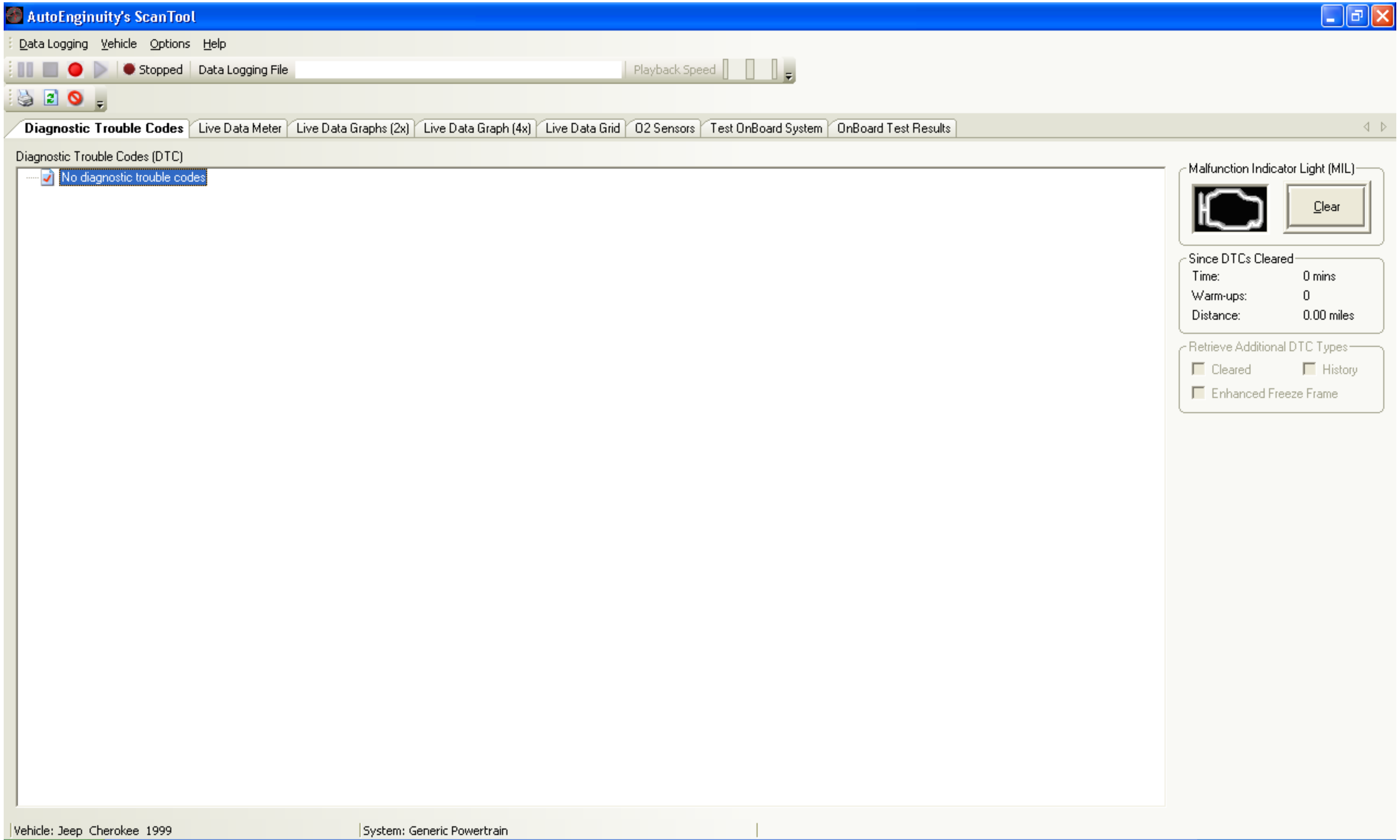
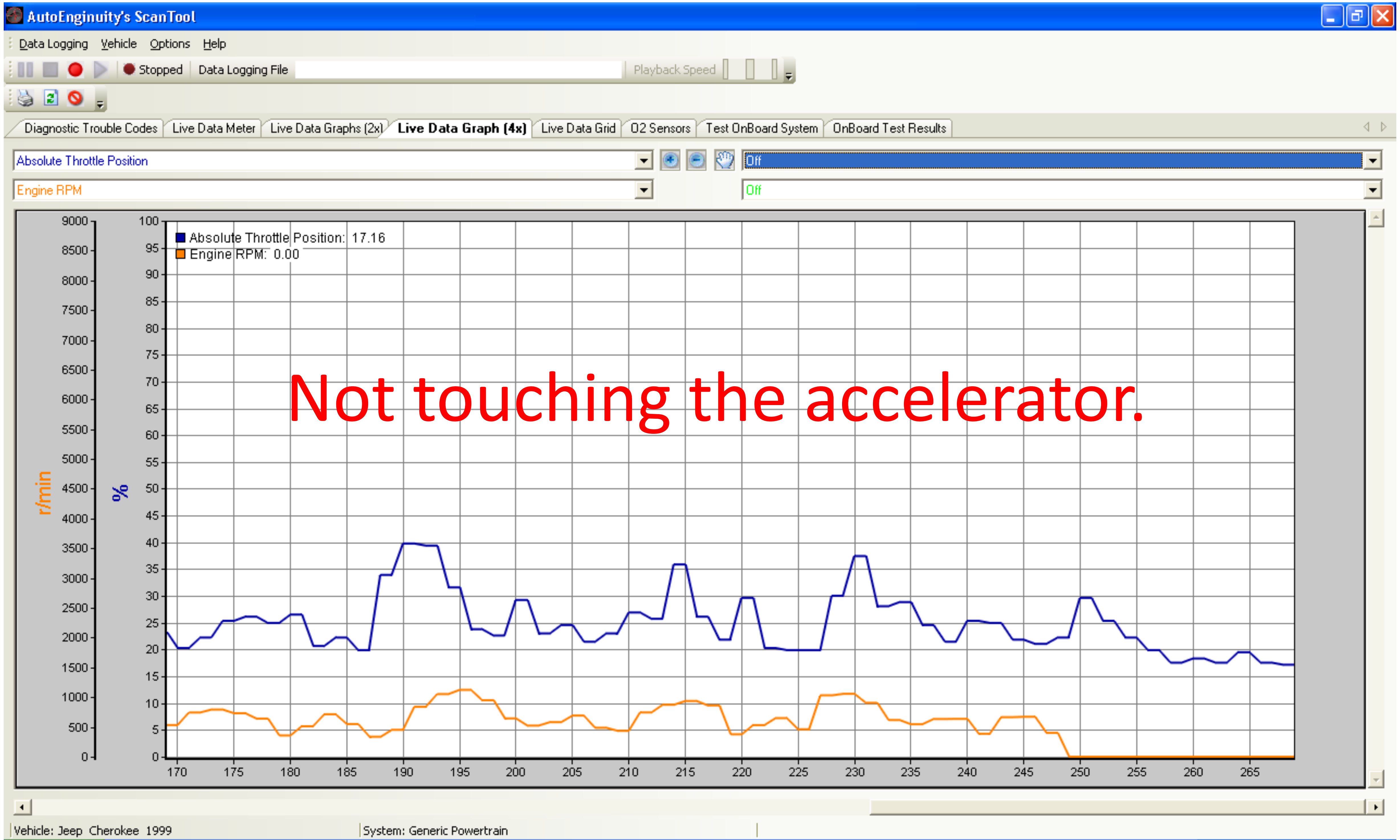
1999 Jeep Grand Cherokee
4.7 L

Surges/dies @ idle

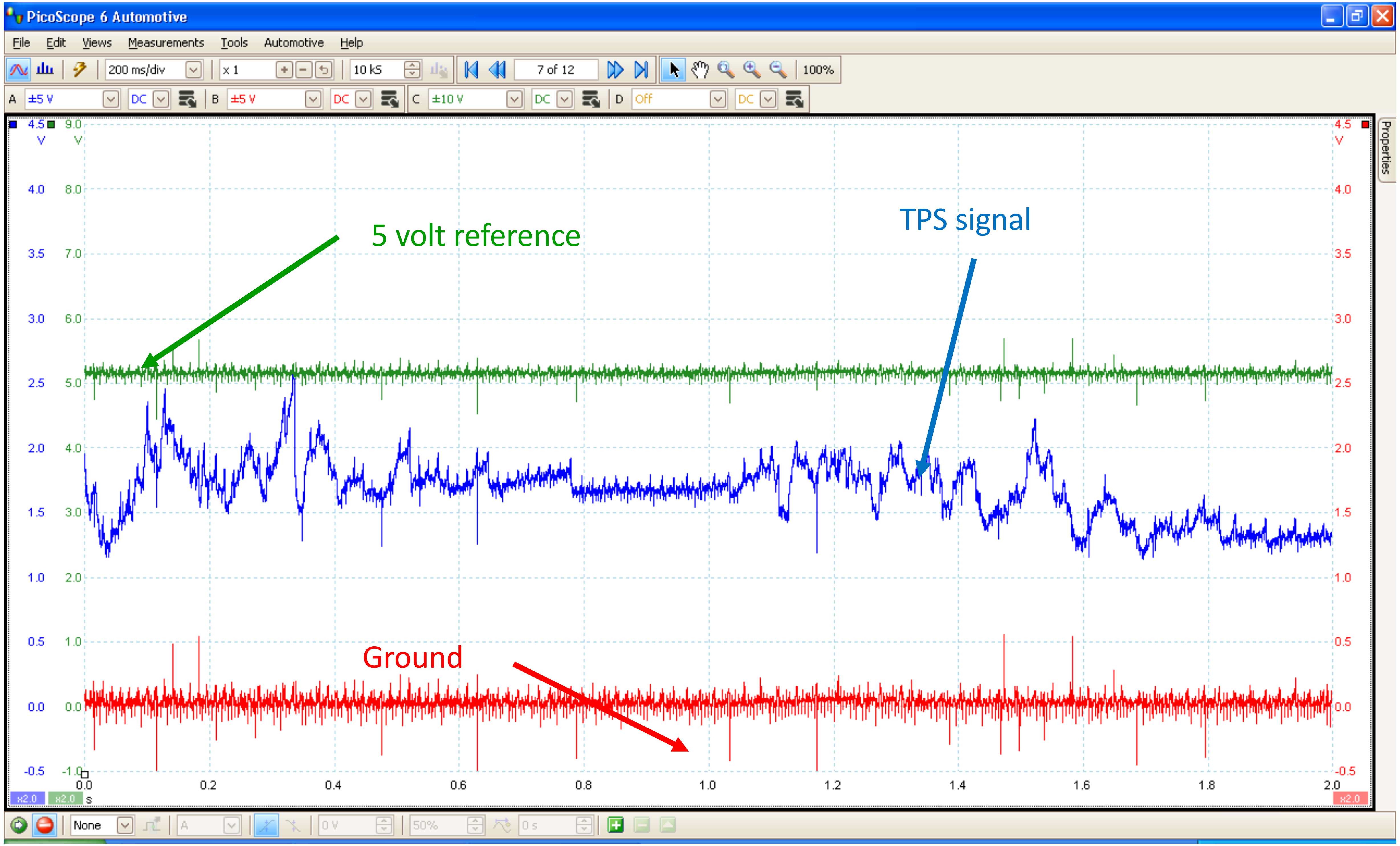
No MIL


AutoEnginuity's ScanTool
Data Logging
Vehicle
Options
Help
Stopped
Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
Diagnostic Trouble Codes (DTC)
No diagnostic trouble codes
Malfunction Indicator Light (MIL)
Clear
Since DTCs Cleared
Time: 0 mins
Warm-ups: 0
Distance: 0.00 miles
Retrieve Additional DTC Types
Cleared
History
Enhanced Freeze Frame
Vehicle: Jeep Cherokee 1999
System: Generic Powertrain

Sensor Name	Value	Units
Calculated Load	2	%
Coolant Temperature	187	F
Short Term Fuel Trim Bank One	0.00	%
Long Term Fuel Trim Bank One	-24.96	%
Intake Manifold Absolute Pressure	8.9	in.hg
Engine RPM	929	r/min
Vehicle Speed	0	MPH
Ignition Timing Advance for #1	21.0	deg
Intake Air Temperature	127	F
Absolute Throttle Position	38	%
B1S1 O2 Sensor Output Voltage	1.140	V
B1S1 O2 Sensor Fuel Trim	0.00	%
B1S2 O2 Sensor Output Voltage	1.080	V
B1S2 O2 Sensor Fuel Trim	99.06	%



AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File Playback Speed
Diagnostic Trouble Codes Live Data Meter Live Data Graphs (2x) Live Data Graph (4x) Live Data Grid O2 Sensors Test OnBoard System OnBoard Test Results
Absolute Throttle Position
Engine RPM
Off
Off
Absolute Throttle Position: 17.16
Engine RPM: 0.00
Not touching the accelerator.
r/min
%
Vehicle: Jeep Cherokee 1999
System: Generic Powertrain



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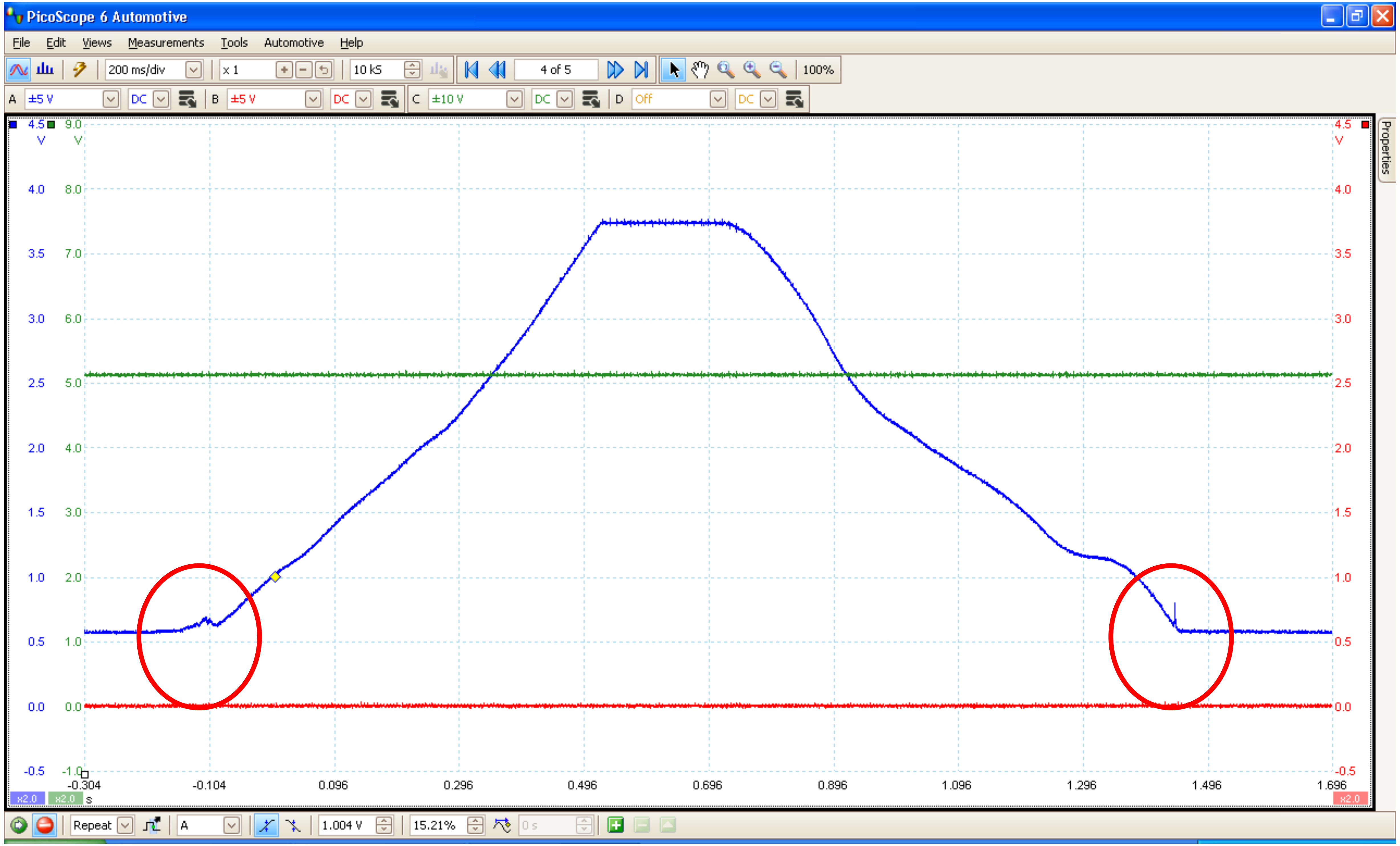
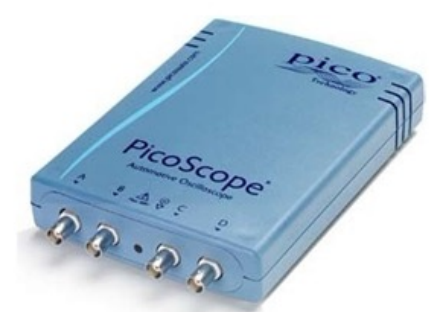

PicoScope 6 Automotive
File Edit Views Measurements Tools Automotive Help
200 ms/div
x 1
10 kS
4 of 5
100%
A ±5 V DC B ±5 V DC C ±10 V DC D Off DC
Repeat
A
1.004 V
15.21%
0 s
Properties
-0.304 -0.104 0.096 0.296 0.496 0.696 0.896 1.096 1.296 1.496 1.696
s
x2.0

So what did we just do?

- Phase I
  - Verify Complaint
  - Gather scan data/info
  - Analyze available info to narrow down potential faults
- Phase II
  - Perform testing to backup conclusions from Phase I
  - Come to a concrete conclusion of actual fault
- Today we will concentrate on Phase I

Which is the Most Powerful Diagnostic Tool in Your Toolbox?



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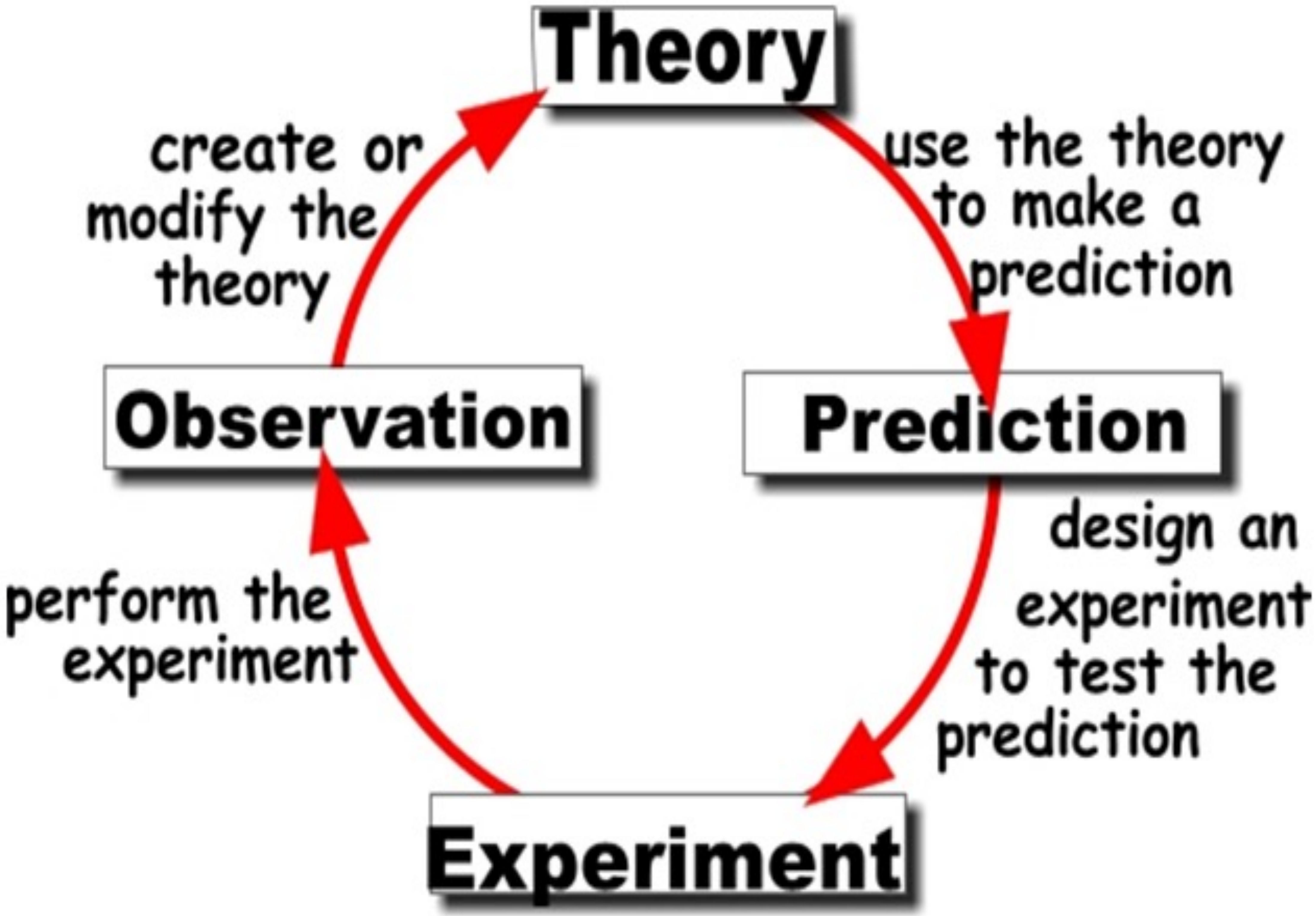
YOU are the most powerful tool!!

Ideas

- Gather as much scan data as possible early in the diagnosis
- Use your mind to eliminate potential causes of failure
- Avoid potentially time consuming tests that may be unnecessary to diagnose the actual fault
- Do as much of this as possible before popping the hood and getting dirty


Theory
use the theory to make a prediction
Prediction
design an experiment to test the prediction
Experiment
perform the experiment
Observation
create or modify the theory

How do we do this?

- Have a plan of attack
- Look at the big picture
  - then you can see the small one
- I know it is cliché, but “Work Smarter Not Harder.”

Lazy

la-zy

adjective

unwilling to work or use energy.

Efficient

ef-fi-cient

adjective

achieving maximum productivity with minimum wasted effort or expense.

How do we accomplish PHASE I?

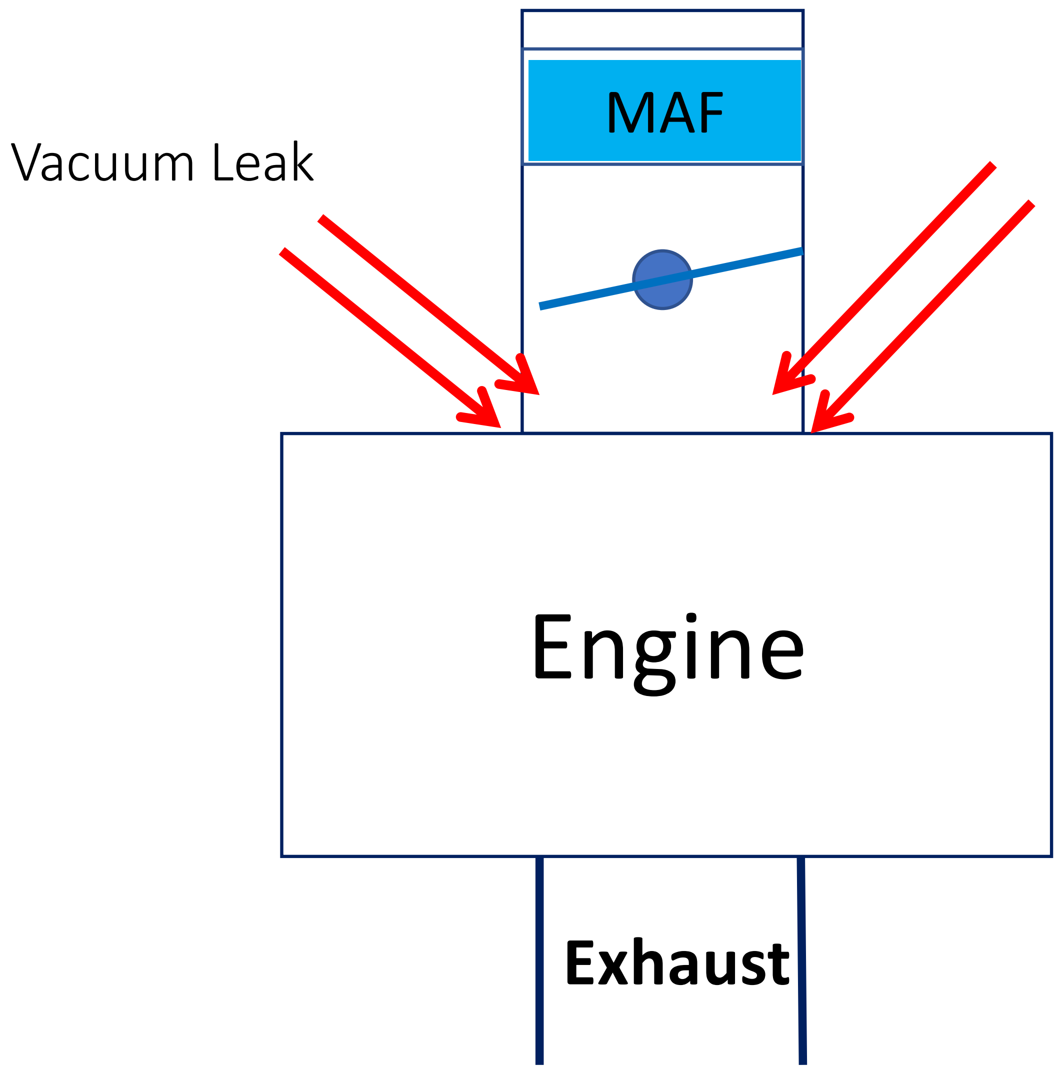
- Verify the customer complaint
- Test drive
- Hook up a scan tool code or not

- Be aware of the tools you are using and the vehicles you are working on

Scan Tool Data Analysis

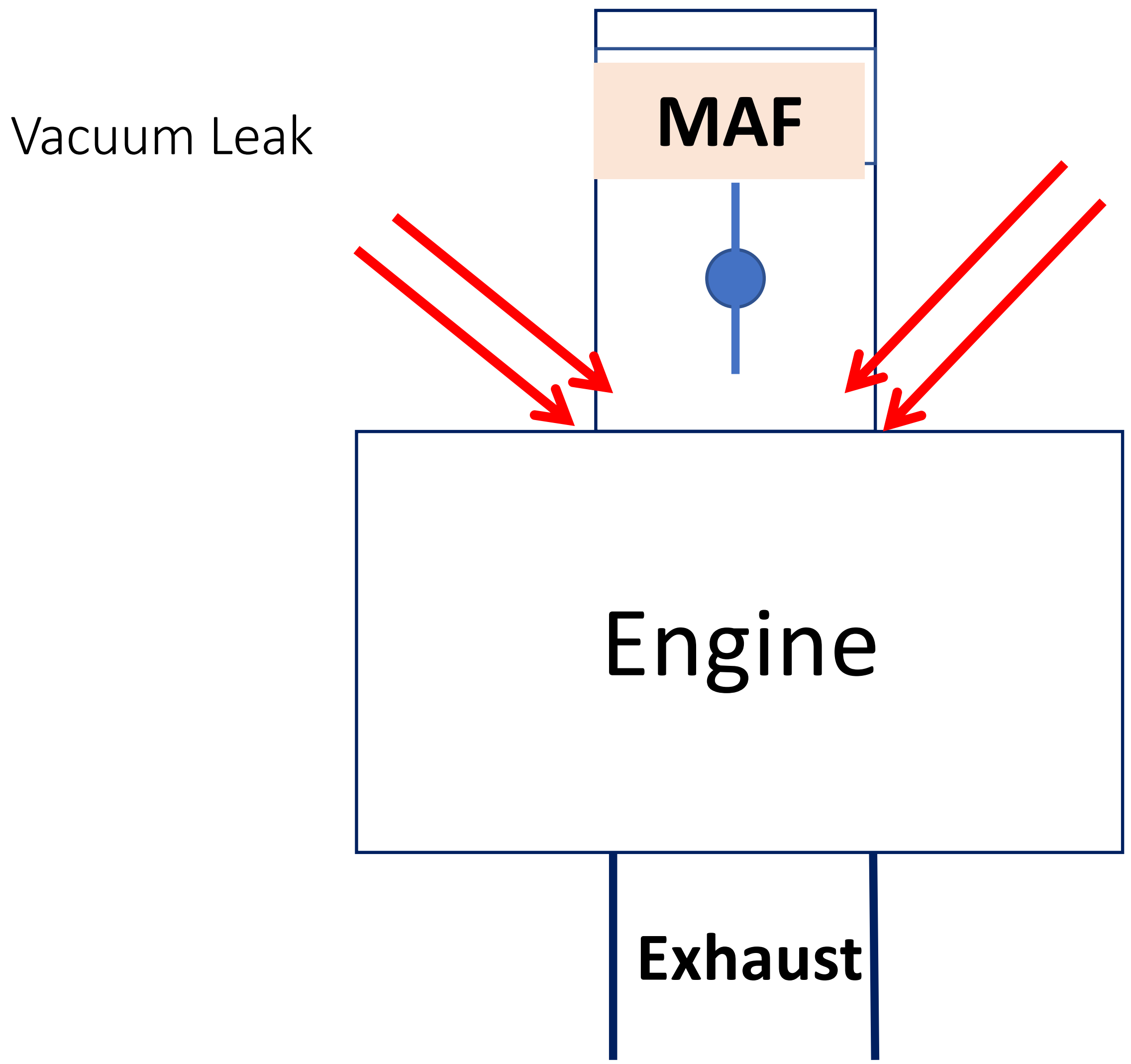
- Lean Codes
  - Scan Tool?
  - A logical Approach
- Misfire Analysis
  - Scan Tool?
  - A Logical Approach
- Low Power
  - Scan Tool?
  - A Logical Approach

Vacuum Leak



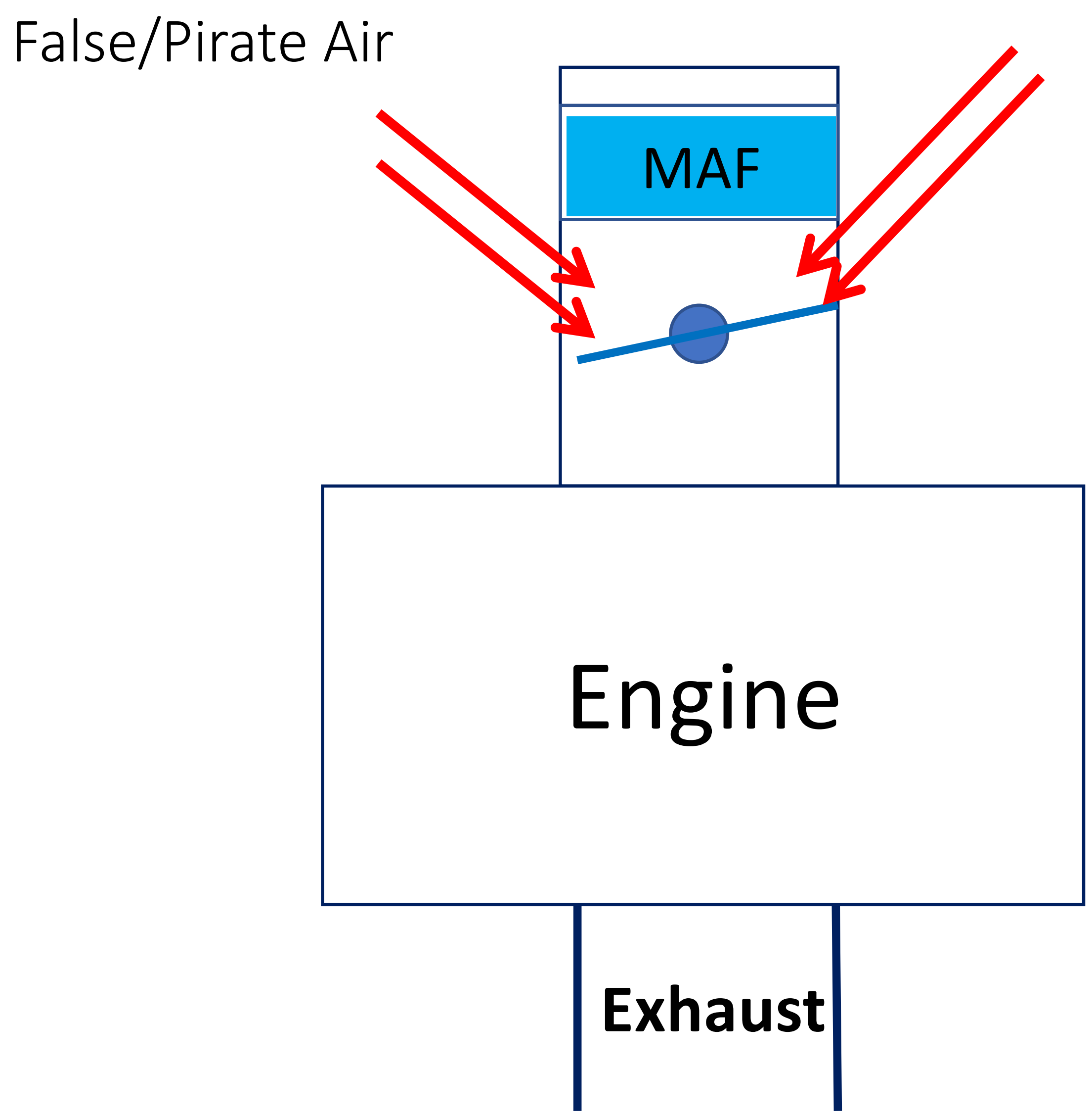
- Air that enters the engine that the MAF cannot measure
- The leak is greater percentage of air flow at idle
- The leak is on the intake side of the throttle blade

Vacuum Leak



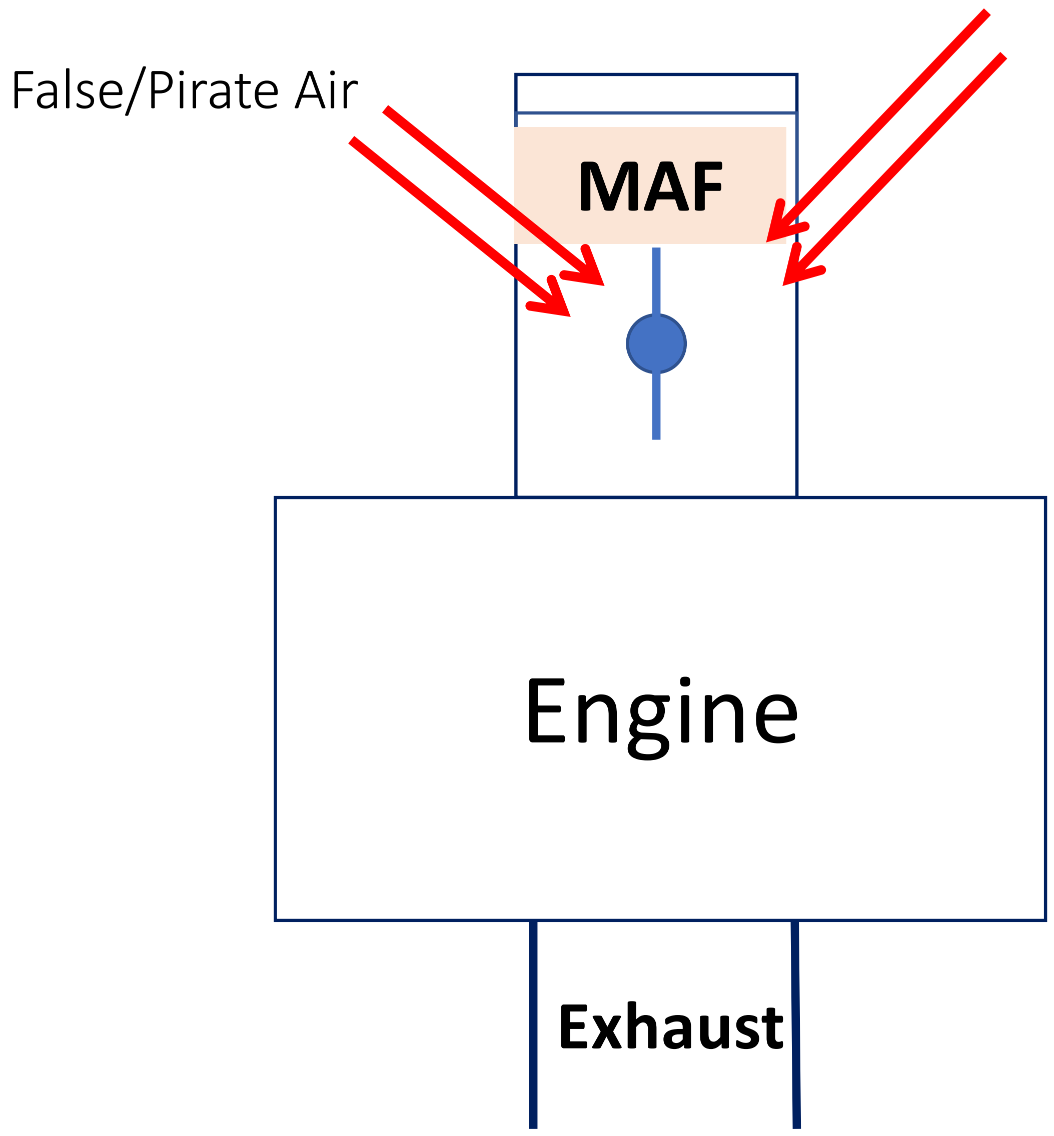
- As the throttle blade opens the measurement error decreases
- The leak is now the smaller percentage of the total air mass entering the engine

False/Pirate Air

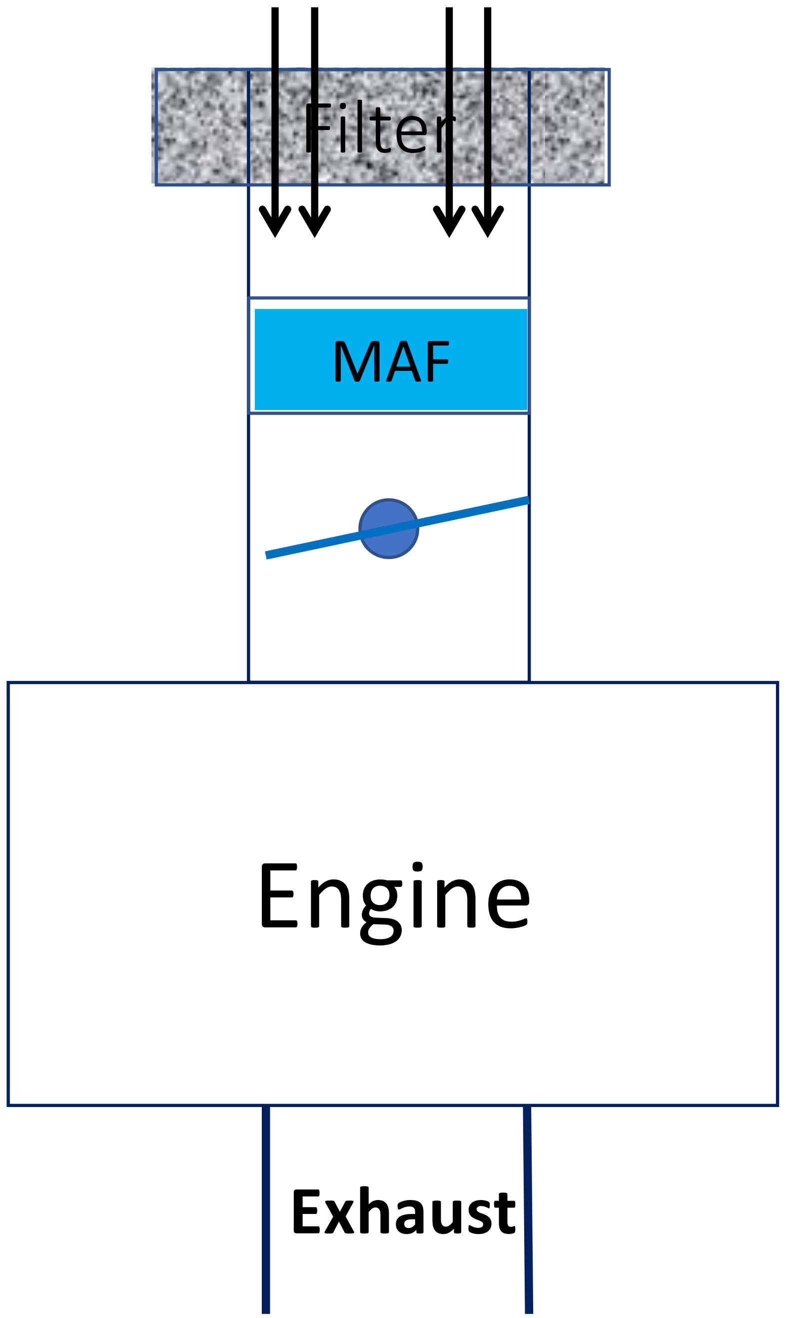


- Air that enters the engine that is not measured but is not a vacuum leak
- Measurement error at idle can be great

False/Pirate Air



- When the throttle blade open the measurement error may or may not diminish
- This can **really** mimic a failed MAF sensor



Disruption in Airflow

- Normal airflow should flow in parallel layers. This is referred to as laminar flow.

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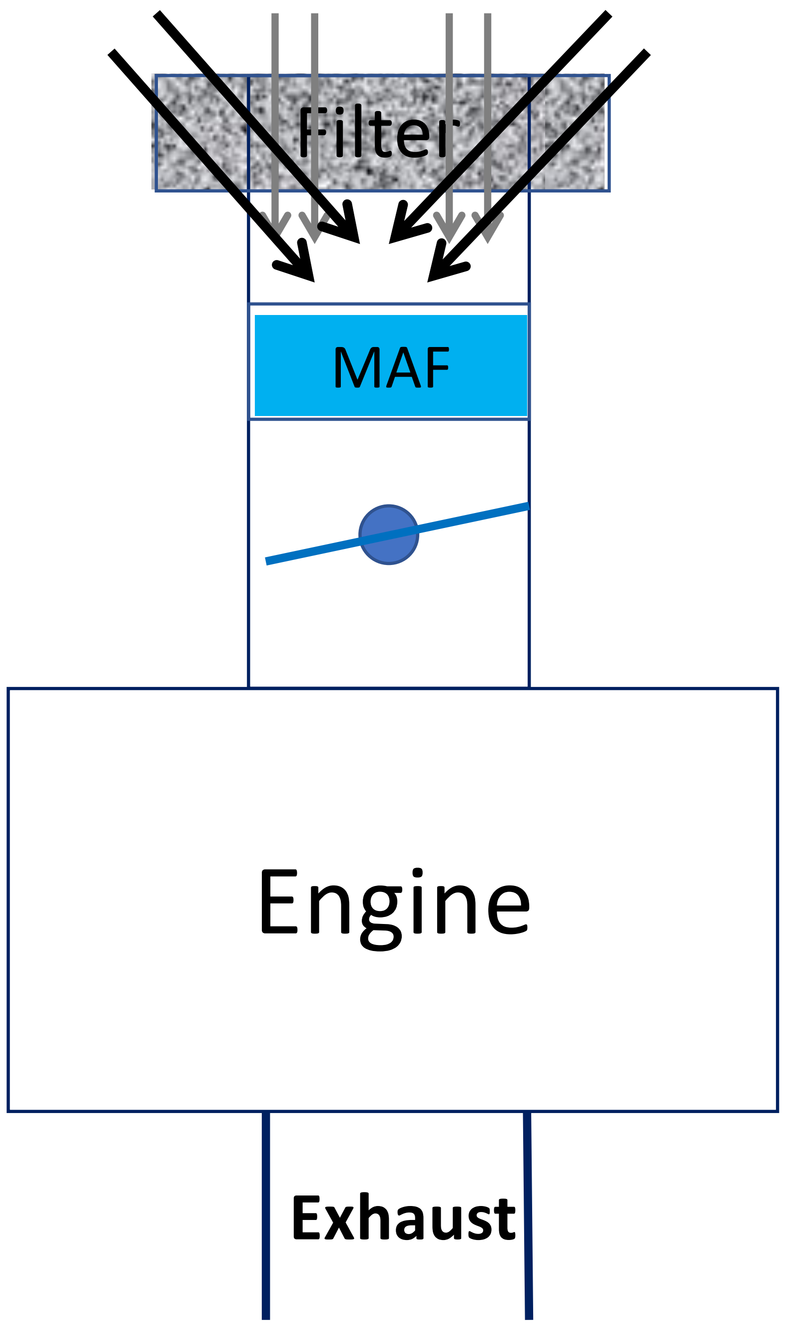
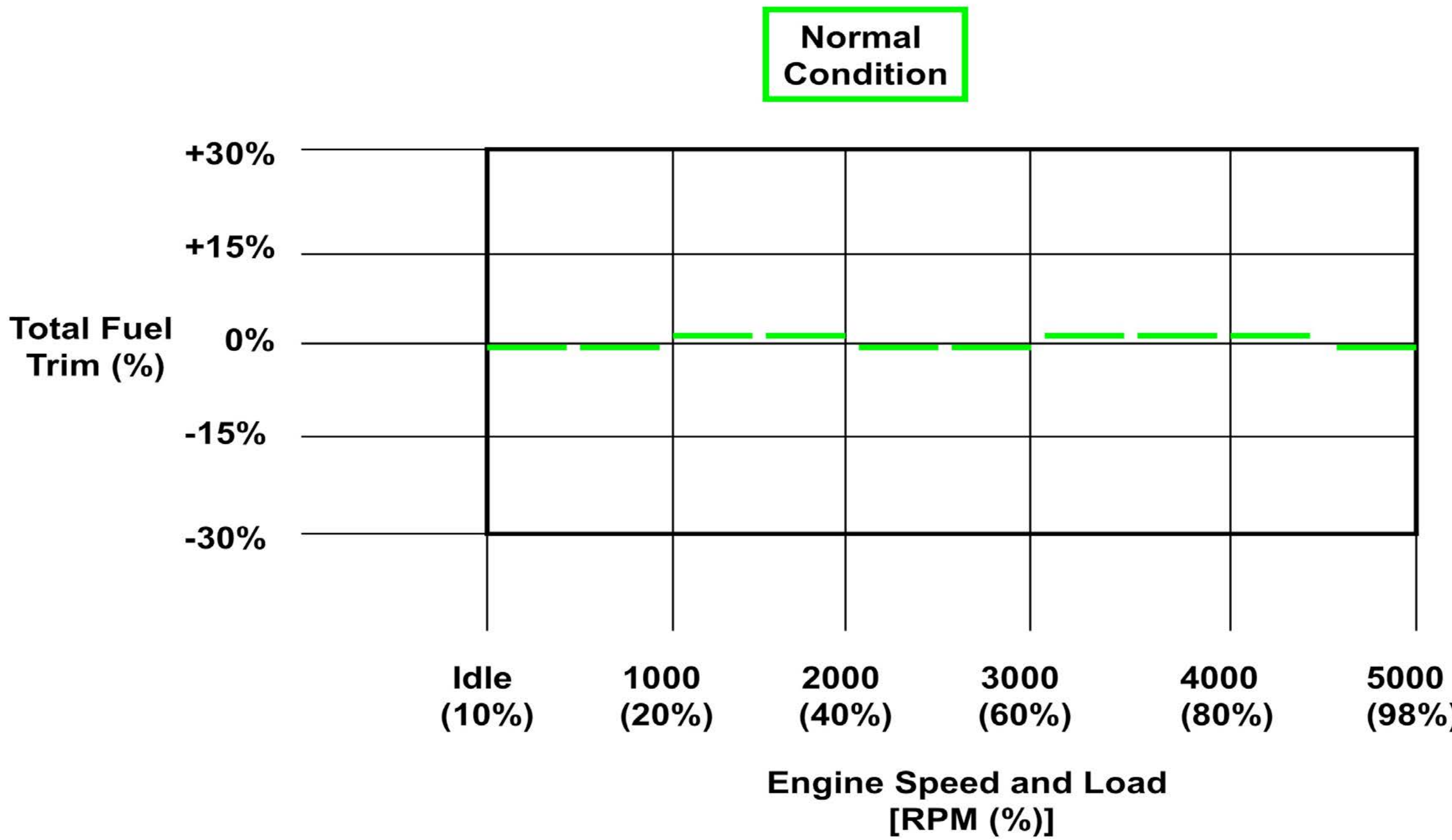


Disruption in Airflow

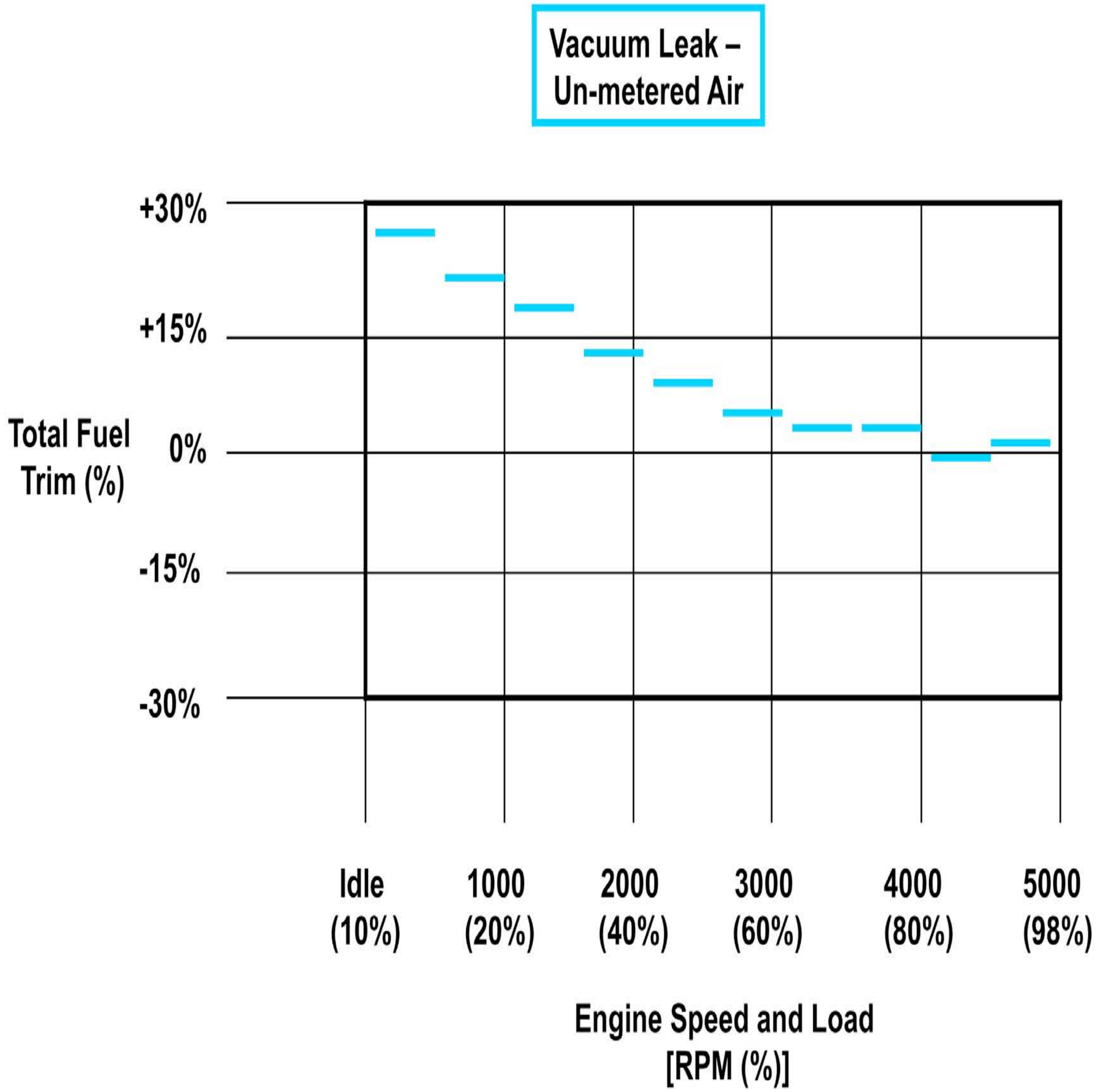
- Any deviation in airflow i.e. poorly sealed filter, warped filter housing, incorrect or no filter can all affect how the MAF sensor measures air mass entering the engine

Normal FT Corrections



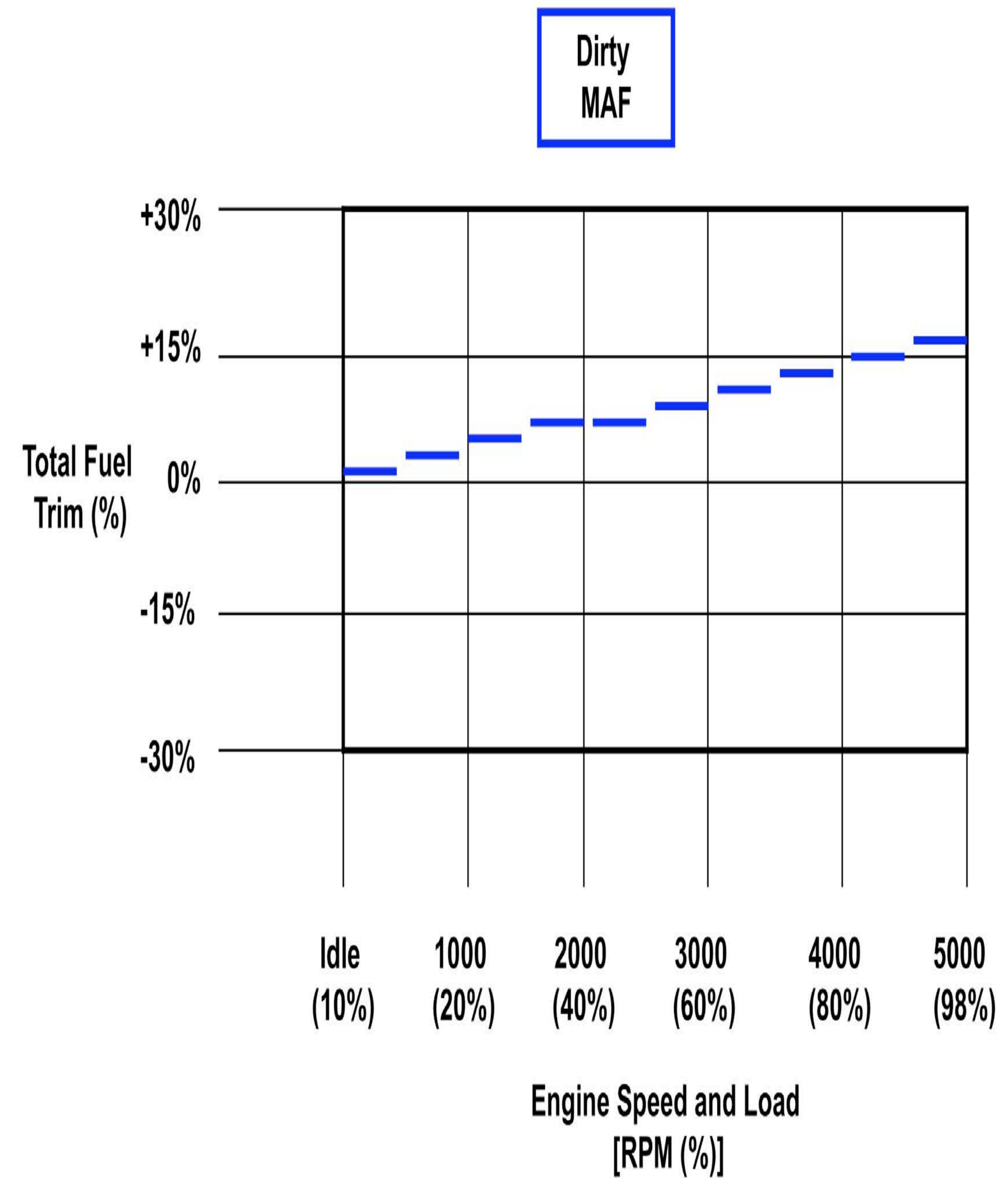
Diagnosing a Vacuum Leak on a MAF System

- Fuel trim can be used to diagnose vacuum leaks on a mass air system.
- Idle speed drops or the engine stalls on a mass air system because the fuel system is lean.
- At idle FT correction is high (+) and decreases as the throttle blade opens.

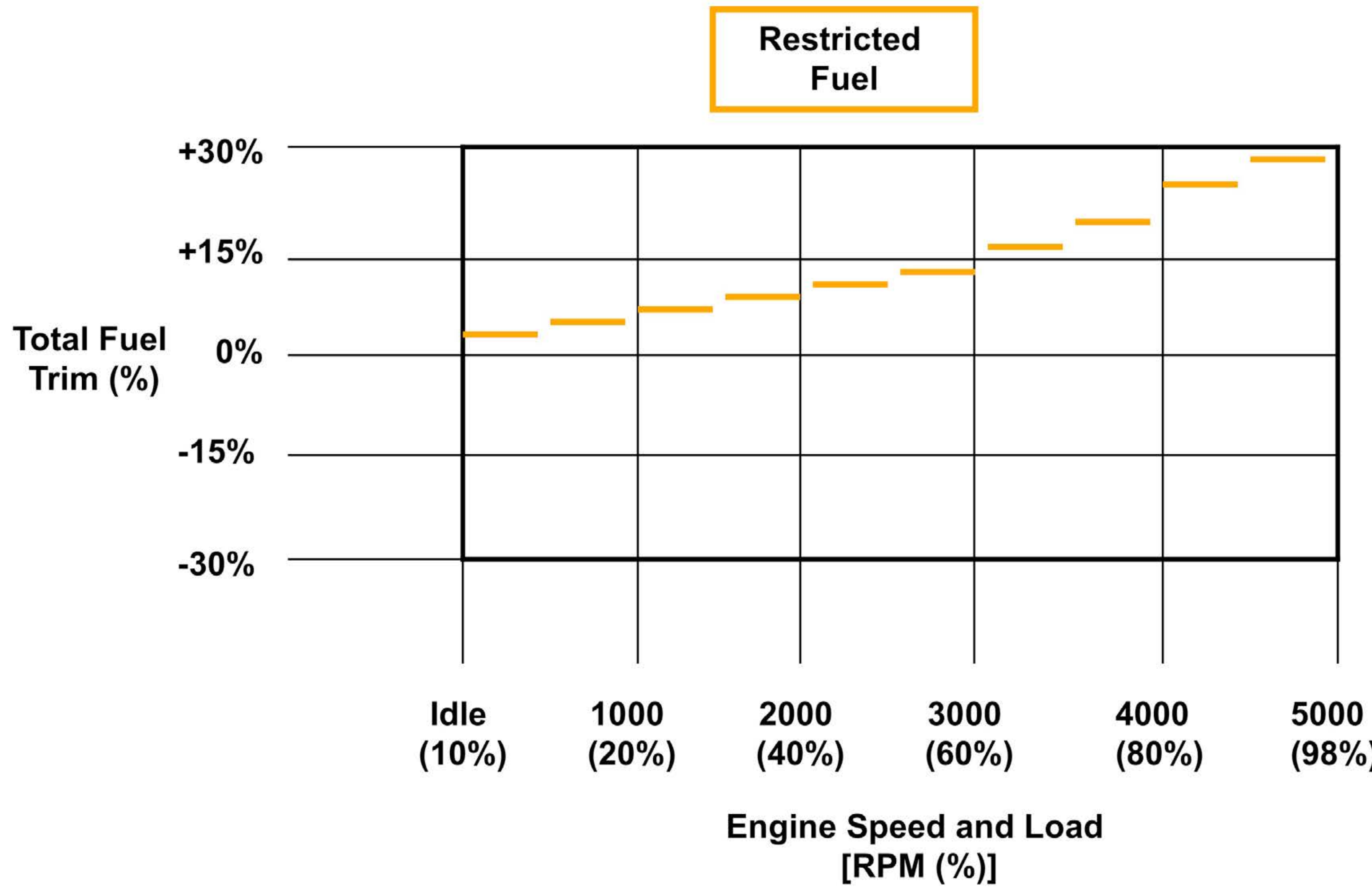


MAF Contamination

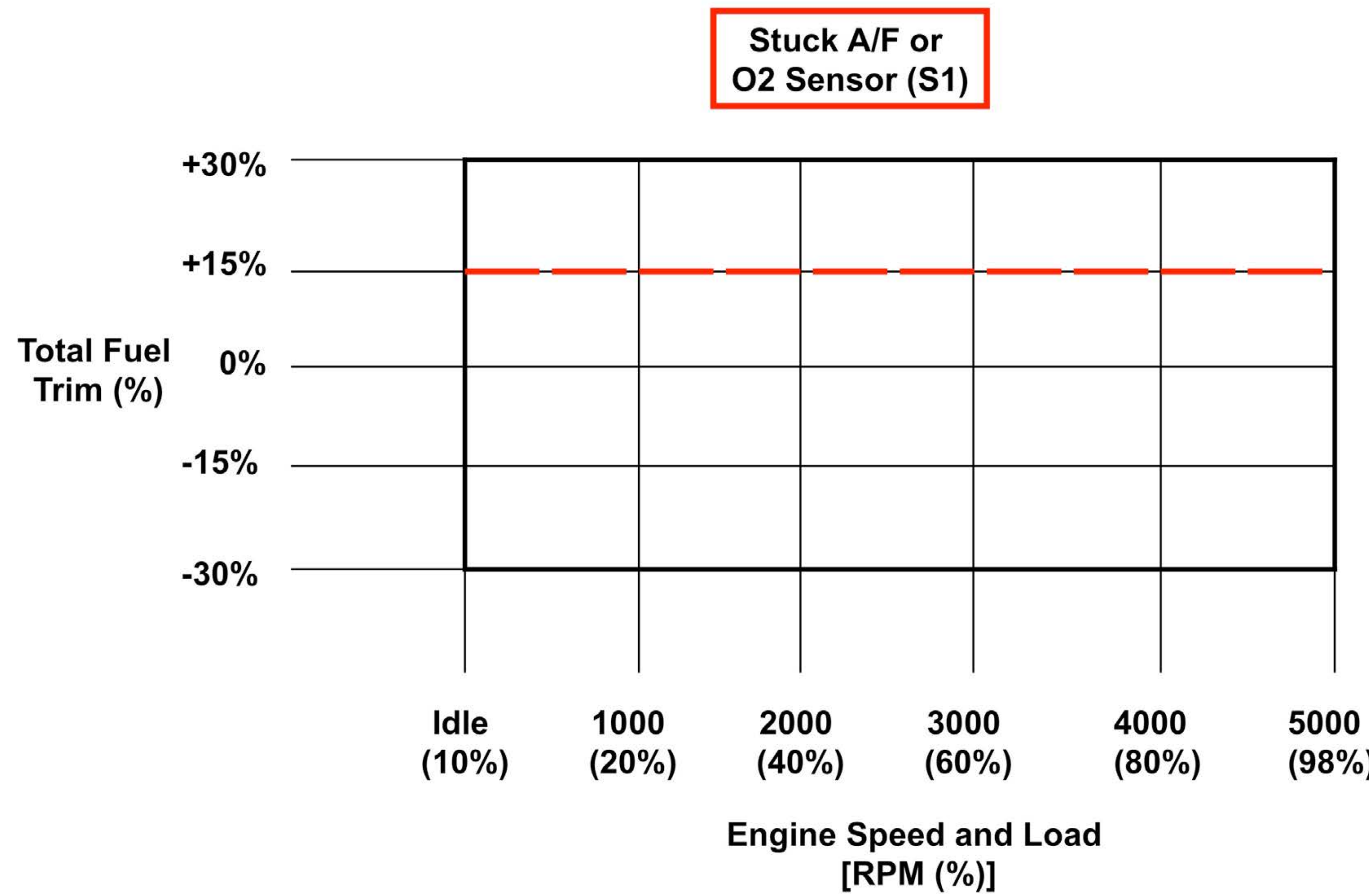
- Dirty MAFs tend to overestimate air mass @ idle and underestimate under load (typically)
- FT's usually "follow" the throttle because of the error in estimation
- Cleaning MAFs may give some temporary benefit but replacement is the real repair.



Restricted Fuel



A/F or O2 Sensor Failure



P0171/P0174

Fuel System Lean Codes

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Suggested Technique: Lean Codes

1. Check TSB's
2. Record Codes and Freeze Frame Data
3. Verify O2 sensor operation and exhaust integrity
4. Look at live data during a test drive (include a WOT portion)
5. Note following information:
    1. Fuel Trim Numbers
    2. Load PID and/or VE
6. Choose an area to focus testing efforts (Cheat Sheet)

Lean Code Cheat Sheet

Suspect Condition	Fuel Trims (Total Correction)			Fuel Trim Notes:	Load PID/ VE (@WOT)	Possible driveability characteristics
	Idle	2500 RPM	Loaded			
Vacuum Leak	Positive	Closer to Normal	Normal	Trims get better as RPM and Load increase	Normal	May have poor idle especially cold/open loop. Normal driving conditions could appear OK.
Low fuel volume	Normal or Positive	Positive	Positive	Trims can start normal or positive, but get worse as RPM, and especially load, increase. Degree of positive depends on how poor the fuel volume is.	Normal	May have low power, worse at WOT. May have starting problems such as a long crank time.
Air Metering	Close to Normal	Positive	More Positive	Trims can start negative, normal or positive but get worse as RPM and load increase	Poor	May have low power, worse at WOT.
Wrong fuel (too much ethanol)	Positive	Positive	Positive	Trims will be equally positive under all conditions	Normal	May have starting issues. Runs worse in open loop.

2001 Chevy Suburban 5.3 L

P0171 and P0174

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Initial Checks:

- No TSB's
- Exhaust integrity verified
- O2 sensors operating correctly

Freeze Frame (Frame 0)

- Absolute Throttle Position: 0 %
- Air Flow Rate From Mass Air Flow Sensor: 0.77 lb/min
- Coolant Temperature: 194 F
- Engine RPM: 697 r/min
- Fuel System Status Bank One: Closed Loop
- Fuel System Status Bank Two: Closed Loop
- Intake Manifold Absolute Pressure: 9.4 in.hg
- Long Term Fuel Trim Bank One: 15.60 %
- Long Term Fuel Trim Bank Two: 16.38 %
- Short Term Fuel Trim Bank One: -3.90 %
- Short Term Fuel Trim Bank Two: -3.90 %
- Vehicle Speed: 7 MPH

Running – Live Data

Sensor Name	Value	Units
Short Term Fuel Trim Bank One	3.90	%
Long Term Fuel Trim Bank One	24.96	%
Short Term Fuel Trim Bank Two	5.46	%
Long Term Fuel Trim Bank Two	24.96	%
Engine RPM	544	r/min

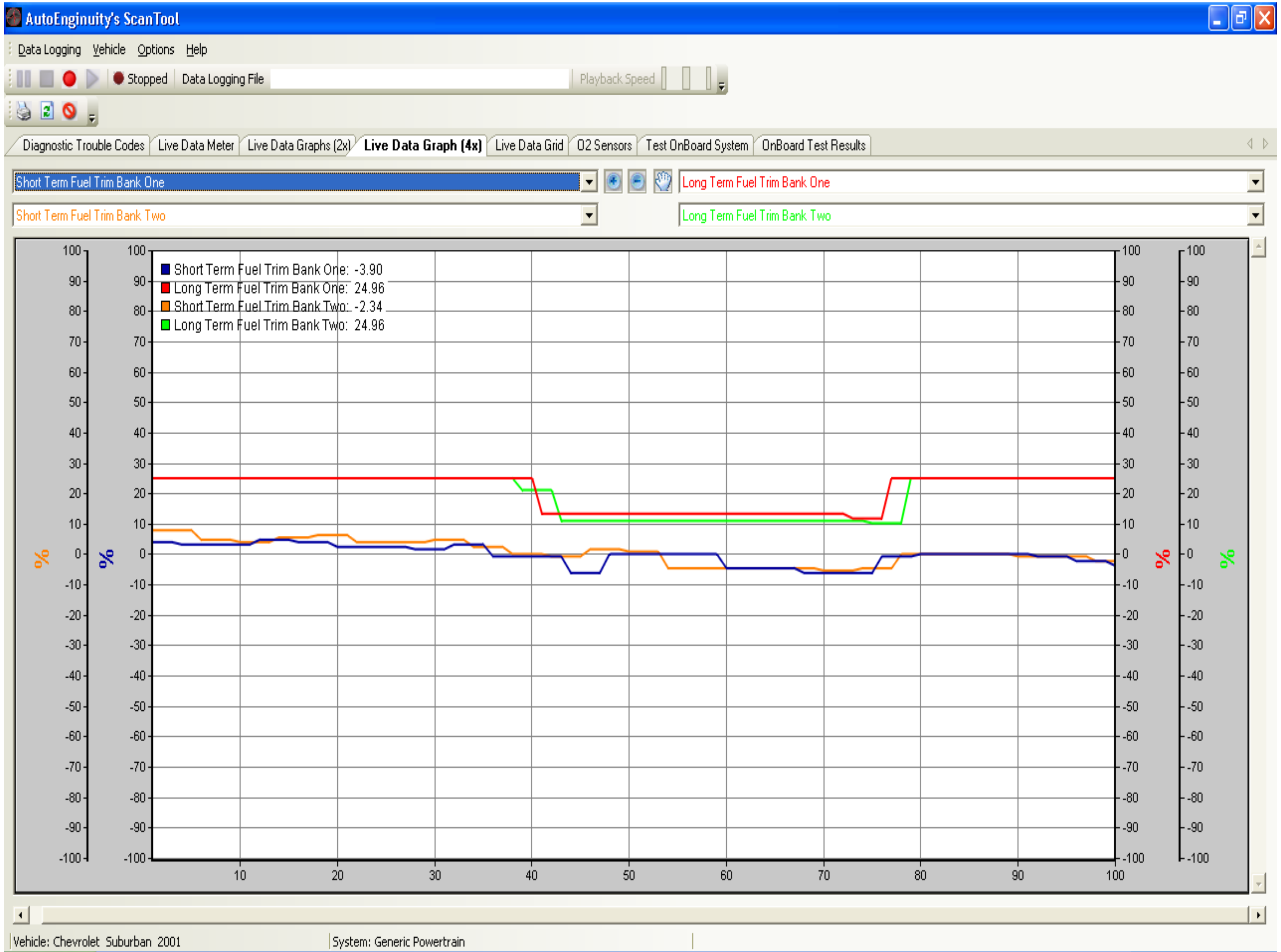
28.86% B1

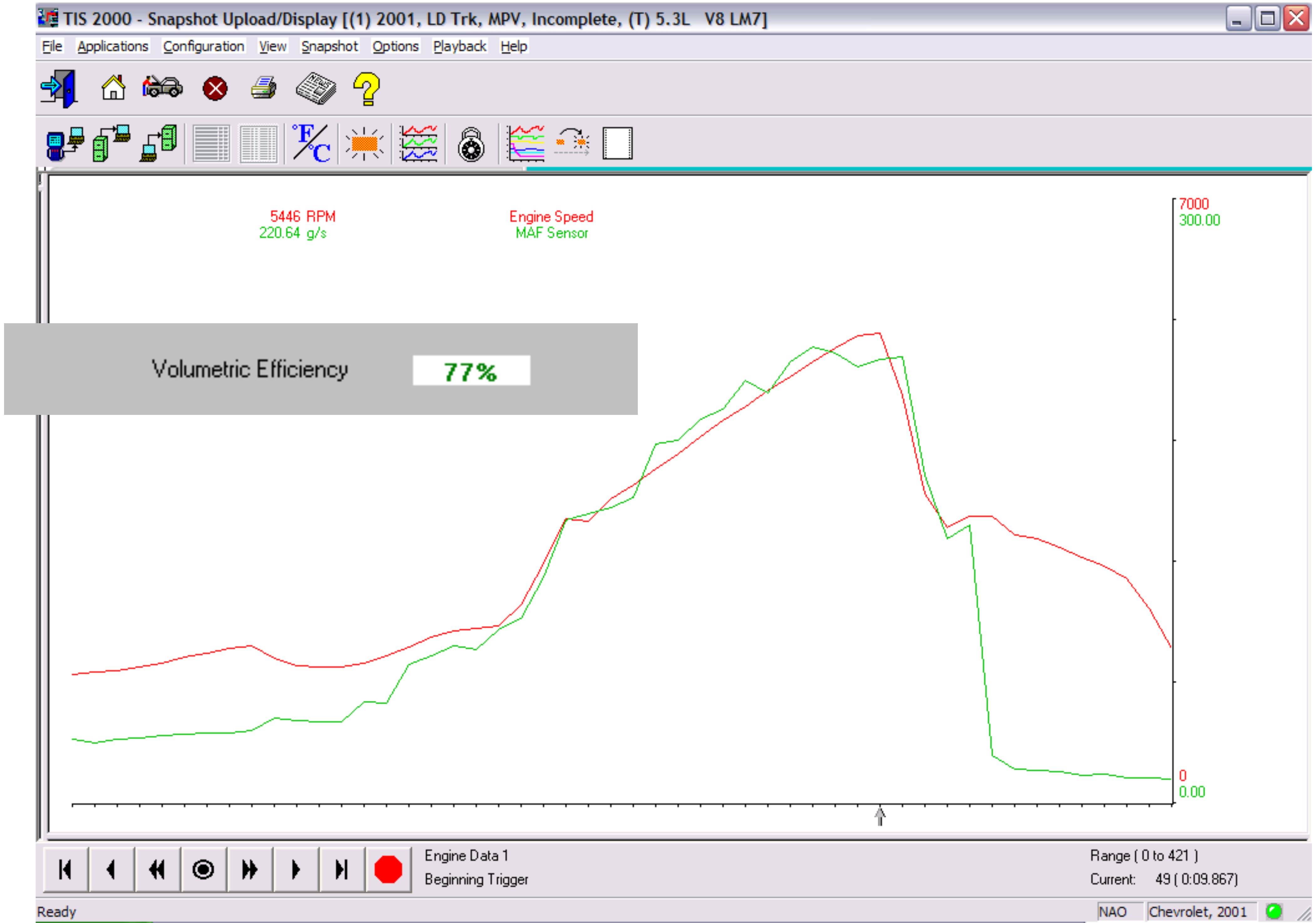
30.42% B2

Sensor Name	Value	Units
Short Term Fuel Trim Bank One	-6.24	%
Long Term Fuel Trim Bank One	14.04	%
Short Term Fuel Trim Bank Two	-5.46	%
Long Term Fuel Trim Bank Two	10.92	%
Engine RPM	3076	r/min

7.80% B1

5.46% B2


AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
Short Term Fuel Trim Bank One
Long Term Fuel Trim Bank One
Short Term Fuel Trim Bank Two
Long Term Fuel Trim Bank Two
Short Term Fuel Trim Bank One: -3.90
Long Term Fuel Trim Bank One: 24.96
Short Term Fuel Trim Bank Two: -2.34
Long Term Fuel Trim Bank Two: 24.96
%
Vehicle: Chevrolet Suburban 2001
System: Generic Powertrain



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2002 Escape

P0171 and P0174

IDS

Select Option

DTC's w/TSB or SSMs Information

- P1131
- P1151
- P0171
- P0174

Engine CMDTCs

- P0171 - PCM
- P0174 - PCM
- P1000 - PCM

Freeze Frame - Mode 2

- P0171 - PCM

Pending DTC

- P1131 - PCM
- P1151 - PCM

Powertrain Control Module

Description - P0171

System Too Lean Bank 1

The PCM monitors the adaptive fuel table to ensure fuel control system components do not vary from their nominal values. The fuel control strategy within the PCM uses the adaptive fuel table to compensate for normal wear or aging of fuel control system components. The code is set when the PCM can no longer compensate for additional changes in the fuel system.

This DTC may be caused by :

Suspect Low fuel pressure.

Crankcase Ventilation System

Suspect air intake system leak.

Suspect engine vacuum leak.

Suspect HO2S11 circuit.

Suspect PCM.

A blocked fuel filter will restrict the flow of fuel to the pressure regulator. If the fuel supply to the fuel filter is O.K. the fuel filter may be blocked.

Obstructed or dirty fuel injector(s)

PTS OASIS

IDS

Select Option	
DTC's w/TSB or SSMs Information	▶
P1131	▶
P1151	▶
P0171	▶
P0174	▶
Engine CMDTCs	▶
P0171 - PCM	▶
P0174 - PCM	▶
P1000 - PCM	▶
Freeze Frame - Mode 2	▶
P0171 - PCM	▶
Pending DTC	▶
P1131 - PCM	▶
P1151 - PCM	▶

Freeze Frame - Mode 2

FUELSYS1 : Closed Loop

FUELSYS2 : ------

LOAD : 48.6%

ECT : 192.2°F

SFT1 : 17.2%

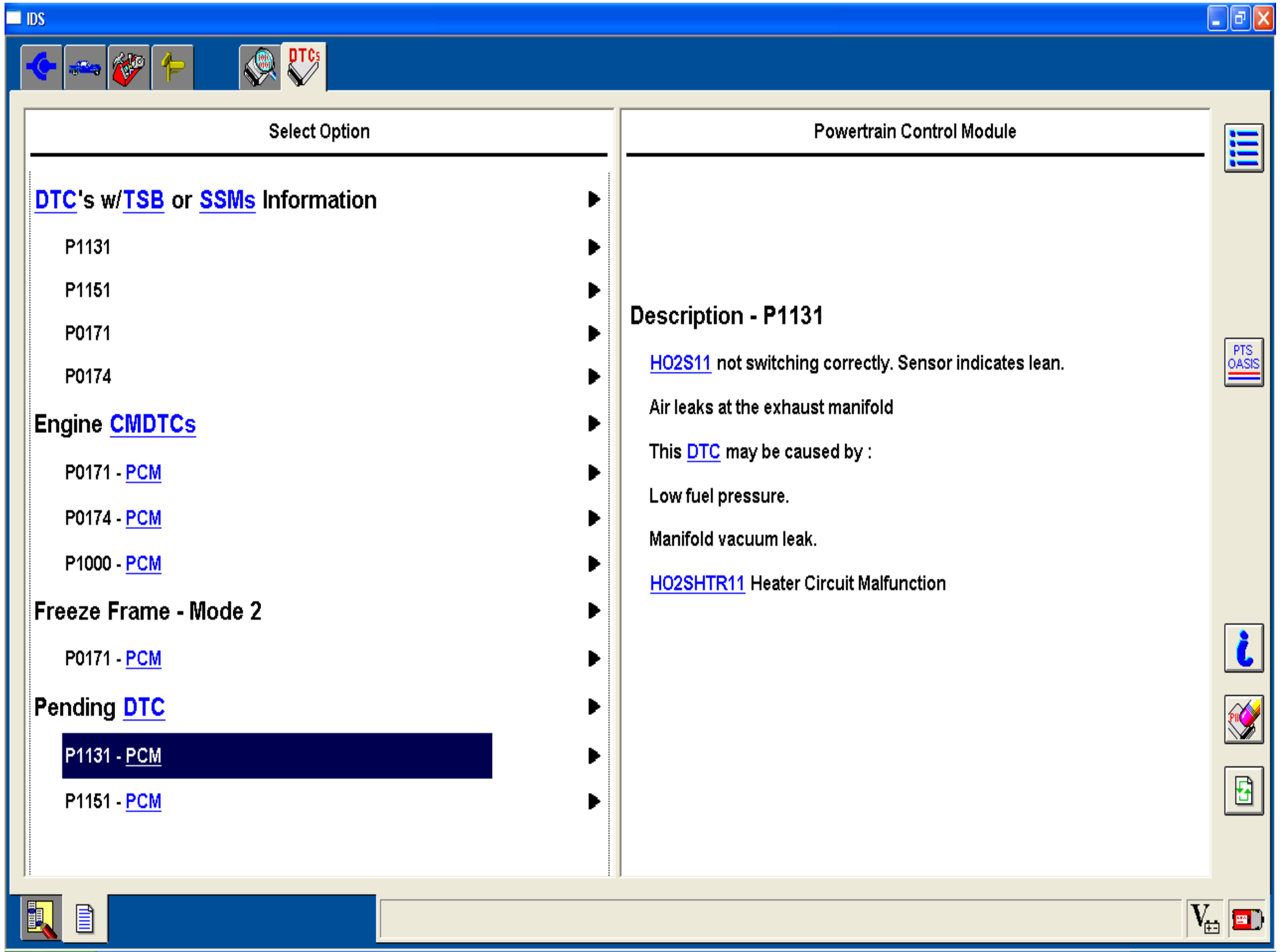
LFT1 : 25%

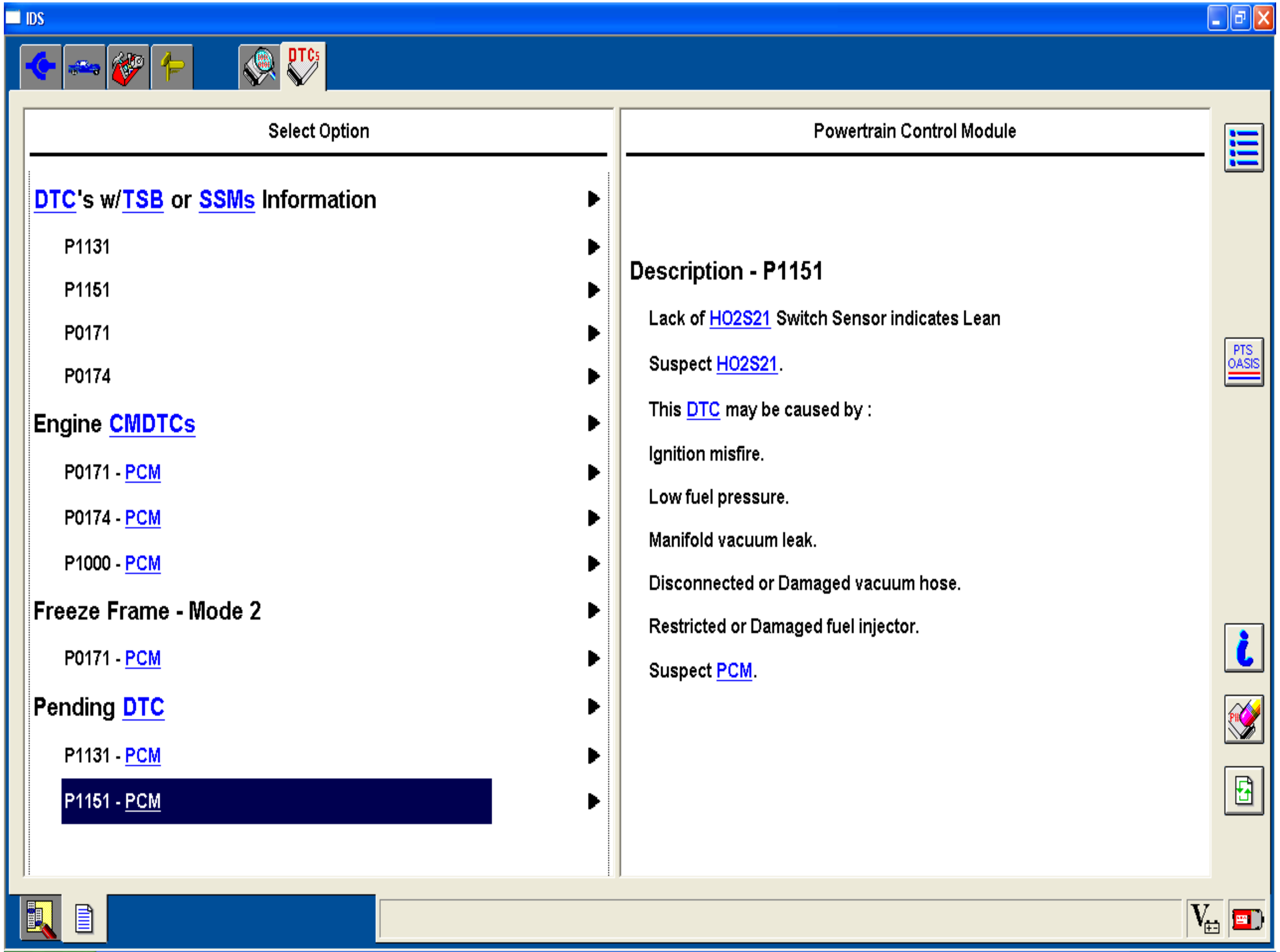
SFT2 : 14.8%

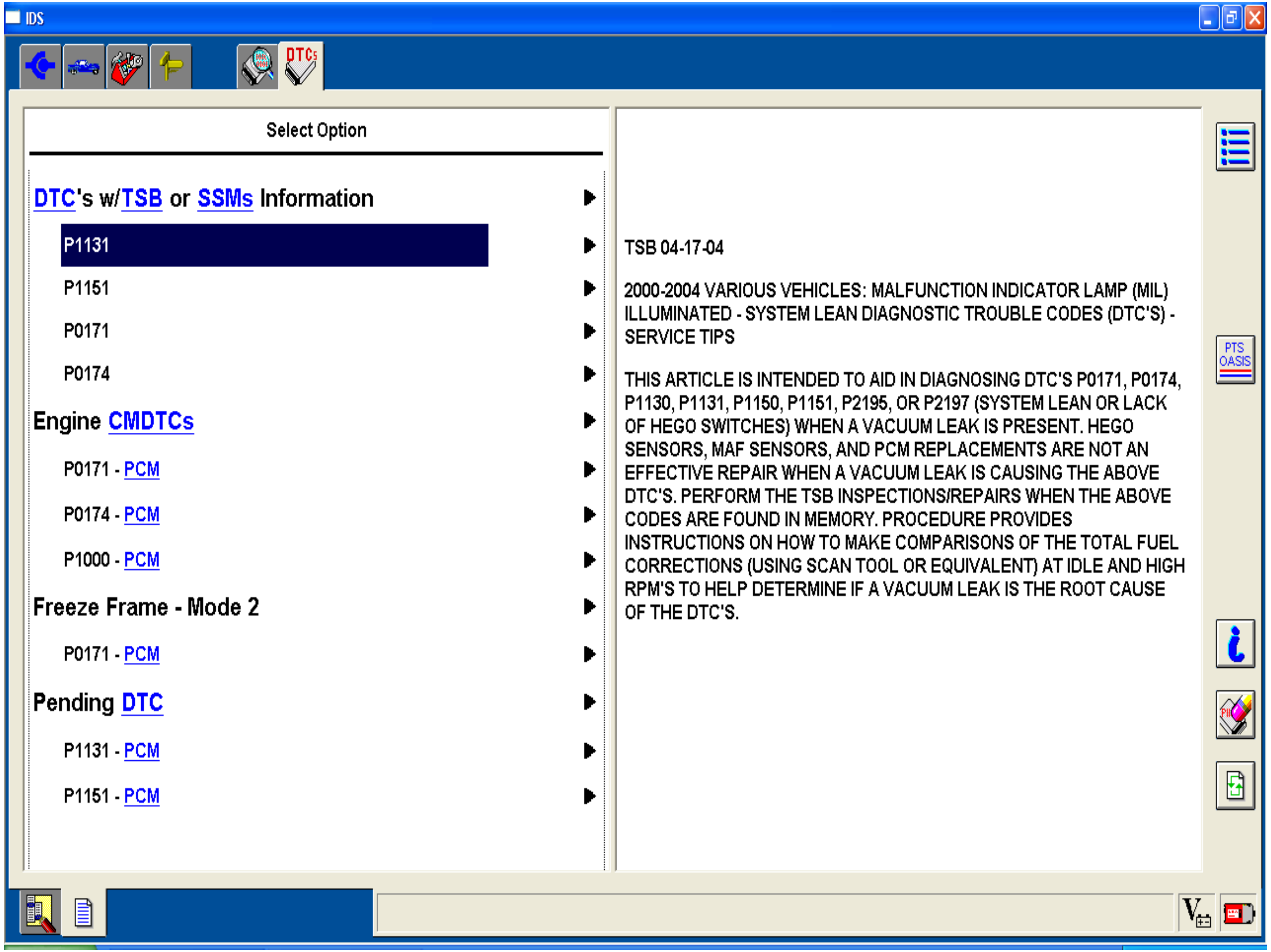
LFT2 : 25%

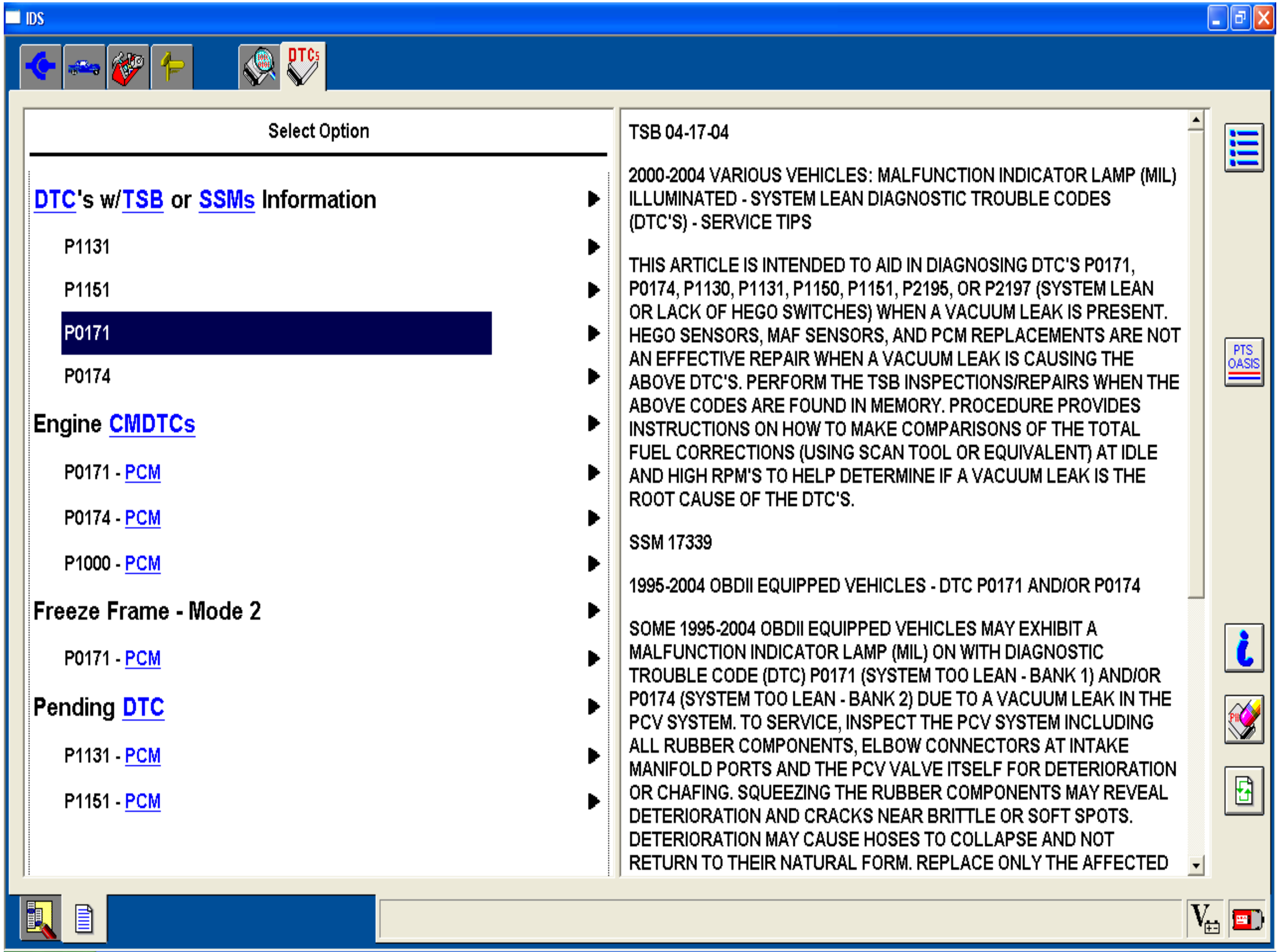
RPM : 2160RPM

VS : 36.047MPH


IDS
Select Option
DTC's w/TSB or SSMs Information
P1131
P1151
P0171
P0174
Engine CMDTCs
P0171 - PCM
P0174 - PCM
P1000 - PCM
Freeze Frame - Mode 2
P0171 - PCM
Pending DTC
P1131 - PCM
P1151 - PCM
Powertrain Control Module
Description - P1131
HO2S11 not switching correctly. Sensor indicates lean.
Air leaks at the exhaust manifold
This DTC may be caused by :
Low fuel pressure.
Manifold vacuum leak.
HO2SHTR11 Heater Circuit Malfunction
PTS OASIS


IDS
DTCs
Select Option
DTC's w/TSB or SSMs Information
P1131
P1151
P0171
P0174
Engine CMDTCs
P0171 - PCM
P0174 - PCM
P1000 - PCM
Freeze Frame - Mode 2
P0171 - PCM
Pending DTC
P1131 - PCM
P1151 - PCM
Powertrain Control Module
Description - P1151
Lack of HO2S21 Switch Sensor indicates Lean
Suspect HO2S21.
This DTC may be caused by :
Ignition misfire.
Low fuel pressure.
Manifold vacuum leak.
Disconnected or Damaged vacuum hose.
Restricted or Damaged fuel injector.
Suspect PCM.
PTS OASIS


IDS
DTCs
Select Option
DTC's w/TSB or SSMs Information
P1131
P1151
P0171
P0174
Engine CMDTCs
P0171 - PCM
P0174 - PCM
P1000 - PCM
Freeze Frame - Mode 2
P0171 - PCM
Pending DTC
P1131 - PCM
P1151 - PCM
TSB 04-17-04
2000-2004 VARIOUS VEHICLES: MALFUNCTION INDICATOR LAMP (MIL) ILLUMINATED - SYSTEM LEAN DIAGNOSTIC TROUBLE CODES (DTC'S) - SERVICE TIPS
THIS ARTICLE IS INTENDED TO AID IN DIAGNOSING DTC'S P0171, P0174, P1130, P1131, P1150, P1151, P2195, OR P2197 (SYSTEM LEAN OR LACK OF HEGO SWITCHES) WHEN A VACUUM LEAK IS PRESENT. HEGO SENSORS, MAF SENSORS, AND PCM REPLACEMENTS ARE NOT AN EFFECTIVE REPAIR WHEN A VACUUM LEAK IS CAUSING THE ABOVE DTC'S. PERFORM THE TSB INSPECTIONS/REPAIRS WHEN THE ABOVE CODES ARE FOUND IN MEMORY. PROCEDURE PROVIDES INSTRUCTIONS ON HOW TO MAKE COMPARISONS OF THE TOTAL FUEL CORRECTIONS (USING SCAN TOOL OR EQUIVALENT) AT IDLE AND HIGH RPM'S TO HELP DETERMINE IF A VACUUM LEAK IS THE ROOT CAUSE OF THE DTC'S.
PTS OASIS


IDS
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P0174 - PCM
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Freeze Frame - Mode 2
P0171 - PCM
Pending DTC
P1131 - PCM
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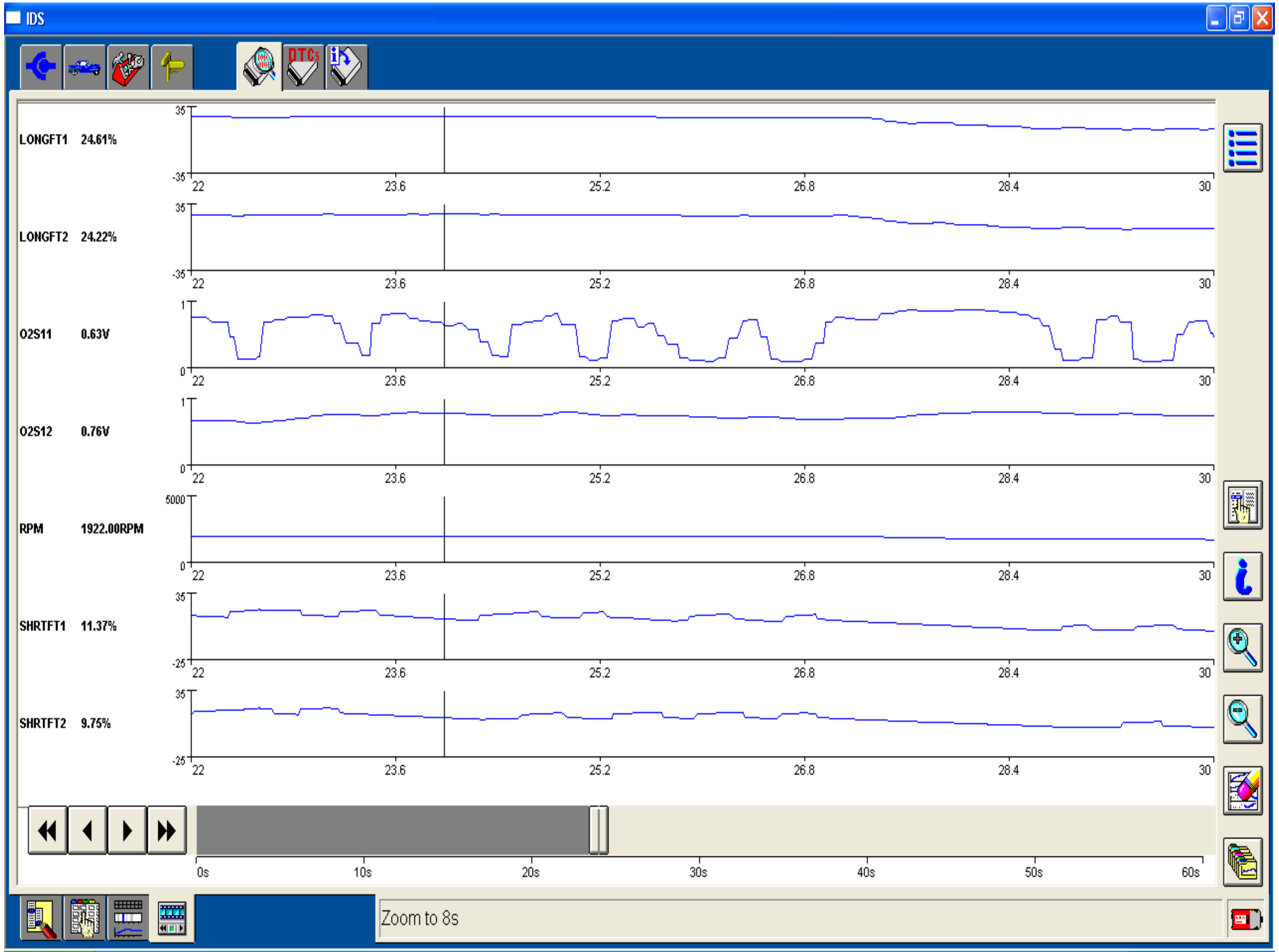
SSM 17339
1995-2004 OBDII EQUIPPED VEHICLES - DTC P0171 AND/OR P0174
SOME 1995-2004 OBDII EQUIPPED VEHICLES MAY EXHIBIT A MALFUNCTION INDICATOR LAMP (MIL) ON WITH DIAGNOSTIC TROUBLE CODE (DTC) P0171 (SYSTEM TOO LEAN - BANK 1) AND/OR P0174 (SYSTEM TOO LEAN - BANK 2) DUE TO A VACUUM LEAK IN THE PCV SYSTEM. TO SERVICE, INSPECT THE PCV SYSTEM INCLUDING ALL RUBBER COMPONENTS, ELBOW CONNECTORS AT INTAKE MANIFOLD PORTS AND THE PCV VALVE ITSELF FOR DETERIORATION OR CHAFING. SQUEEZING THE RUBBER COMPONENTS MAY REVEAL DETERIORATION AND CRACKS NEAR BRITTLE OR SOFT SPOTS. DETERIORATION MAY CAUSE HOSES TO COLLAPSE AND NOT RETURN TO THEIR NATURAL FORM. REPLACE ONLY THE AFFECTED
PTS OASIS

Other Checks:

- Exhaust integrity and O2 sensor operation verified
- Idle fuel trim numbers are slightly positive and idle quality is good.
- Freeze Frame suggests positive correction off idle.
  - These 2 points lead us away from a vacuum leak
- Time to drive the vehicle and make some recordings.



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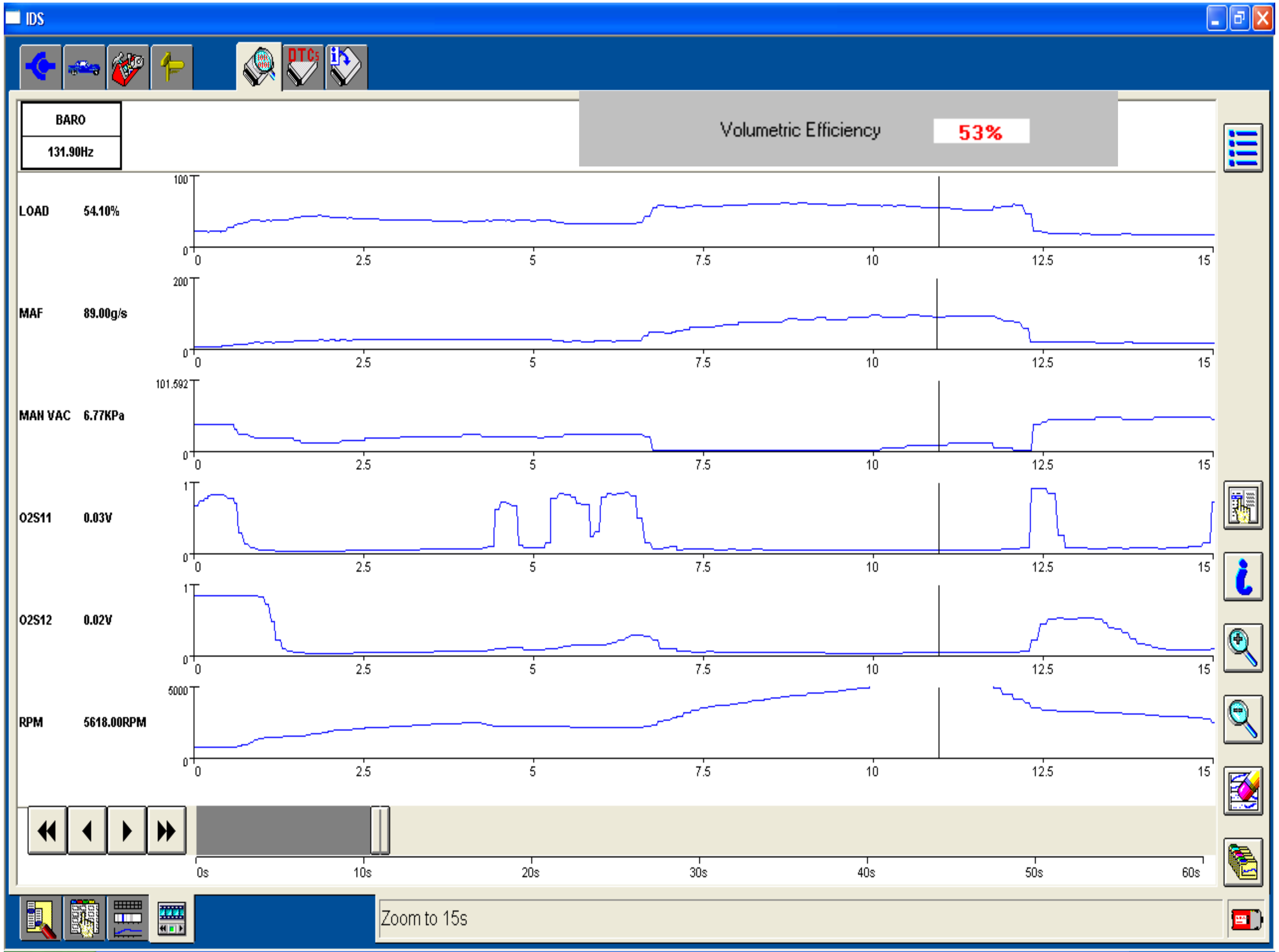

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Lean Code Cheat Sheet

Suspect Condition	Fuel Trims (Total Correction)			Fuel Trim Notes:	Load PID/ VE (@WOT)	Possible driveability characteristics
	Idle	2500 RPM	Loaded			
Vacuum Leak	Positive	Closer to Normal	Normal	Trims get better as RPM and Load increase	Normal	May have poor idle especially cold/open loop. Normal driving conditions could appear OK.
Low fuel volume	Normal or Positive	Positive	Positive	Trims can start normal or positive, but get worse as RPM, and especially load, increase. Degree of positive depends on how poor the fuel volume is.	Normal	May have low power, worse at WOT. May have starting problems such as a long crank time.
Air Metering	Close to Normal	Positive	More Positive	Trims can start negative, normal or positive but get worse as RPM and load increase	Poor	May have low power, worse at WOT.
Wrong fuel (too much ethanol)	Positive	Positive	Positive	Trims will be equally positive under all conditions	Normal	May have starting issues. Runs worse in open loop.

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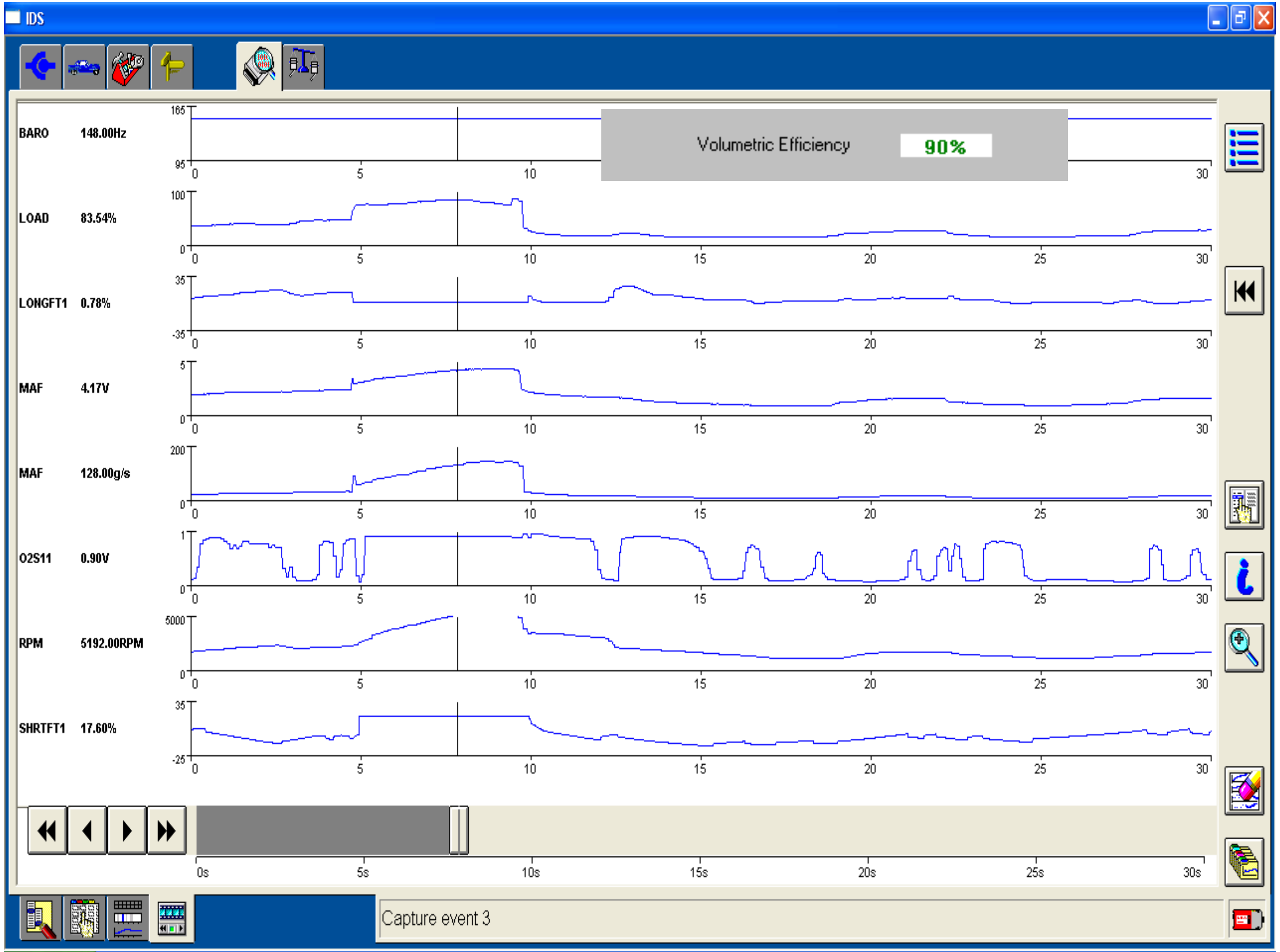
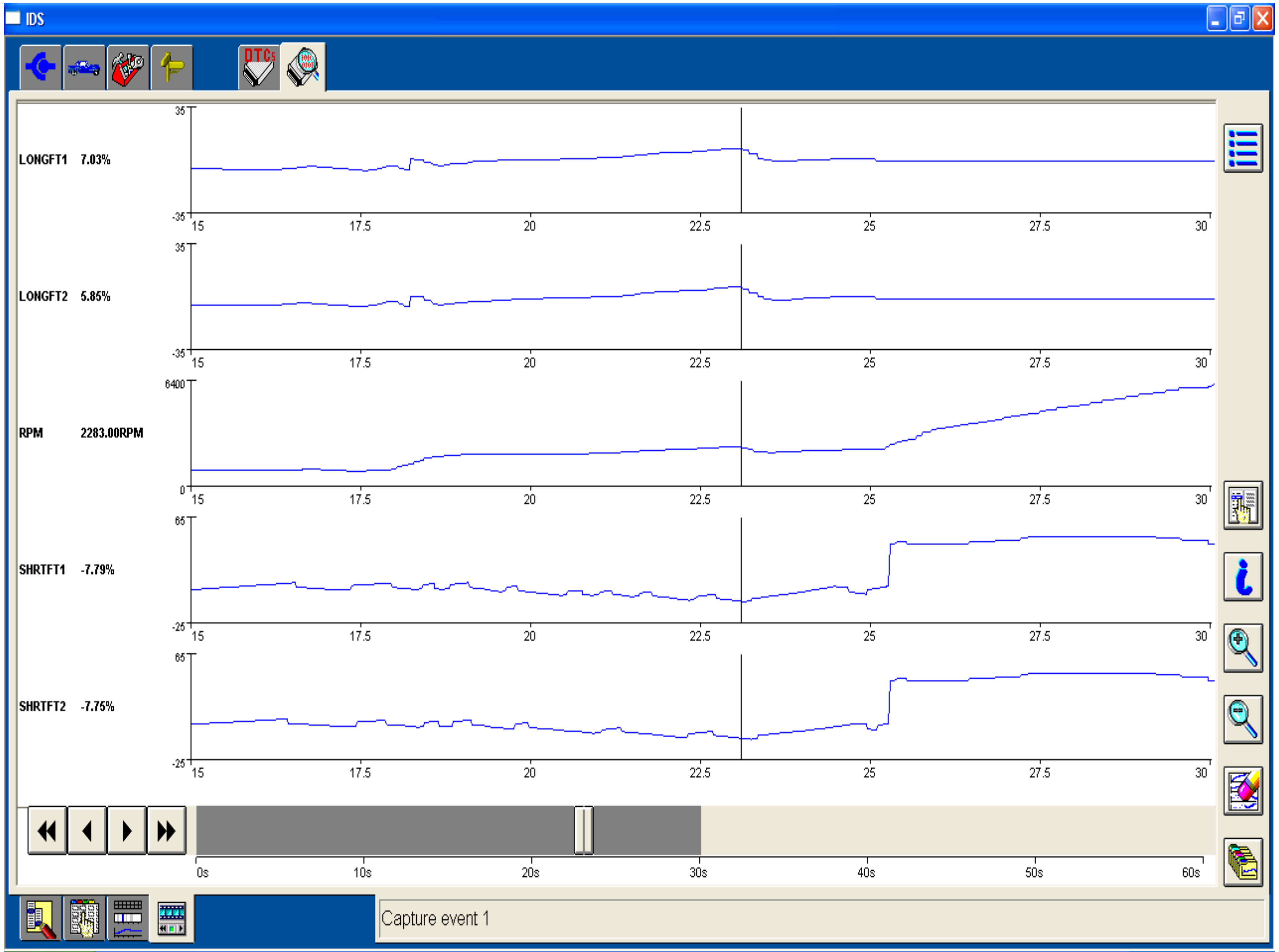

IDS
BARO 148.00Hz
LOAD 83.54%
LONGFT1 0.78%
MAF 4.17V
MAF 128.00g/s
O2S11 0.90V
RPM 5192.00RPM
SHRTFT1 17.60%
Volumetric Efficiency 90%
0s 5s 10s 15s 20s 25s 30s
Capture event 3


IDS
LONGFT1 7.03%
LONGFT2 5.85%
RPM 2283.00RPM
SHRTFT1 -7.79%
SHRTFT2 -7.75%
35
-35
6400
0
65
-25
15
17.5
20
22.5
25
27.5
30
0s
10s
20s
30s
40s
50s
60s
Capture event 1

Misfire Analysis

- Misfire occurs when combustion does not happen (or is incomplete)
- Combustion requires 3 things:
  - Compression
  - Fuel (or correct air to fuel ratio)
  - Ignition
- Where do we test first?

Logical Progression

- Things to take into account:
  - Pattern failures / TSB's
  - Vehicle history
  - Customer description
  - Conditions
    - Under load
    - Humidity
    - Ambient temperature
    - Engine temperature
  - Senses
    - Feeling
    - Sound

Approaches

1. Scan Tool Analysis – Usually quick and clean
2. Mechanical Testing - Usually the last step for most technicians

The approach you choose will depend on each situation.

(Your choice does not effect your success, only the time invested)

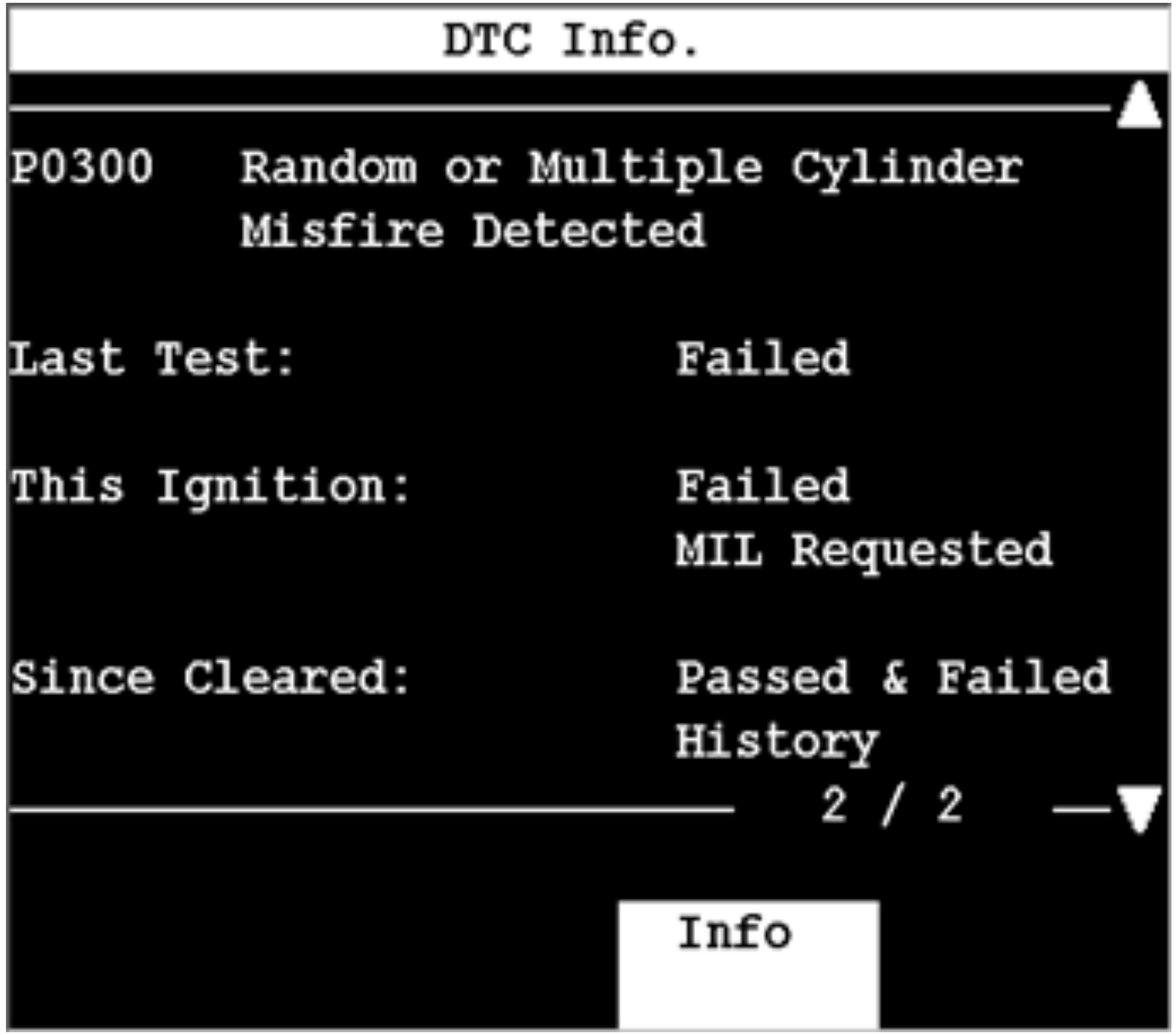
Scan Tool Approach

1. Retrieve DTC's and identify cylinder(s) if possible
2. Analyze fuel trim numbers, Oxygen sensors, and other data to narrow search
3. Perform testing to back up theory

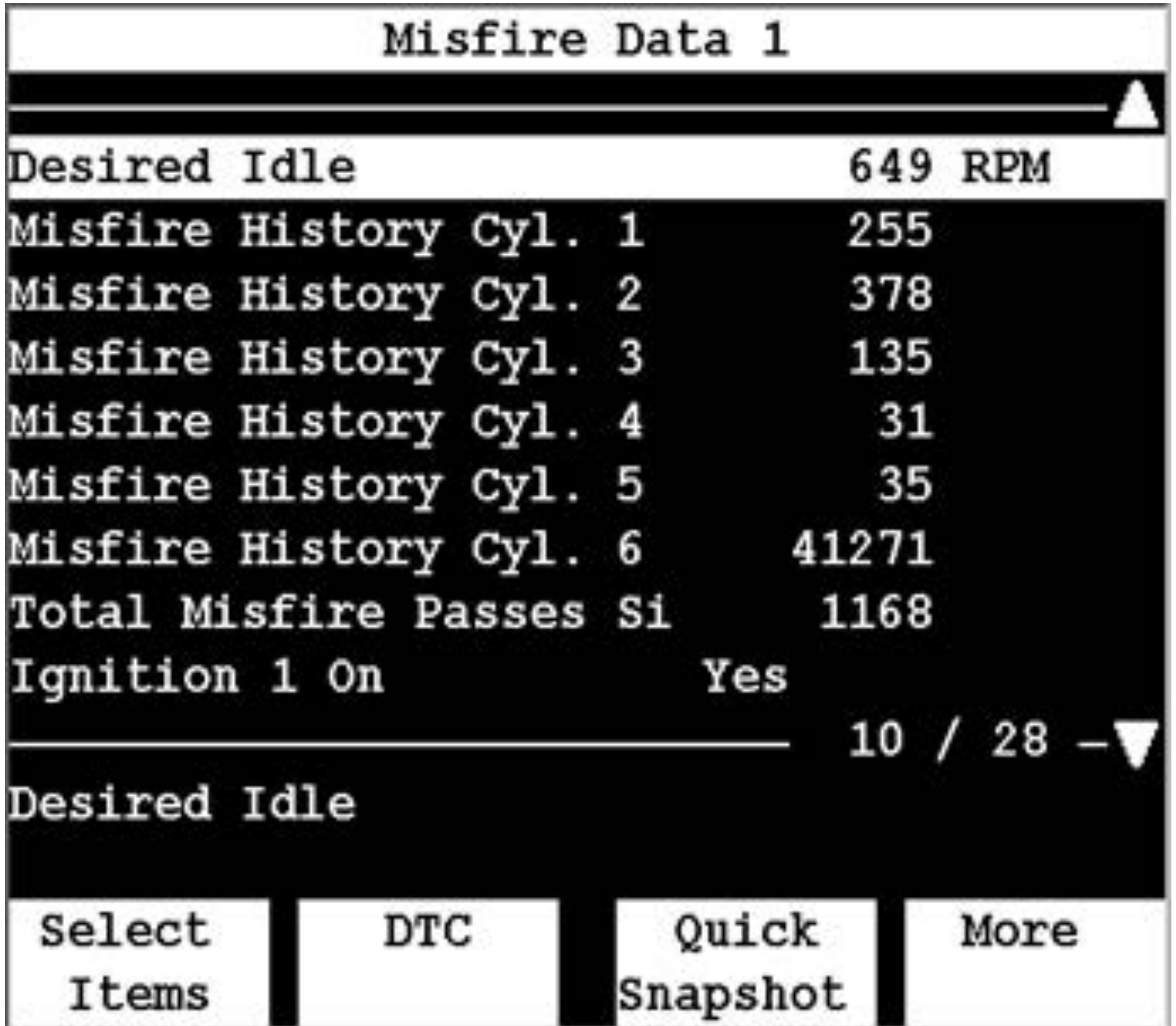
The Goal of the Scan Tool Approach: Fuel or Ignition?

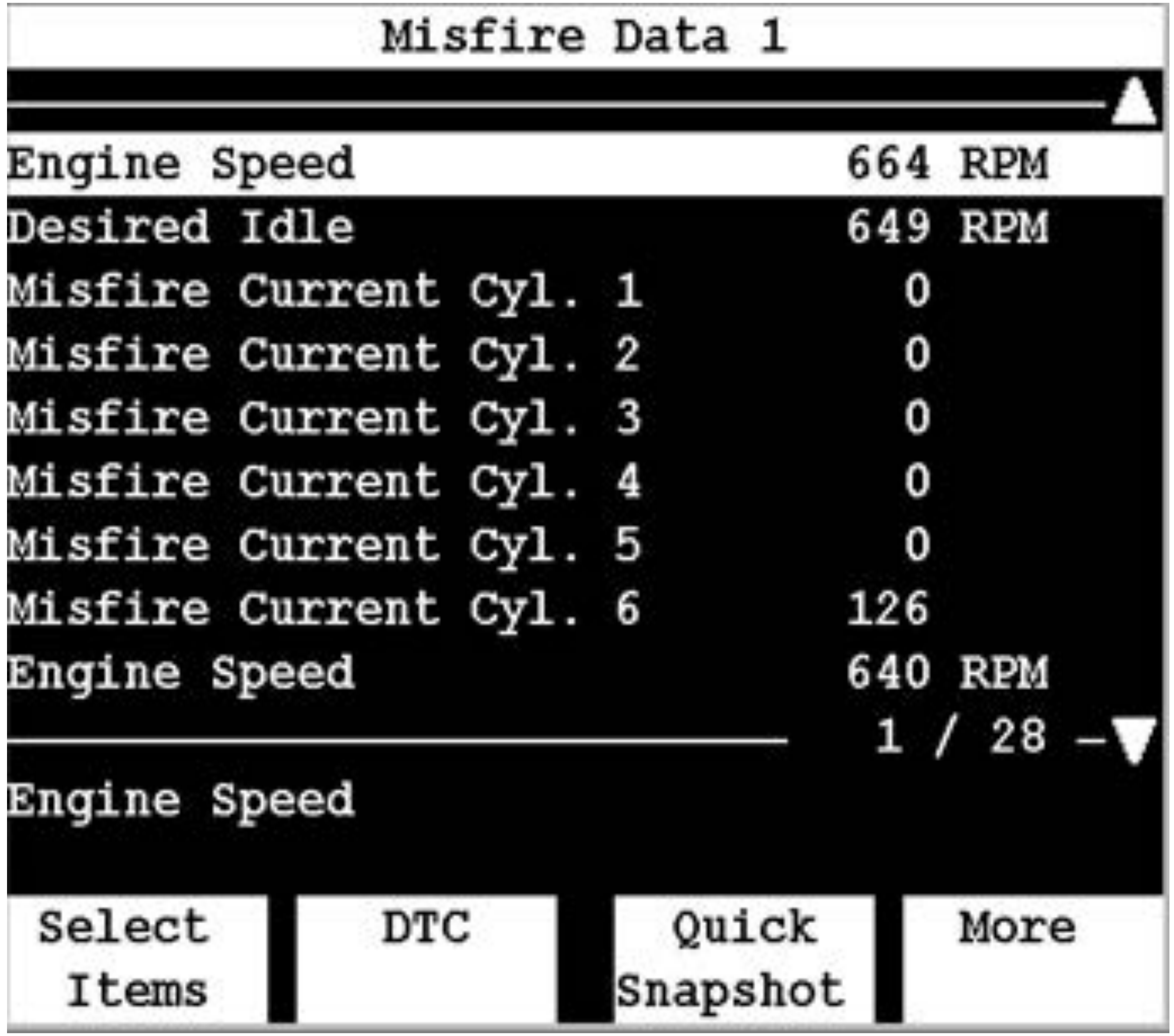
1996 Chevy T10 Blazer 4.3 L

Runs rough and MIL illuminated

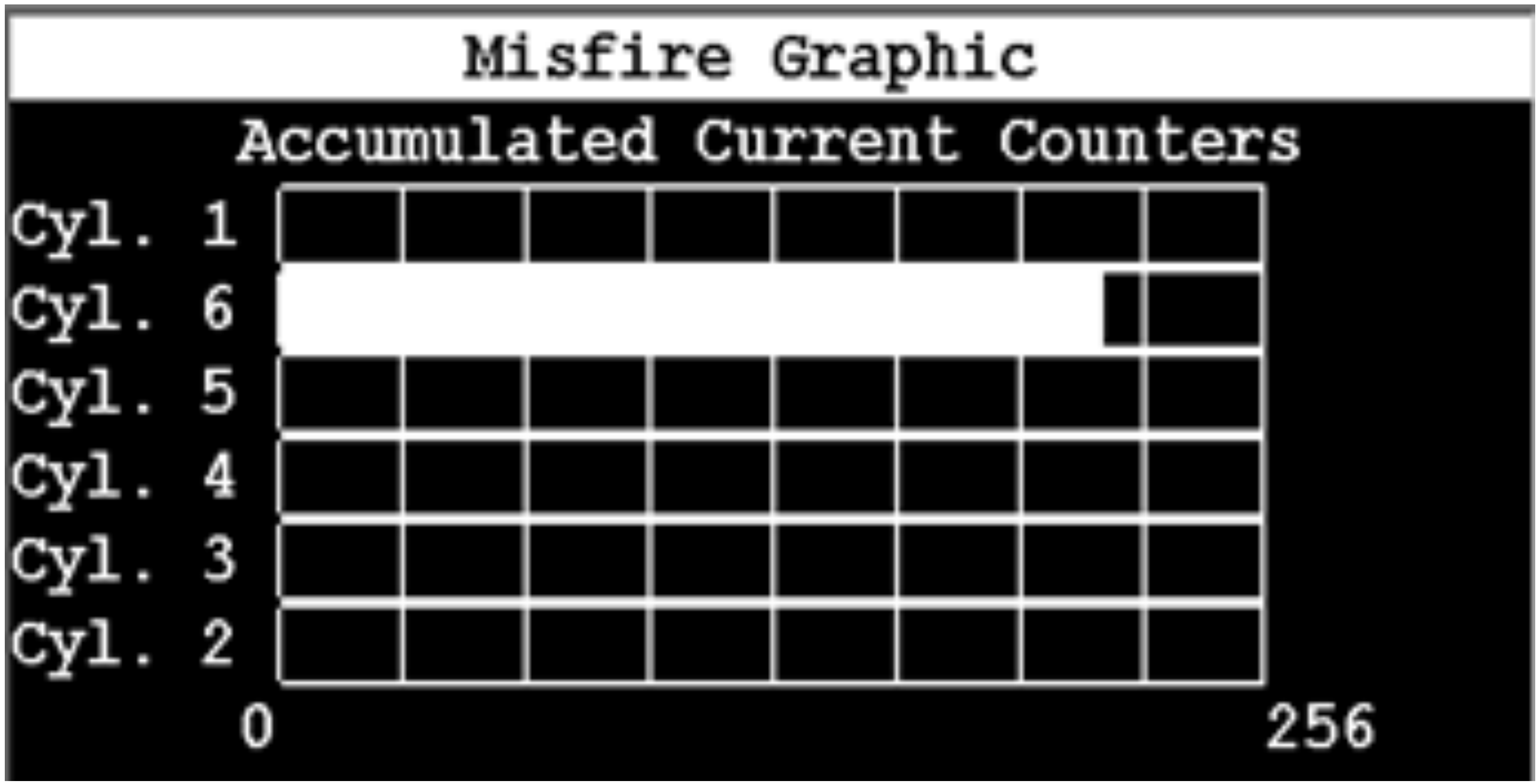


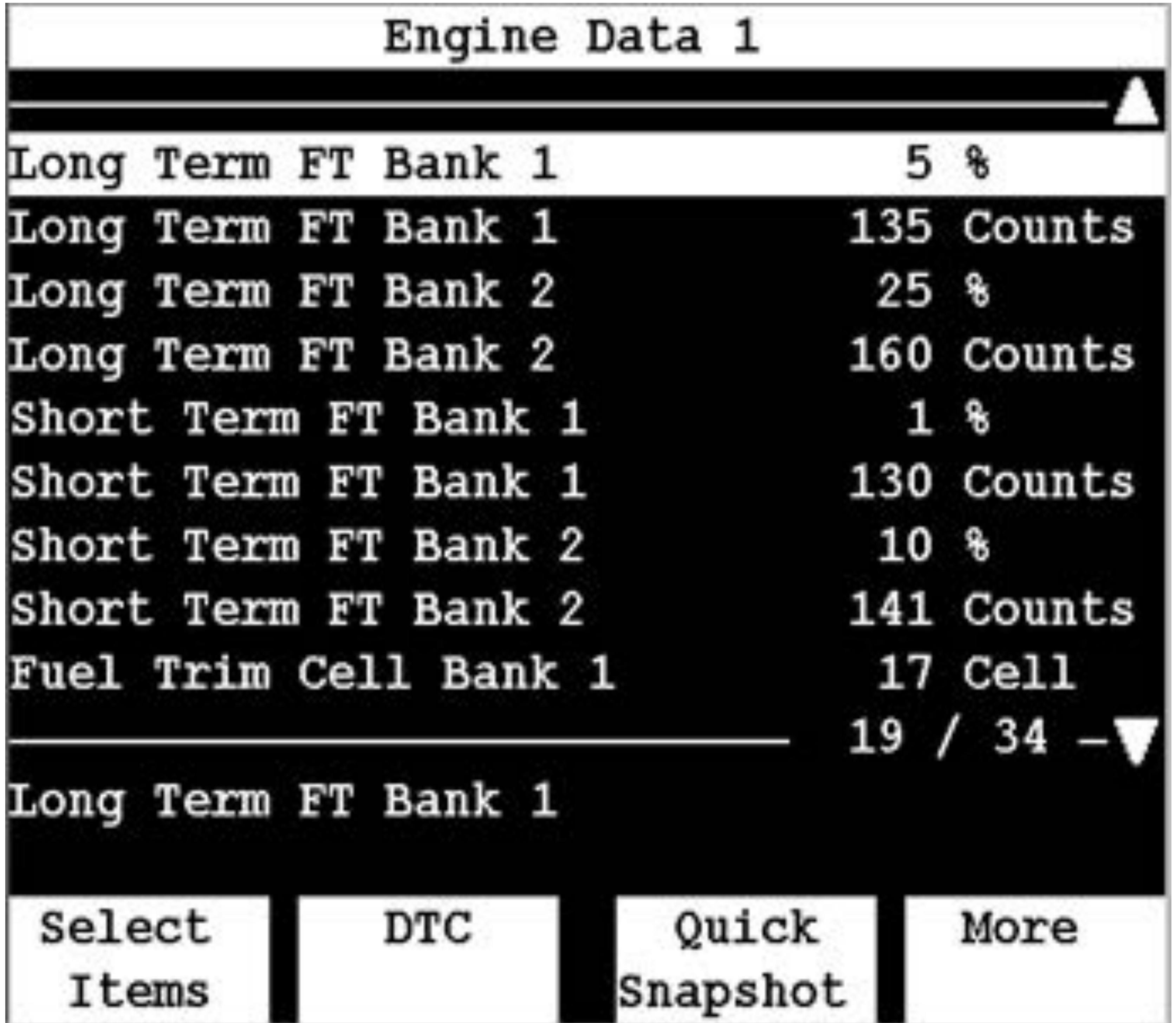
DTC Info.
P0300 Random or Multiple Cylinder Misfire Detected
Last Test: Failed
This Ignition: Failed
MIL Requested
Since Cleared: Passed & Failed
History
2 / 2
Info

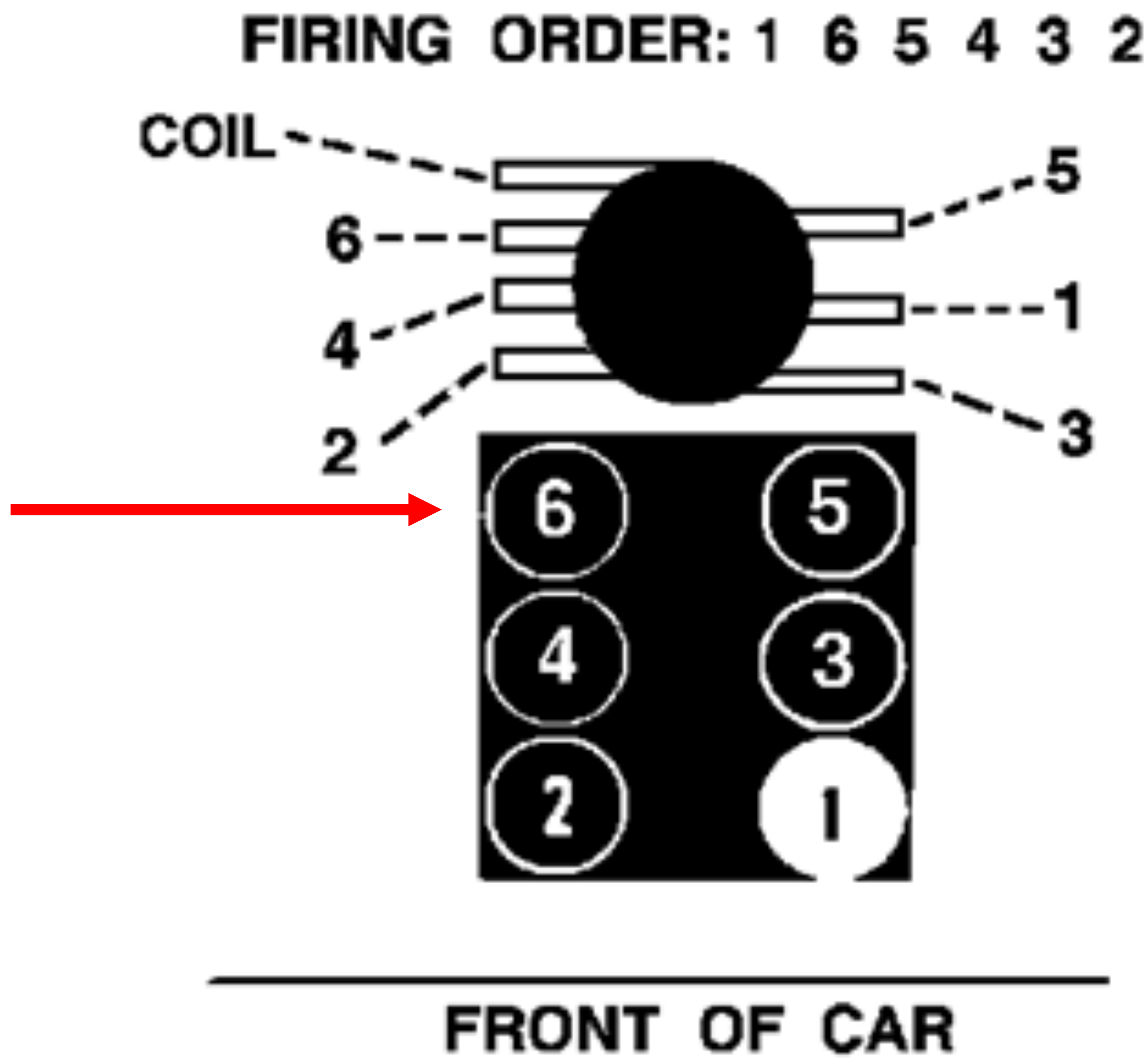

Misfire Data 1
Desired Idle 649 RPM
Misfire History Cyl. 1 255
Misfire History Cyl. 2 378
Misfire History Cyl. 3 135
Misfire History Cyl. 4 31
Misfire History Cyl. 5 35
Misfire History Cyl. 6 41271
Total Misfire Passes Si 1168
Ignition 1 On Yes
10 / 28
Desired Idle
Select Items
DTC
Quick Snapshot
More


Misfire Data 1
Engine Speed 664 RPM
Desired Idle 649 RPM
Misfire Current Cyl. 1 0
Misfire Current Cyl. 2 0
Misfire Current Cyl. 3 0
Misfire Current Cyl. 4 0
Misfire Current Cyl. 5 0
Misfire Current Cyl. 6 126
Engine Speed 640 RPM
1 / 28
Engine Speed
Select Items
DTC
Quick Snapshot
More

What would you like to look at next?




Engine Data 1
Long Term FT Bank 1 5 %
Long Term FT Bank 1 135 Counts
Long Term FT Bank 2 25 %
Long Term FT Bank 2 160 Counts
Short Term FT Bank 1 1 %
Short Term FT Bank 1 130 Counts
Short Term FT Bank 2 10 %
Short Term FT Bank 2 141 Counts
Fuel Trim Cell Bank 1 17 Cell
19 / 34
Long Term FT Bank 1
Select Items
DTC
Quick Snapshot
More


FIRING ORDER: 1 6 5 4 3 2
COIL
6
4
2
5
1
3
6
5
4
3
2
1
FRONT OF CAR

Engine Data 1

Long Term FT Bank 1	5 %
Long Term FT Bank 1	135 Counts
Long Term FT Bank 2	25 %
Long Term FT Bank 2	160 Counts
Short Term FT Bank 1	1 %
Short Term FT Bank 1	130 Counts
Short Term FT Bank 2	10 %
Short Term FT Bank 2	141 Counts
Fuel Trim Cell Bank 1	17 Cell

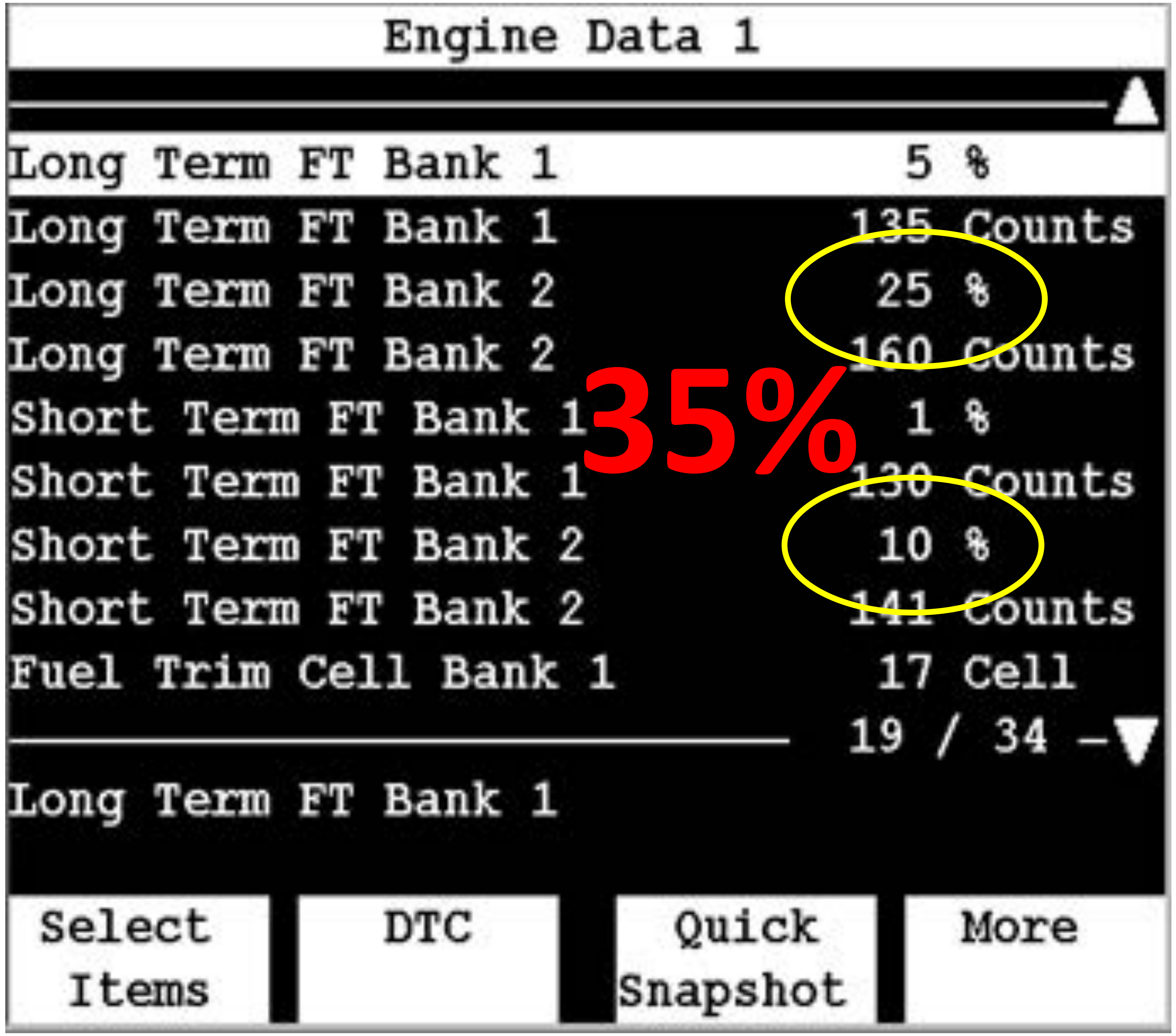
19 / 34

Long Term FT Bank 1

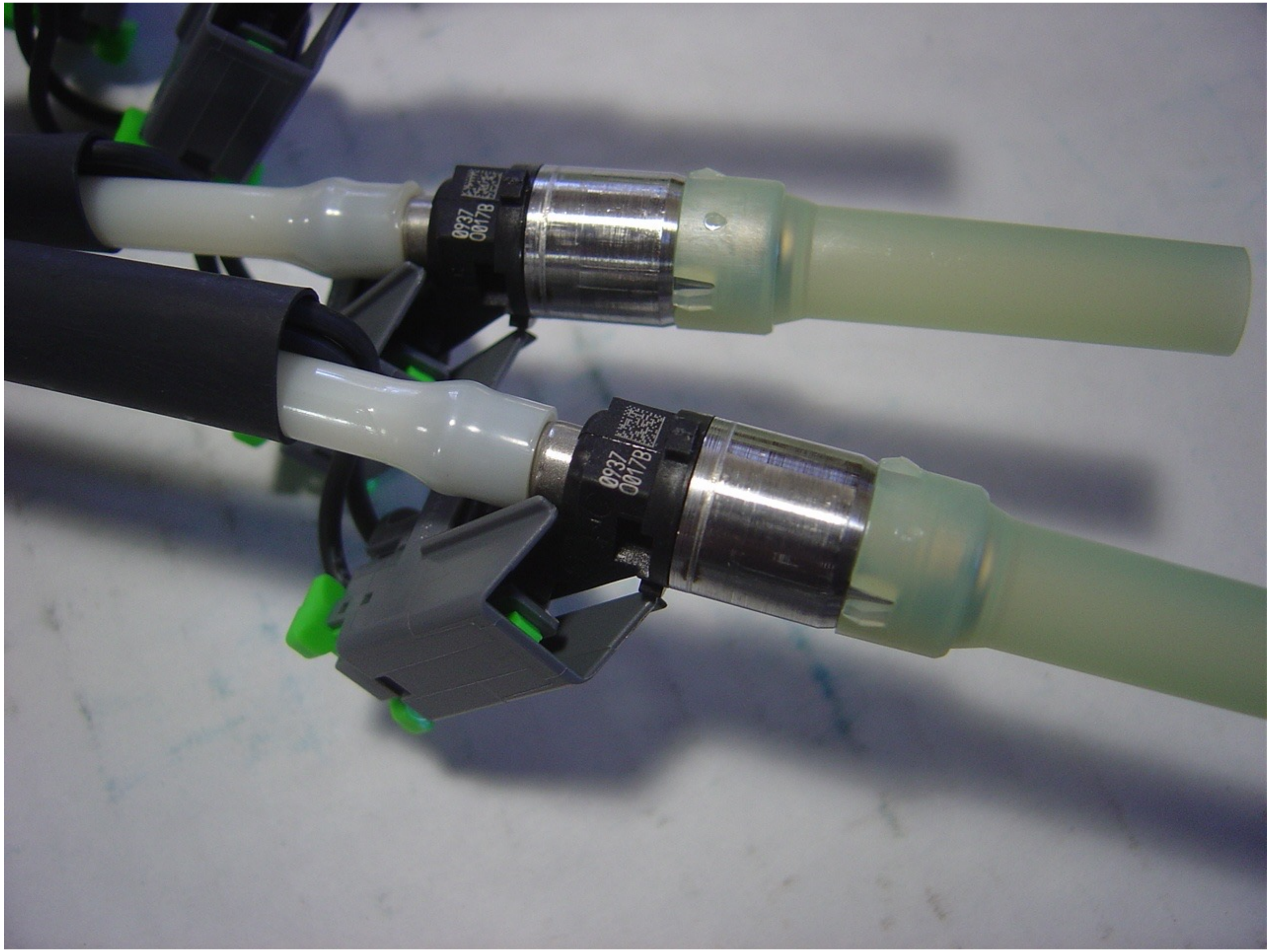
Select Items | DTC | Quick Snapshot | More

How do misfires equate to trims?

- Bank 2 includes 3 cylinders
- 100% of the air/fuel for bank 2 is divided by 3 cylinders
- That means each cylinder is responsible for ~33% of the air/fuel required (per bank)
- Let's apply this to our case study…


Engine Data 1
Long Term FT Bank 1 5 %
Long Term FT Bank 1 135 Counts
Long Term FT Bank 2 25 %
Long Term FT Bank 2 160 Counts
Short Term FT Bank 1 1 %
Short Term FT Bank 1 130 Counts
Short Term FT Bank 2 10 %
Short Term FT Bank 2 141 Counts
Fuel Trim Cell Bank 1 17 Cell
19 / 34
Long Term FT Bank 1
Select Items
DTC
Quick Snapshot
More
35%

Is this a fuel issue or an ignition issue?

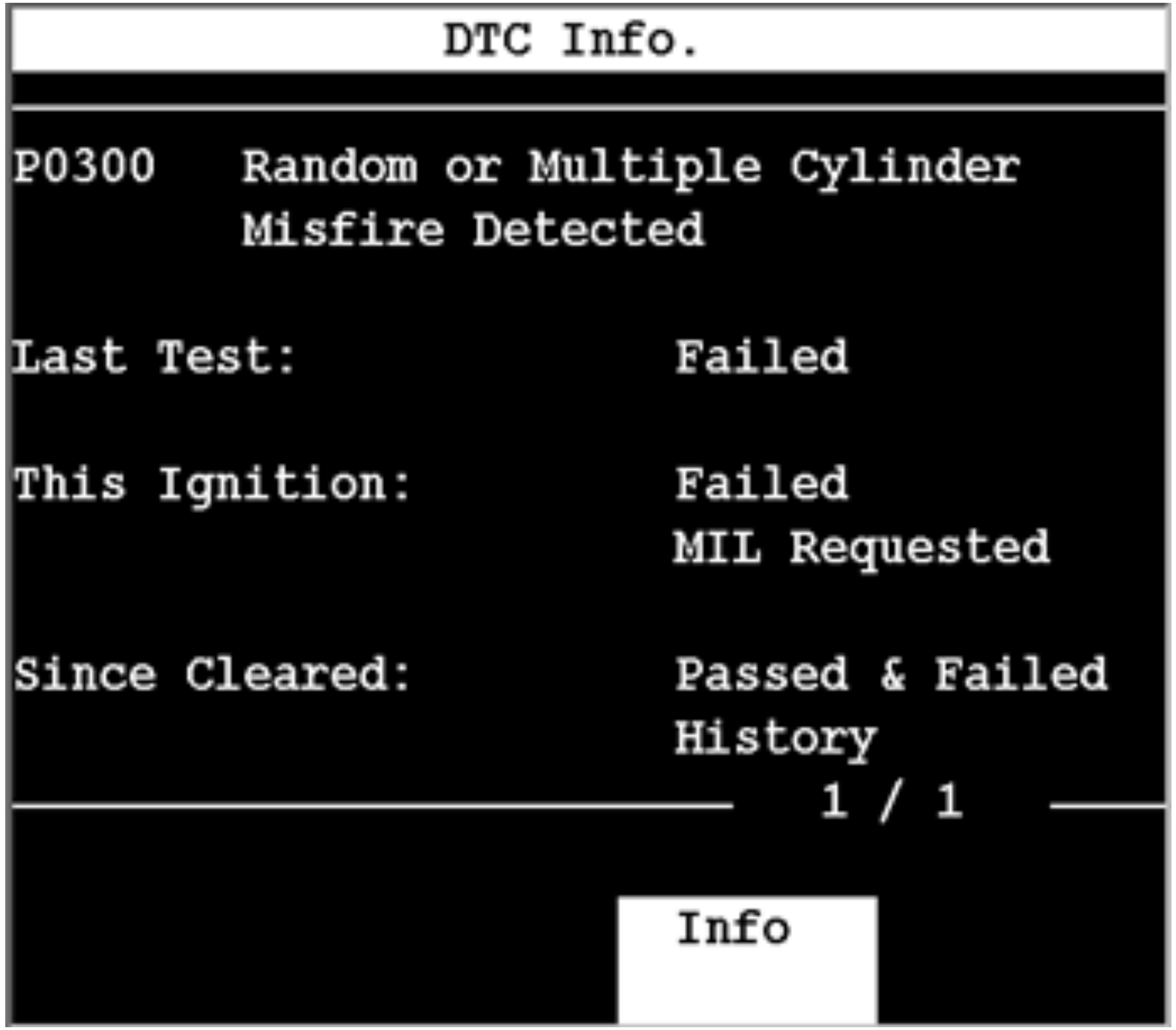


What about an ignition misfire?

- If a cylinder misfires because a fuel injector does not open the cylinder still pumps Oxygen
- If a cylinder misfires because spark does not happen the cylinder still pumps Oxygen
- Shouldn’t the O2 sensor read the same for an ignition misfire as it does for a fuel misfire?

Test the Theory:

- Same vehicle
- Fuel injector assembly has been replaced
- Repair verification was performed
- DTC's were cleared
- An ignition misfire was created for research purposes before returning the vehicle to the customer


DTC Info.
P0300 Random or Multiple Cylinder Misfire Detected
Last Test: Failed
This Ignition: Failed
MIL Requested
Since Cleared: Passed & Failed History
1 / 1
Info

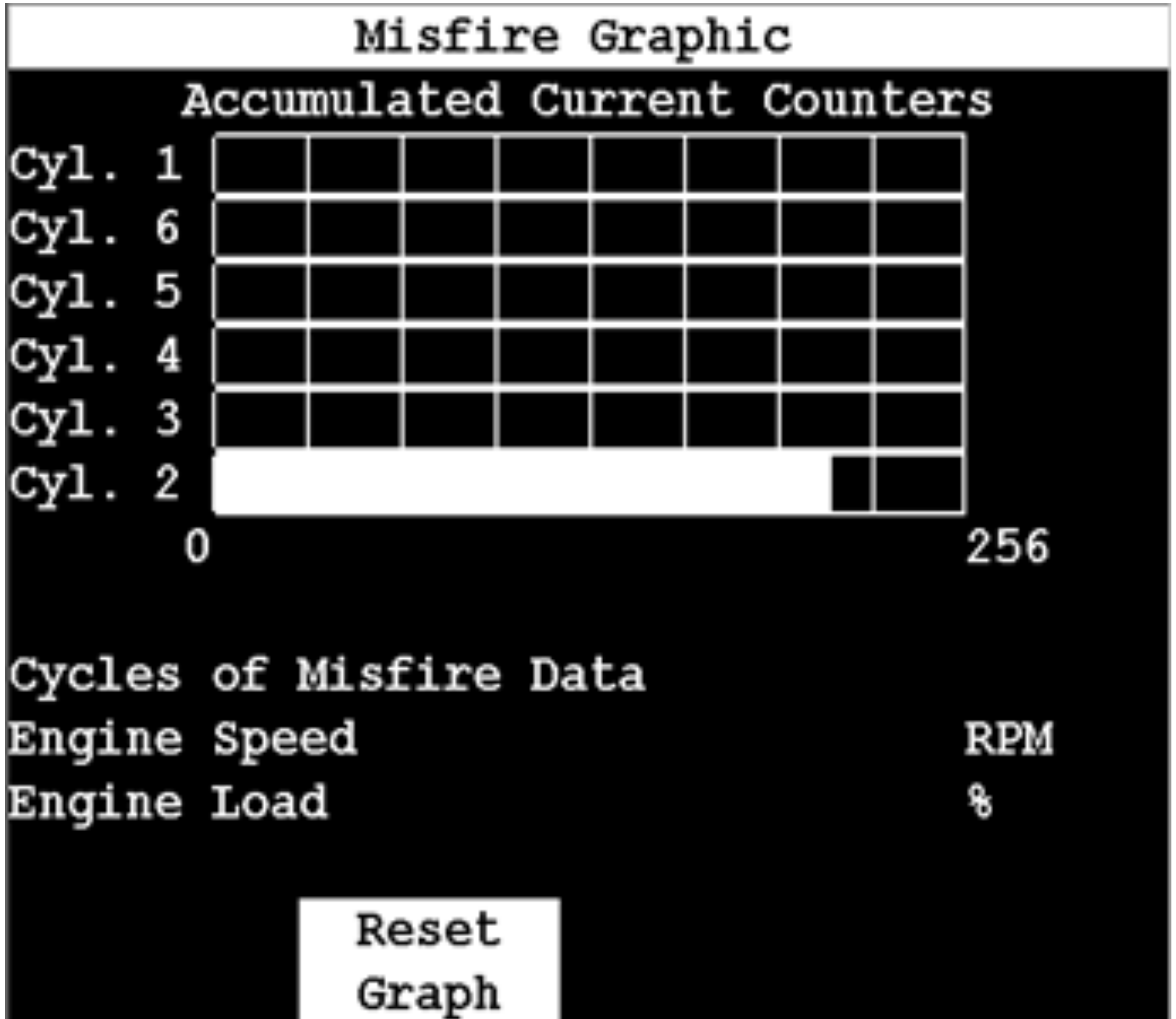
Misfire Data 1

Engine Speed	660 RPM
Desired Idle	649 RPM
Misfire Current Cyl. 1	0
Misfire Current Cyl. 2	130
Misfire Current Cyl. 3	0
Misfire Current Cyl. 4	0
Misfire Current Cyl. 5	0
Misfire Current Cyl. 6	0
Engine Speed	654 RPM

1 / 28

Engine Speed

Select Items | DTC | Quick Snapshot | More



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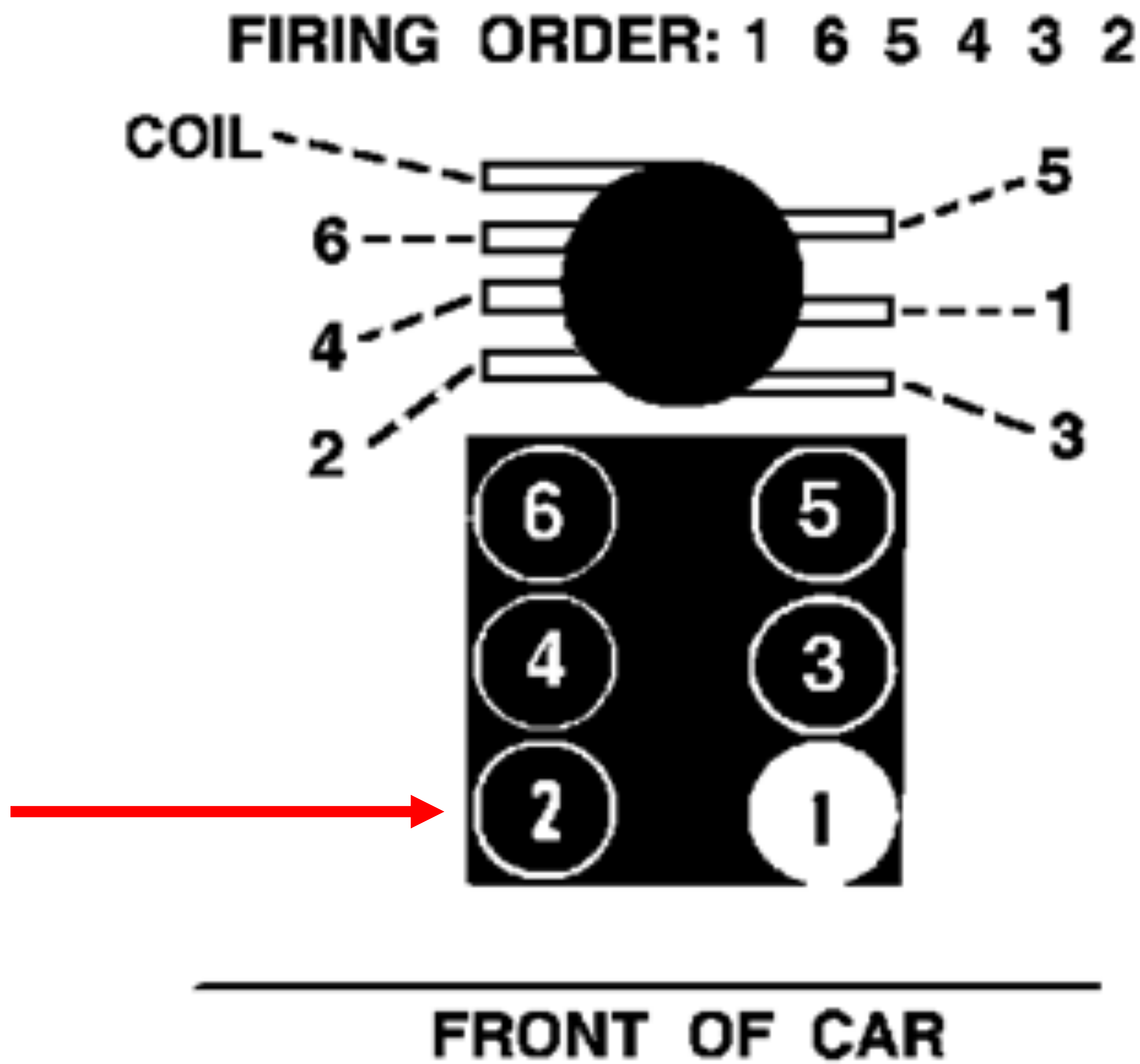

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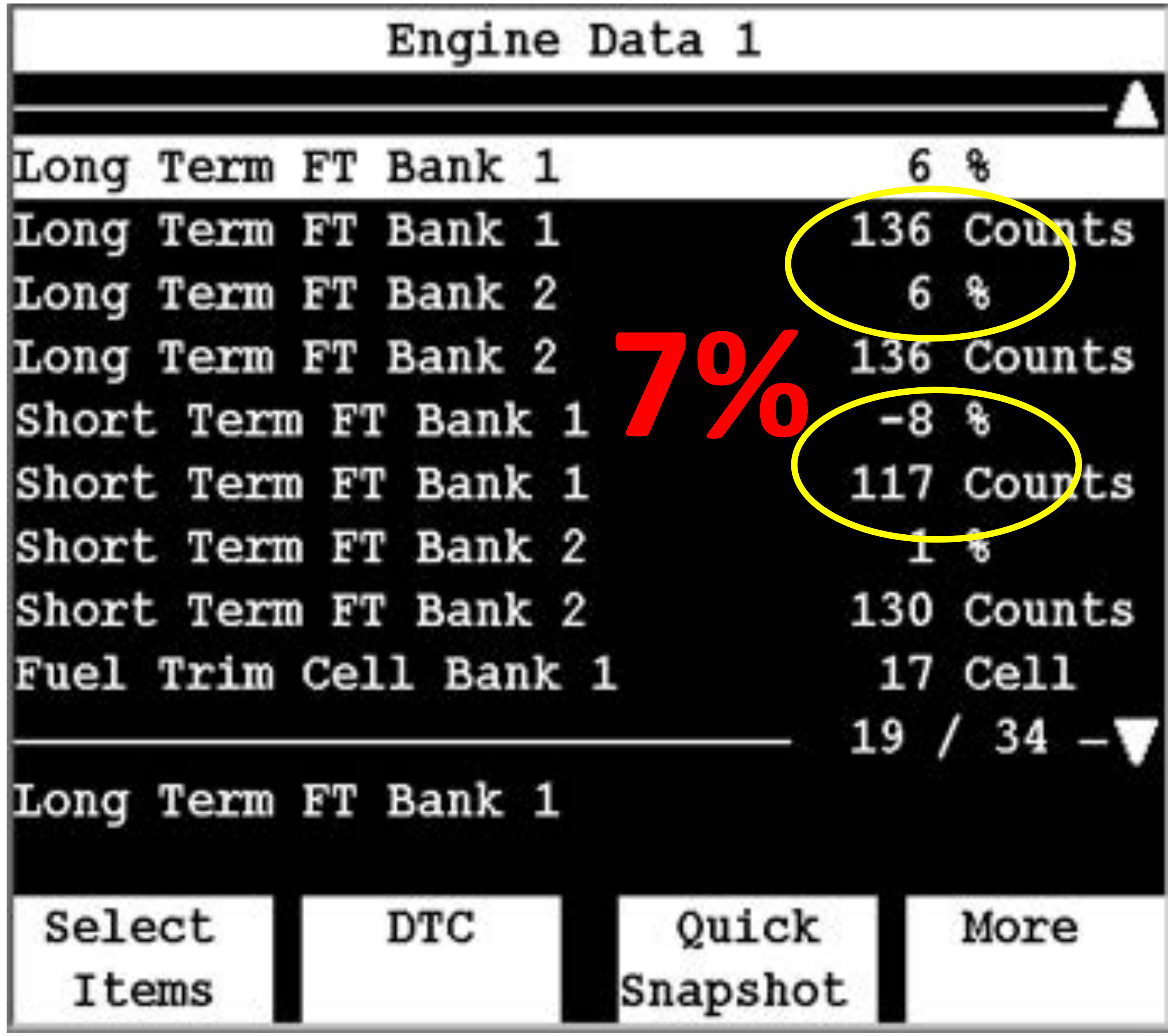


Engine Data 1
Long Term FT Bank 1 6 %
Long Term FT Bank 1 136 Counts
Long Term FT Bank 2 6 %
Long Term FT Bank 2 136 Counts
7%
Short Term FT Bank 1 -8 %
Short Term FT Bank 1 117 Counts
Short Term FT Bank 2 1 %
Short Term FT Bank 2 130 Counts
Fuel Trim Cell Bank 1 17 Cell
19 / 34
Long Term FT Bank 1
Select Items
DTC
Quick Snapshot
More

Trim Chart :
of injectors per bank

Applies to single cylinder fuel misfire

- 2 – 50%
- 3 – 33%
- 4 – 25%
- 5 – 20%
- 6 – 17%
- 8 – 13%

Caution: The greater the number of misfiring cylinders the less accurate this chart is.

1992 Oldsmobile Cierra 3.3 L

Runs Rough

No MIL (OBD I)

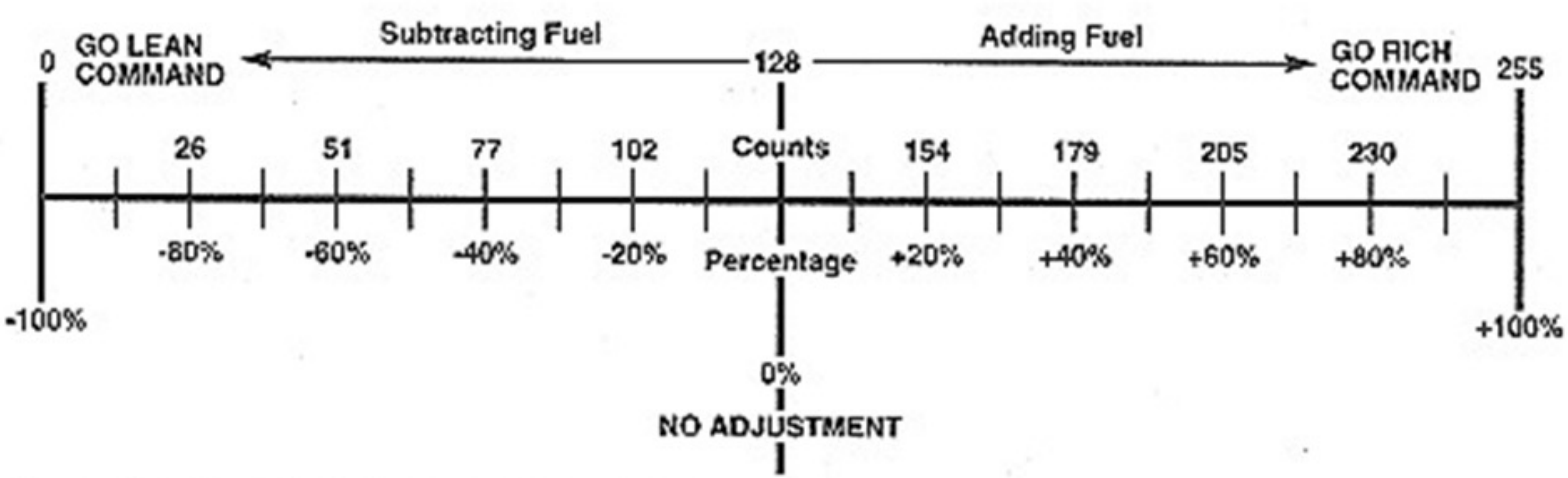
CURRENT
NO TROUBLE CODES

HISTORY
NO TROUBLE CODES

ENGINE RPM	660RPM
THROTTLE POS	0.40V
THROT ANGLE	0%
COOLANT TEMP	187°F
MAF	5.5GPS
LV8	80
O2 SENSOR	475mV
O2 CROSS-COUNTS	21
RICH/LEAN FLAG	LEAN
LOOP	CLOSED
FUEL INTEGRATOR	126
BLK LRN MULT	113

FUEL INTEGRATOR 126 --------- STFT -1.5%

BLOCK LEARN 113 ---------------- LTFT -12%



Conversion of fuel trim from percentages to counts

Positive Percentage Conversions: *128 + (1.28 x percentage)*
Example: To convert +20% to counts, the formula would be *128 + (1.28 x 20) = 154*

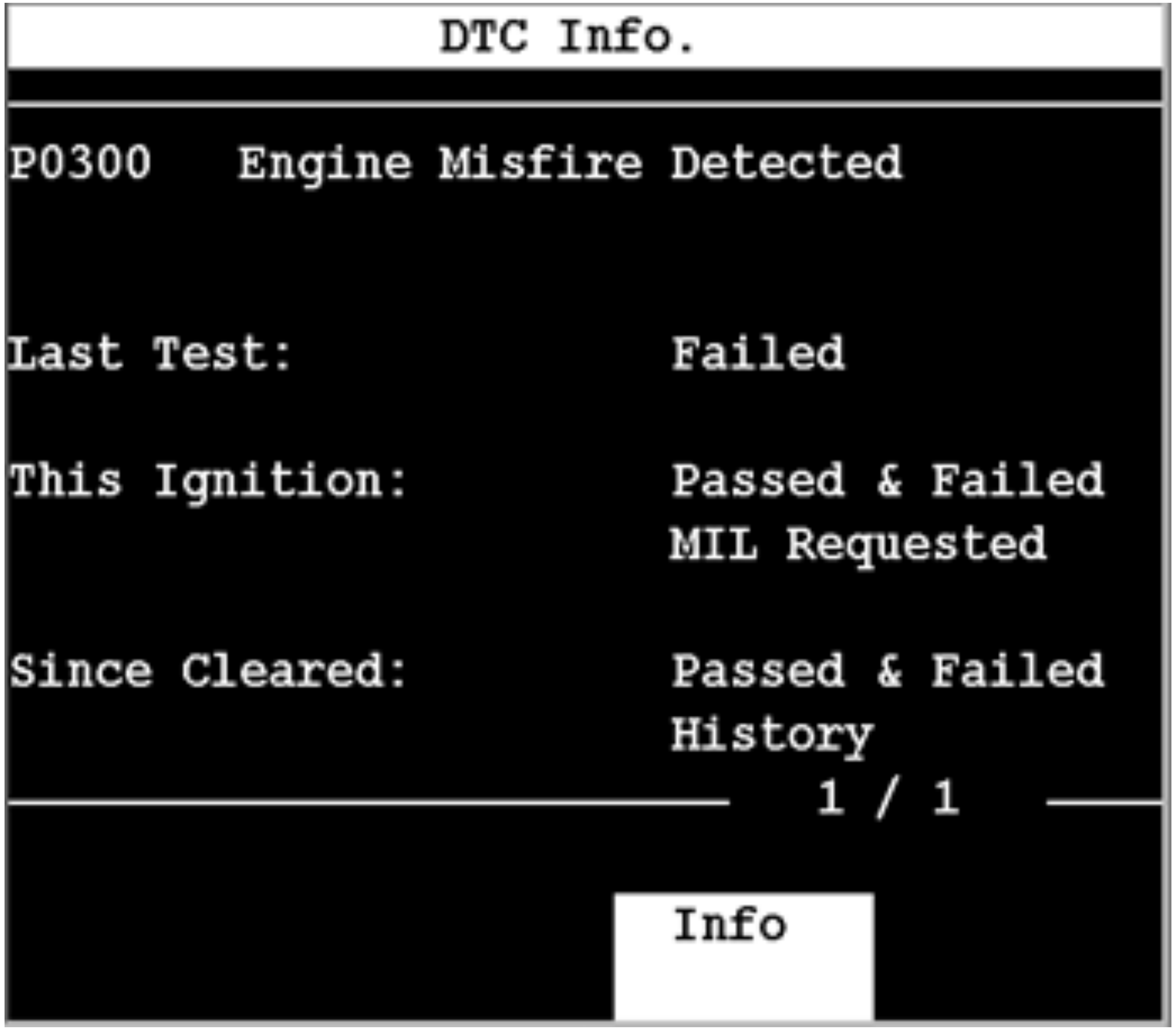
Negative Percentage Conversions: *128 - (1.28 x percentage)*
Example: To convert -20% to counts, the formula would be *128 - (1.28 x 20) = 102*

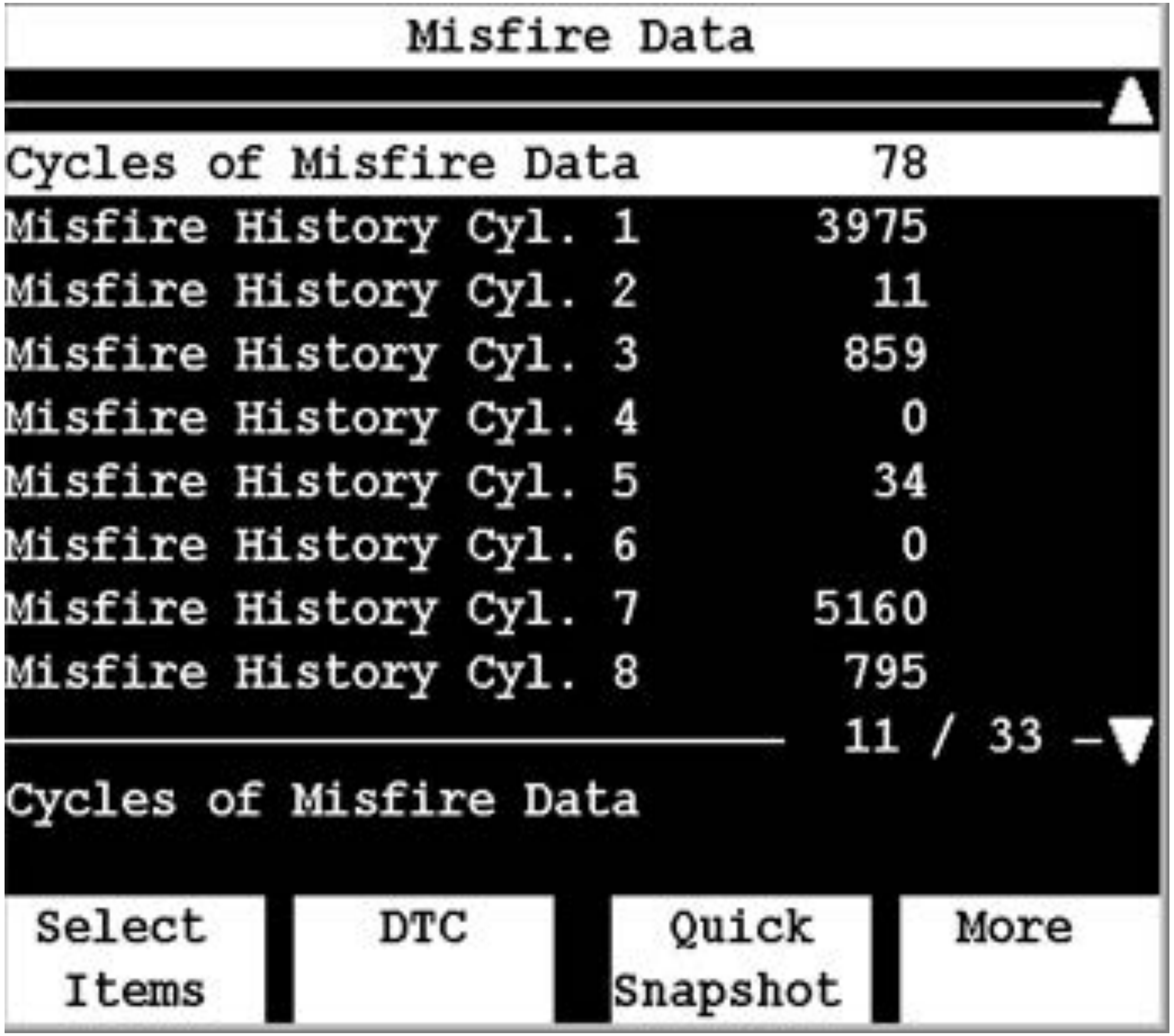
2002 GMC Yukon 5.3 L

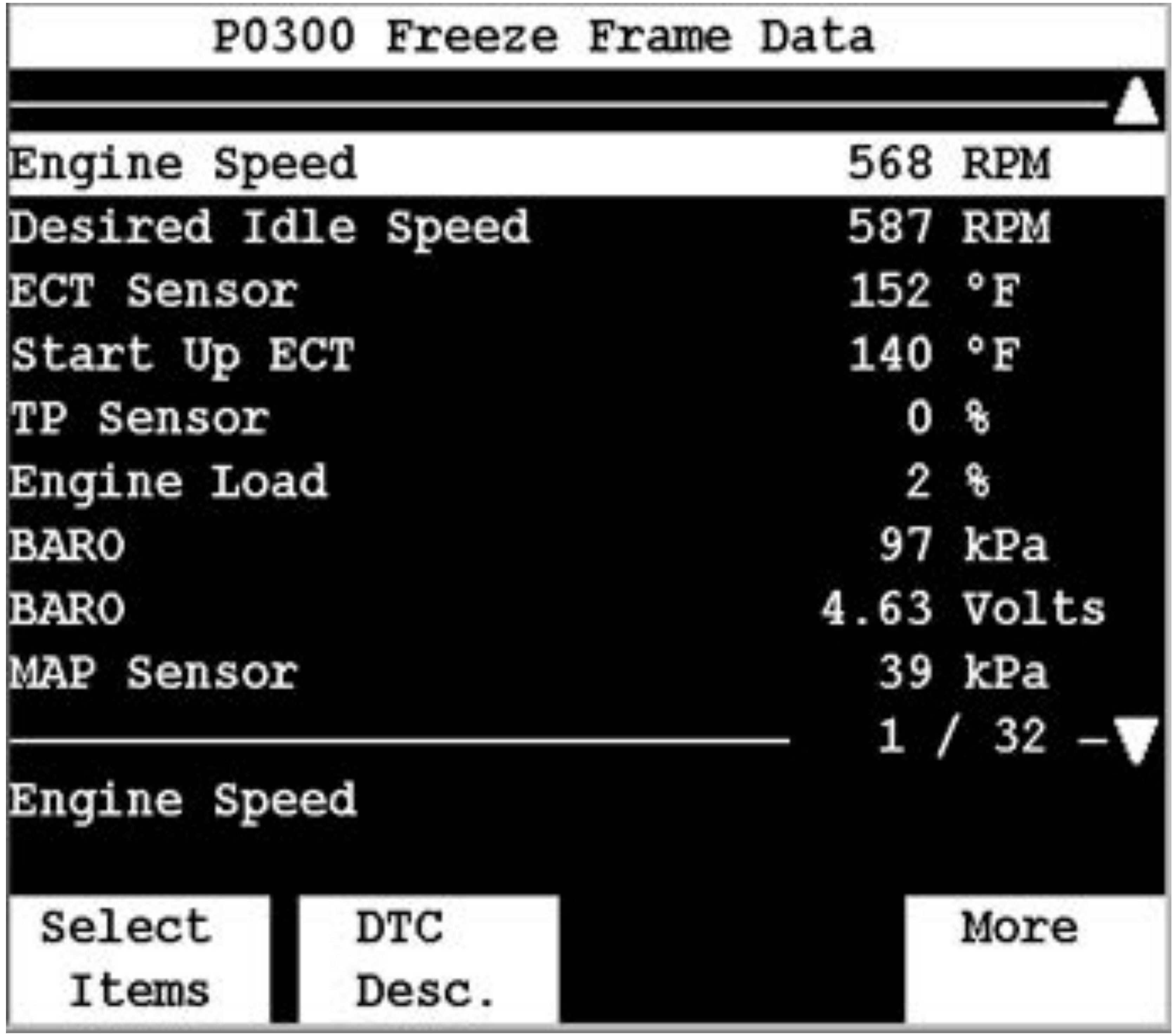
Runs rough / MIL on

P0300

"It ran good yesterday. I let my son borrow it last night. When I tried to drive it this morning it barely ran."


DTC Info.
P0300 Engine Misfire Detected
Last Test: Failed
This Ignition: Passed & Failed
MIL Requested
Since Cleared: Passed & Failed
History
1 / 1
Info


Misfire Data
Cycles of Misfire Data 78
Misfire History Cyl. 1 3975
Misfire History Cyl. 2 11
Misfire History Cyl. 3 859
Misfire History Cyl. 4 0
Misfire History Cyl. 5 34
Misfire History Cyl. 6 0
Misfire History Cyl. 7 5160
Misfire History Cyl. 8 795
11 / 33
Cycles of Misfire Data
Select Items
DTC
Quick Snapshot
More


P0300 Freeze Frame Data
Engine Speed 568 RPM
Desired Idle Speed 587 RPM
ECT Sensor 152 °F
Start Up ECT 140 °F
TP Sensor 0 %
Engine Load 2 %
BARO 97 kPa
BARO 4.63 Volts
MAP Sensor 39 kPa
1 / 32
Engine Speed
Select Items
DTC Desc.
More

P0300 Freeze Frame Data

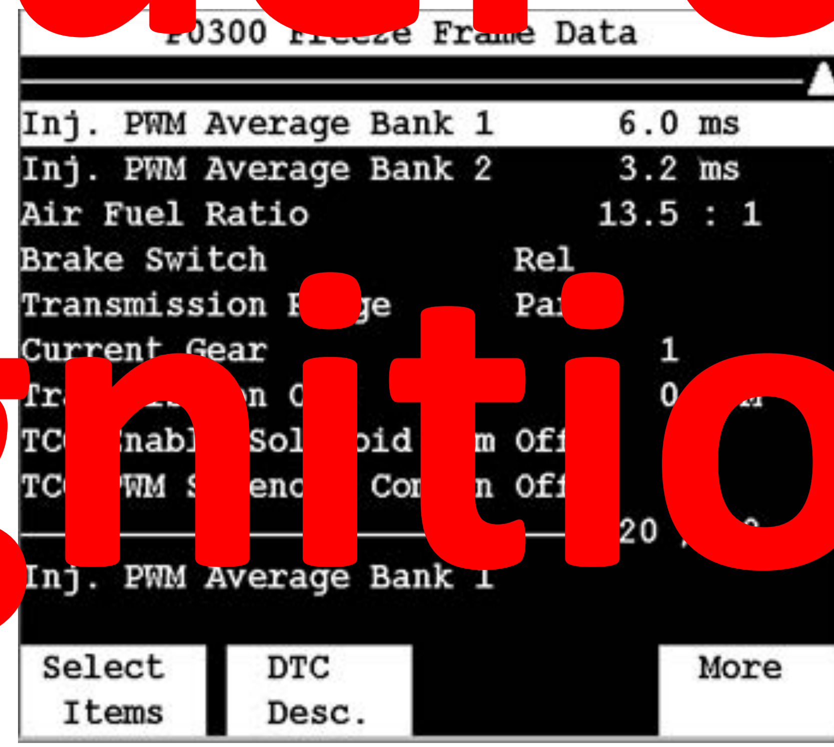
MAF Sensor	6.46 g/s
EGR Position Sensor	0.00 Volts
EGR Position Sensor	0 %
Desired EGR Position	0 %
Loop Status	Clo
Short Term FT Bank 1	51 %
Long Term FT Bank 1	25 %
Short Term FT Bank 2	-2 %
Long Term FT Bank 2	-3 %

11 / 32

MAF Sensor

Select Items | DTC Desc. | More

Fuel or Ignition Issue?



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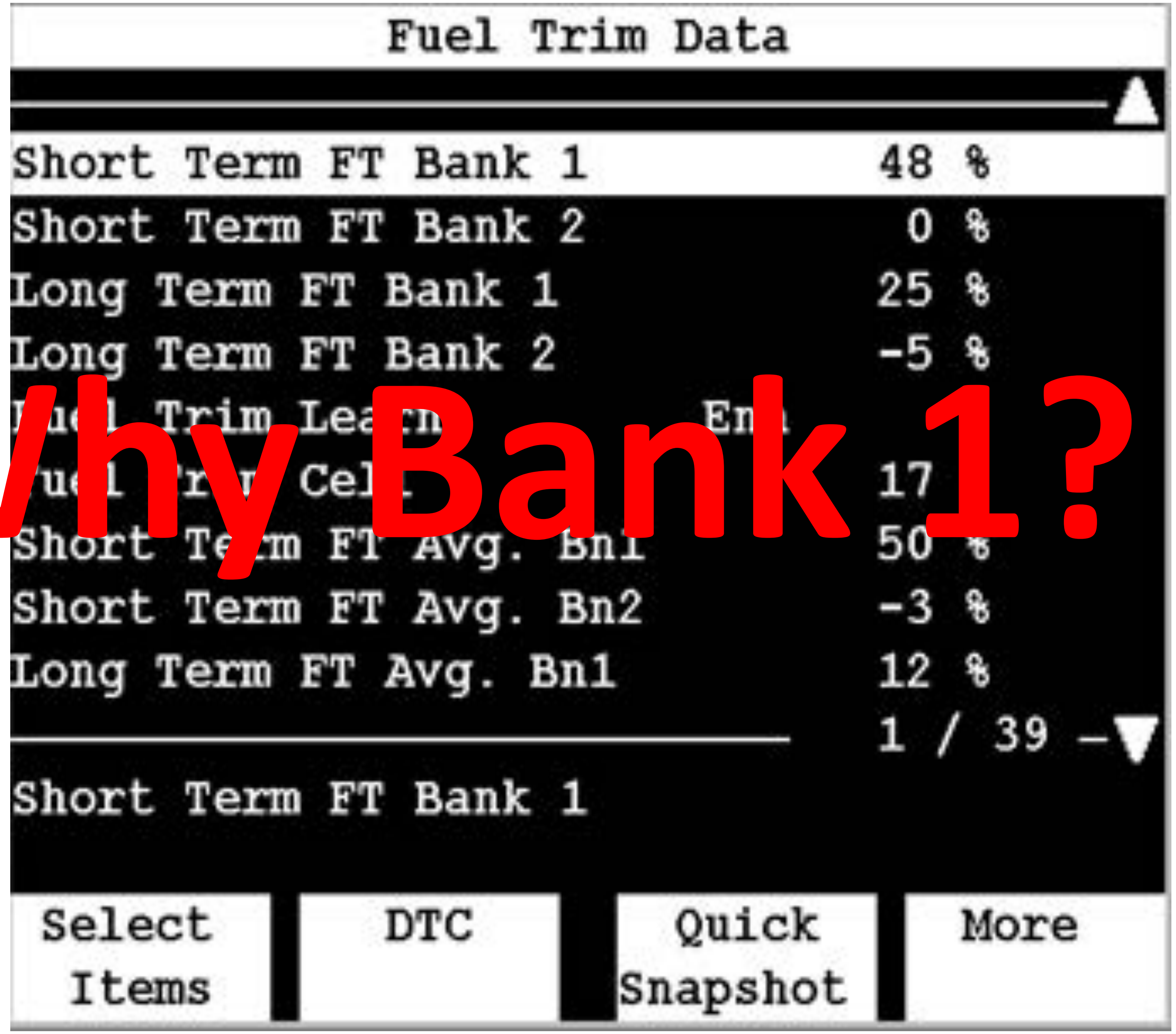
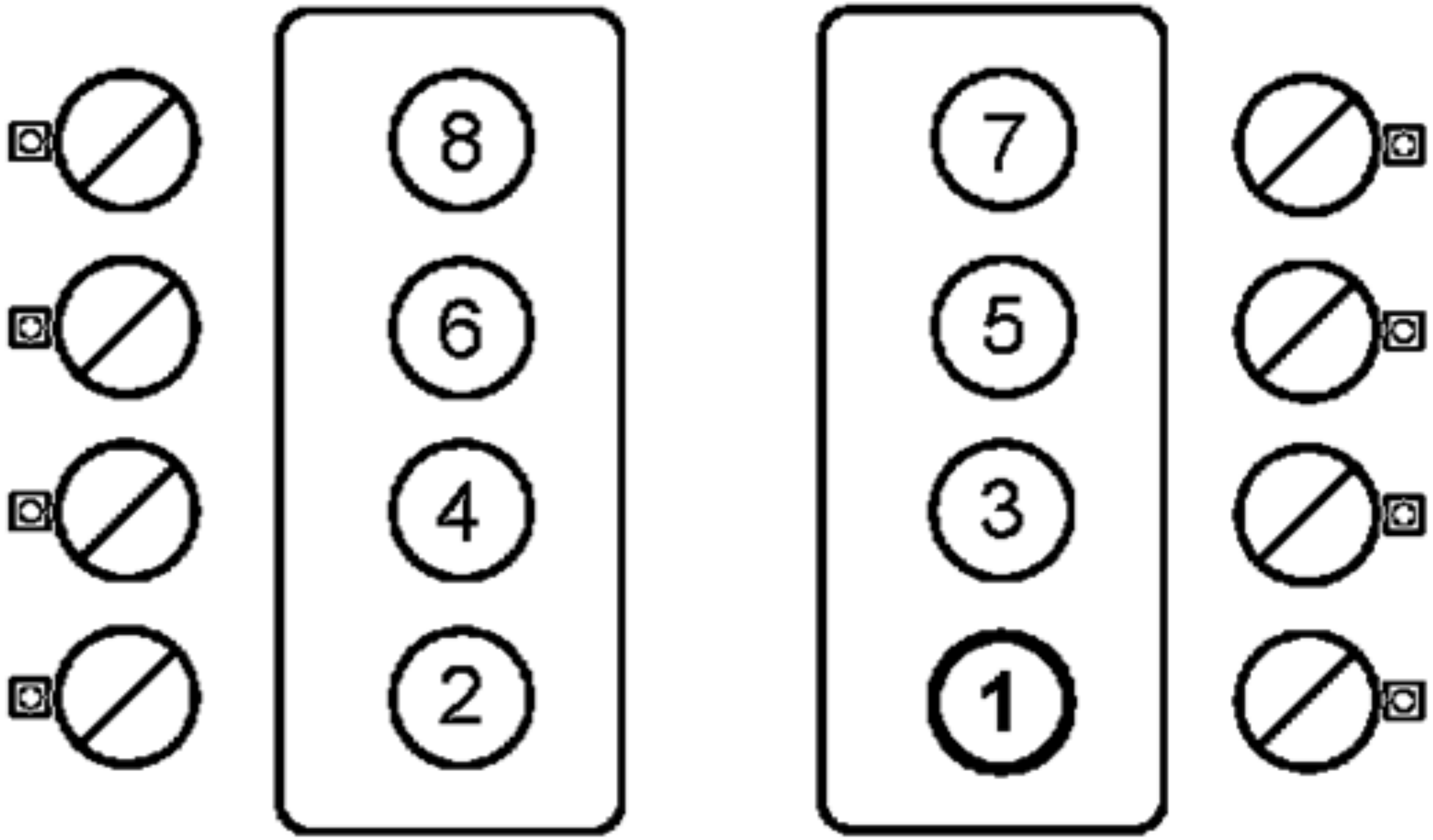
Why Bank 1?

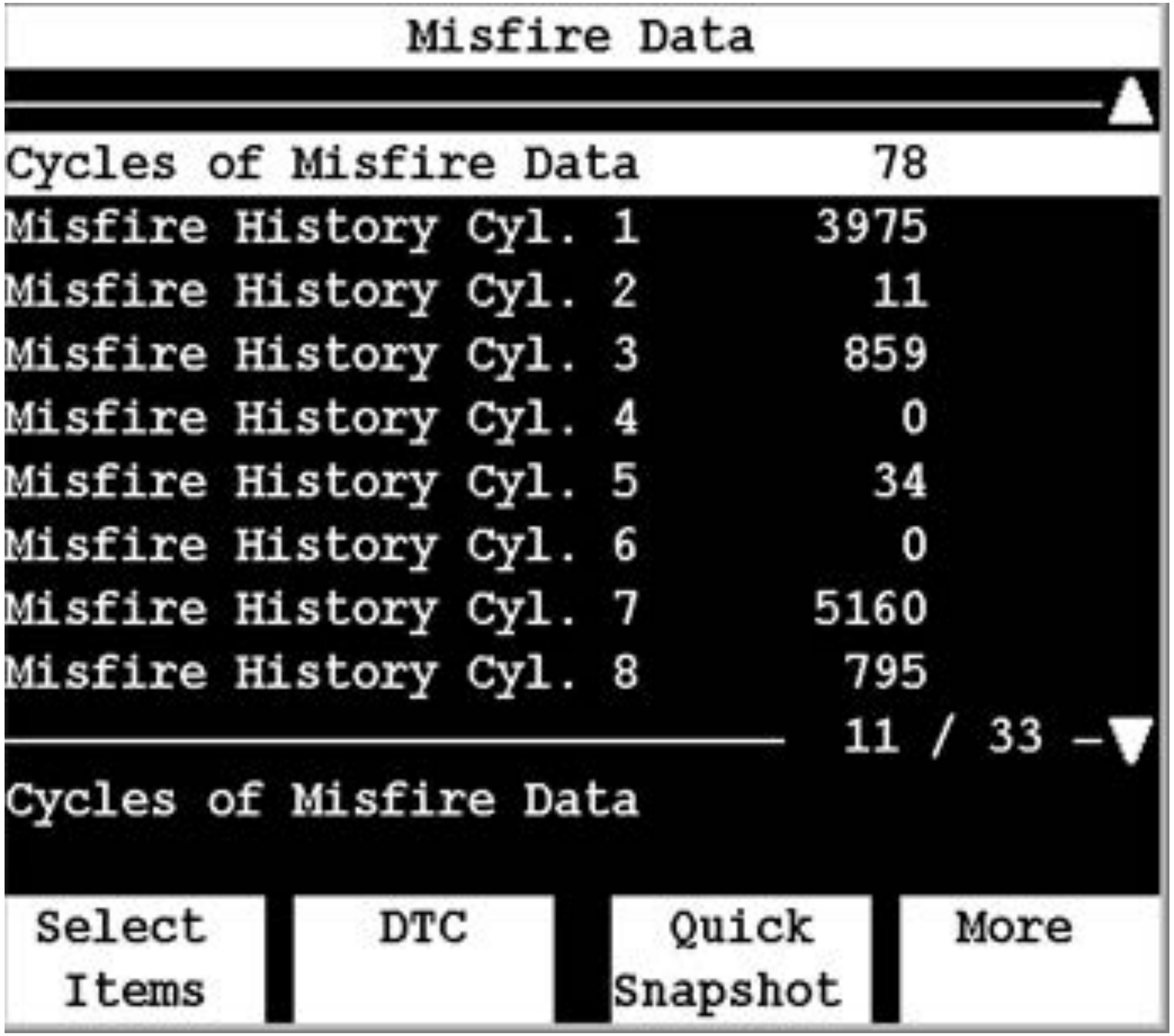


Fuel Trim Data
Short Term FT Bank 1 48 %
Short Term FT Bank 2 0 %
Long Term FT Bank 1 25 %
Long Term FT Bank 2 -5 %
17
50
Short Term FT Avg. Bn2 -3 %
Long Term FT Avg. Bn1 12 %
1 / 39
Short Term FT Bank 1
Select Items
DTC
Quick Snapshot
More

Firing Order :   1-8-7-2-6-5-4-3

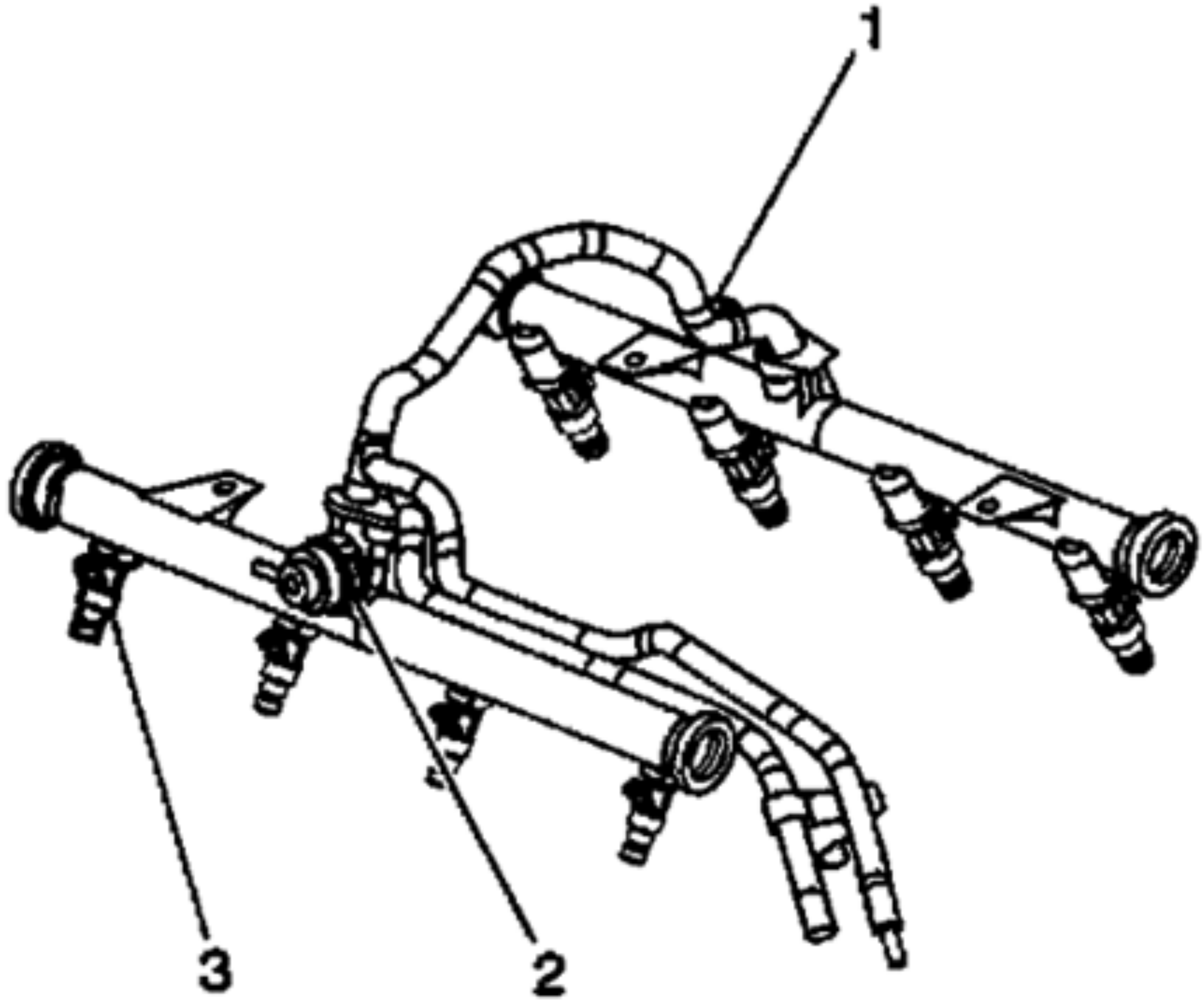


Front of Vehicle

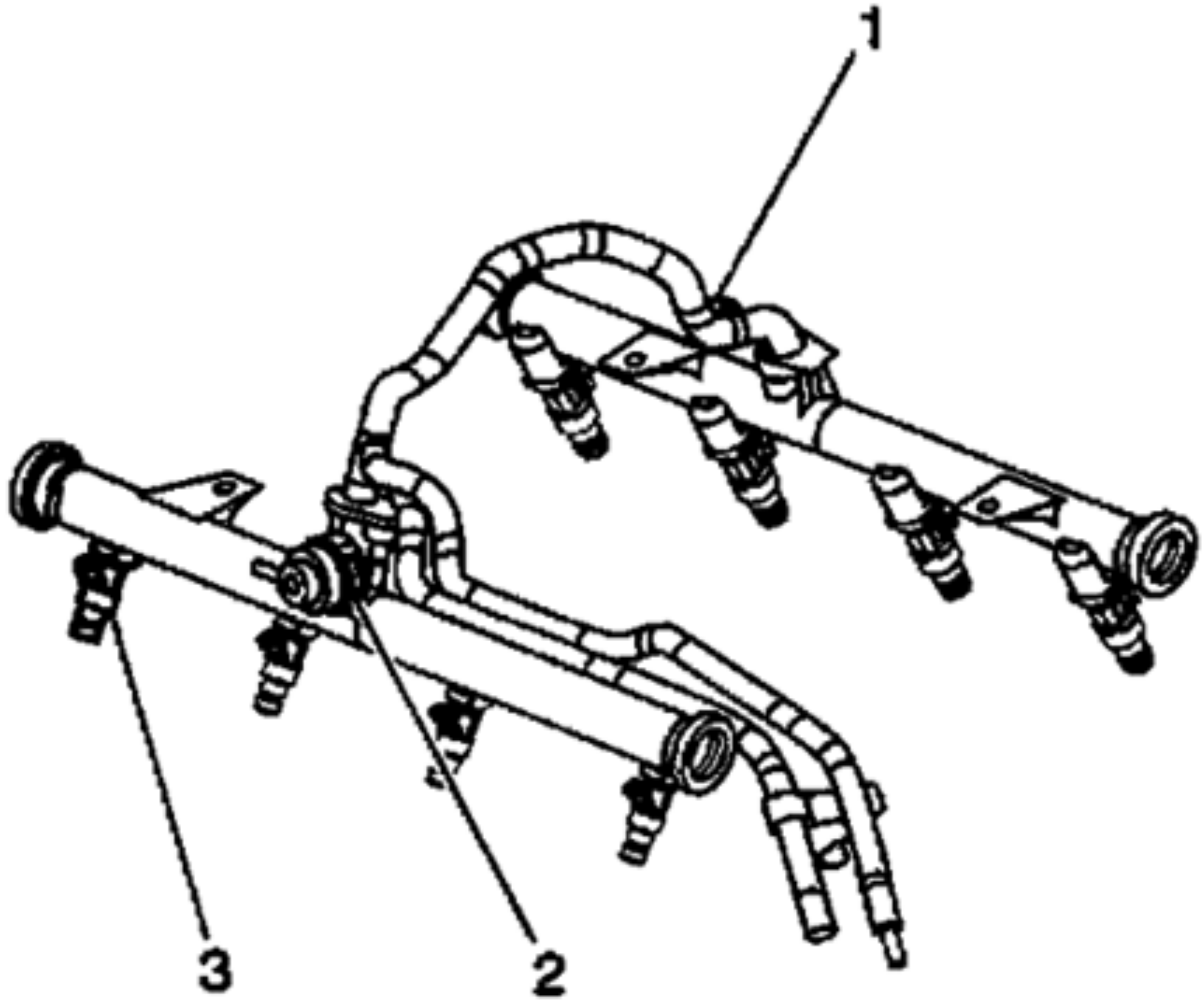

Misfire Data
Cycles of Misfire Data 78
Misfire History Cyl. 1 3975
Misfire History Cyl. 2 11
Misfire History Cyl. 3 859
Misfire History Cyl. 4 0
Misfire History Cyl. 5 34
Misfire History Cyl. 6 0
Misfire History Cyl. 7 5160
Misfire History Cyl. 8 795
11 / 33
Cycles of Misfire Data
Select Items
DTC
Quick Snapshot
More

Let’s talk this one through

- Fuel trim numbers are very positive which suggests a lack of fuel
- Ignition is also not likely because this vehicle is COP
- We also know that 1 injector is not likely to be the only issue…
- But is this still a fuel issue?


1
2
3

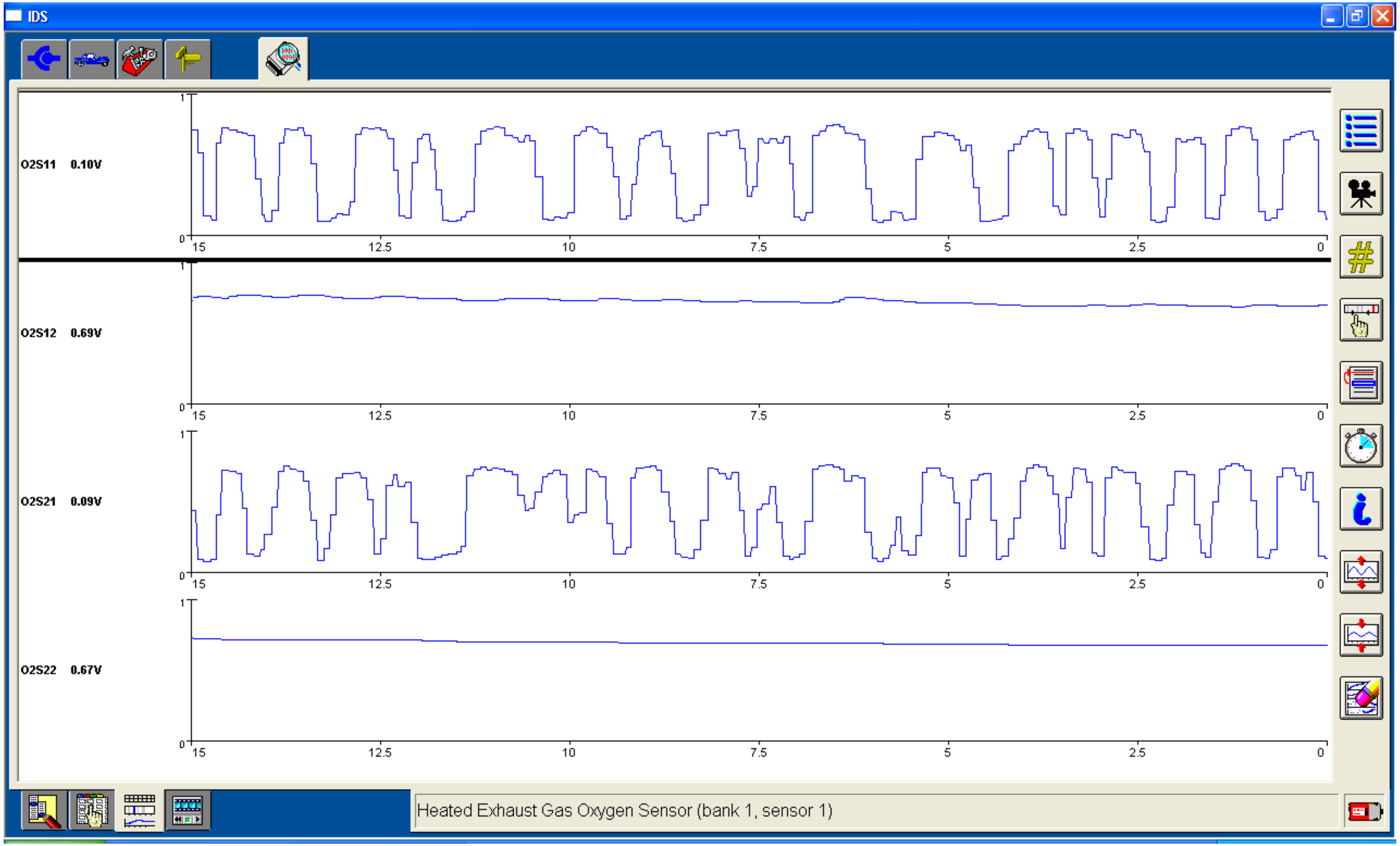

DELPHI


1
2
3

What other data can we use for misfire diagnosis?

Downstream O2 sensors

Downstream O2 sensors are mainly used for catalyst monitoring and minor fuel trim corrections. But that does not mean we can't observe them for diagnostic purposes.



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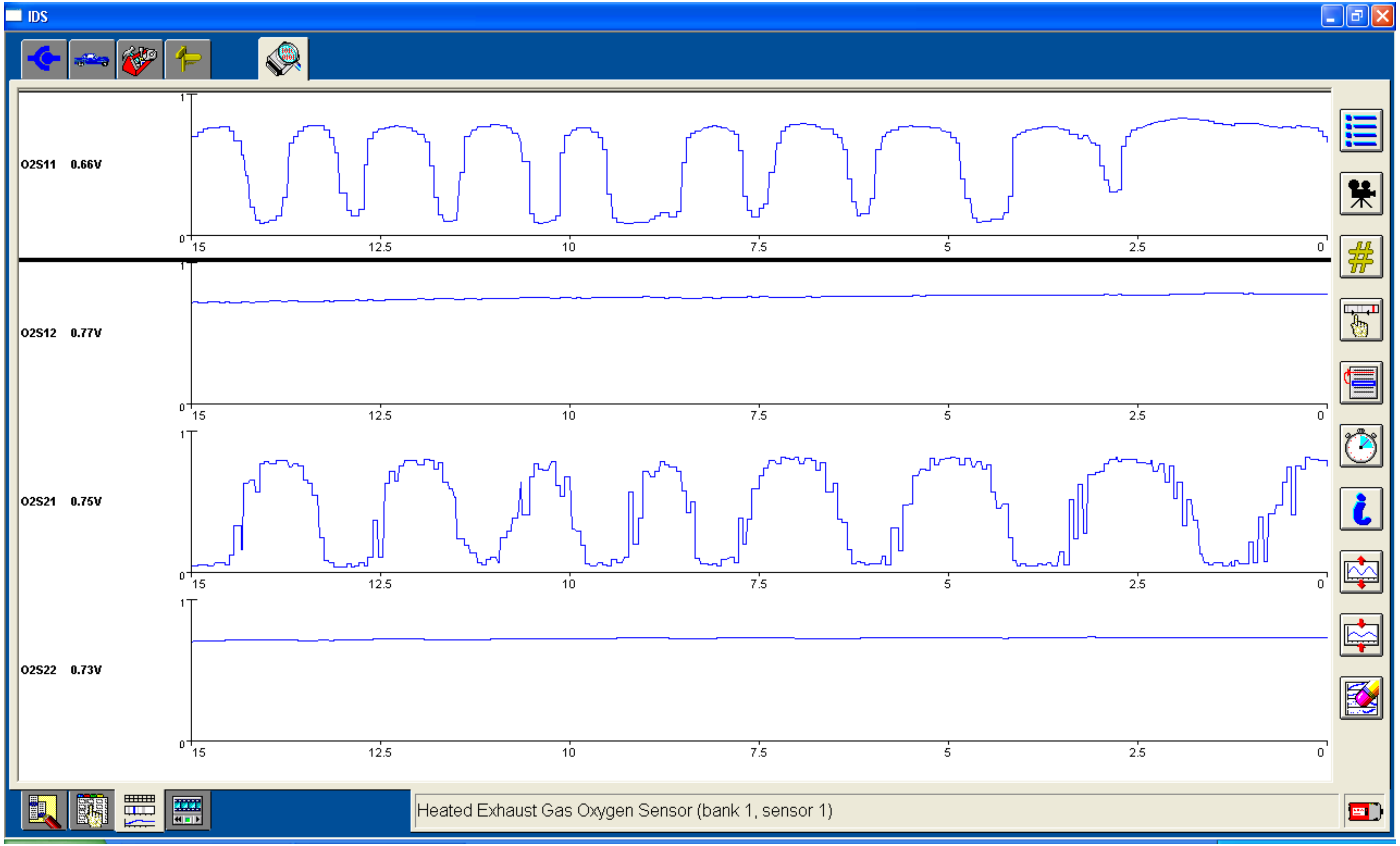
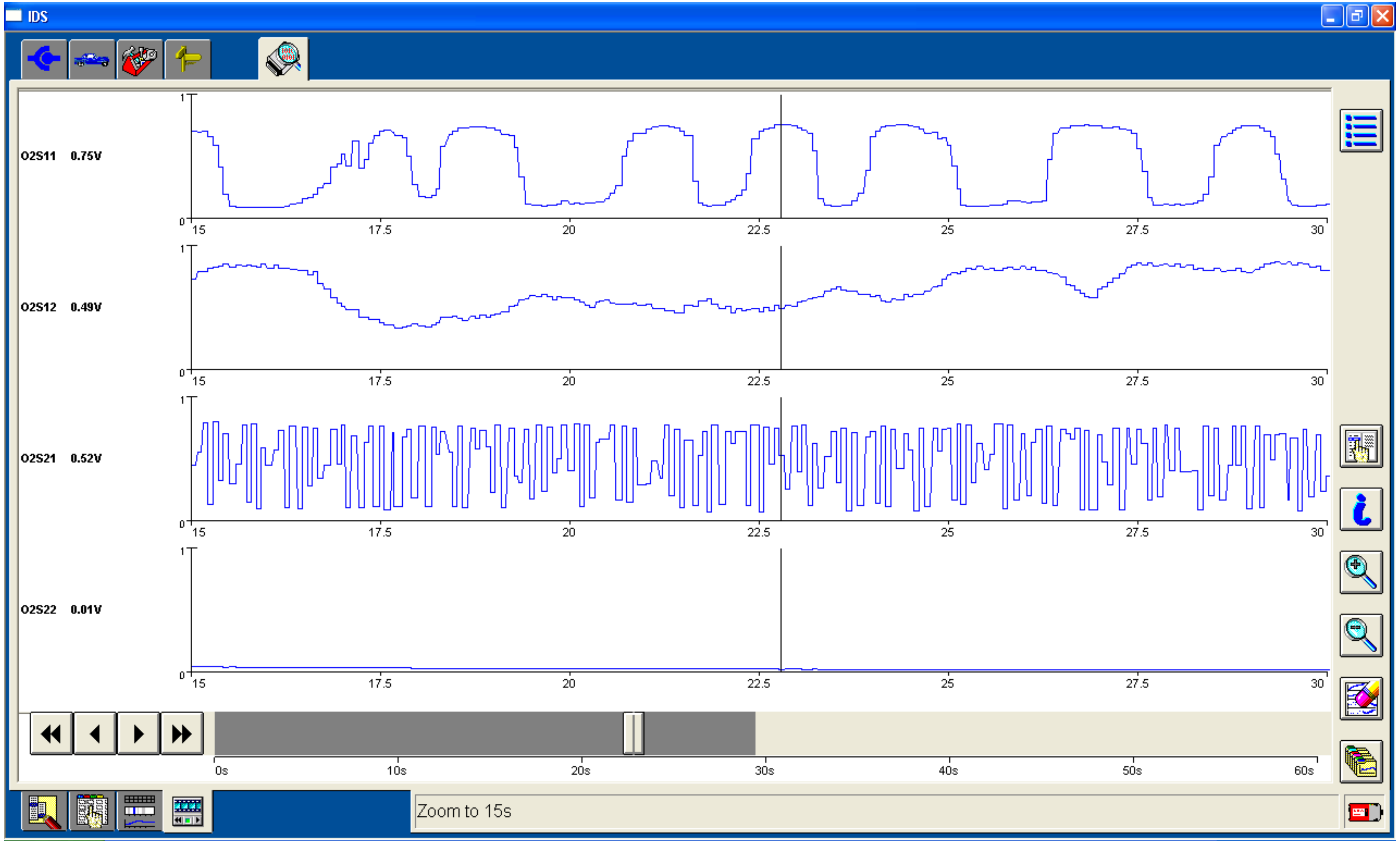


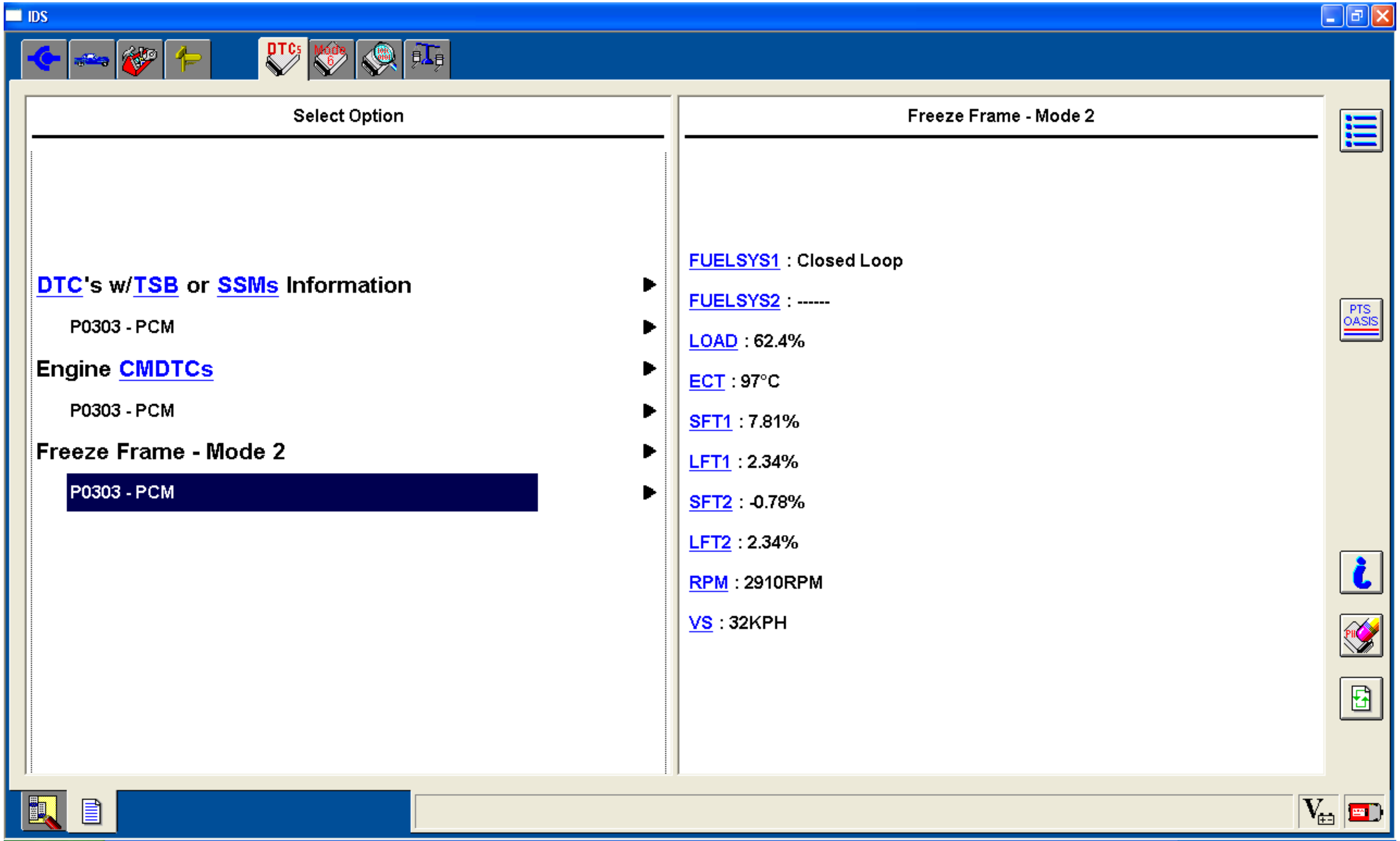
WTI WORLDPAC Training Institute.

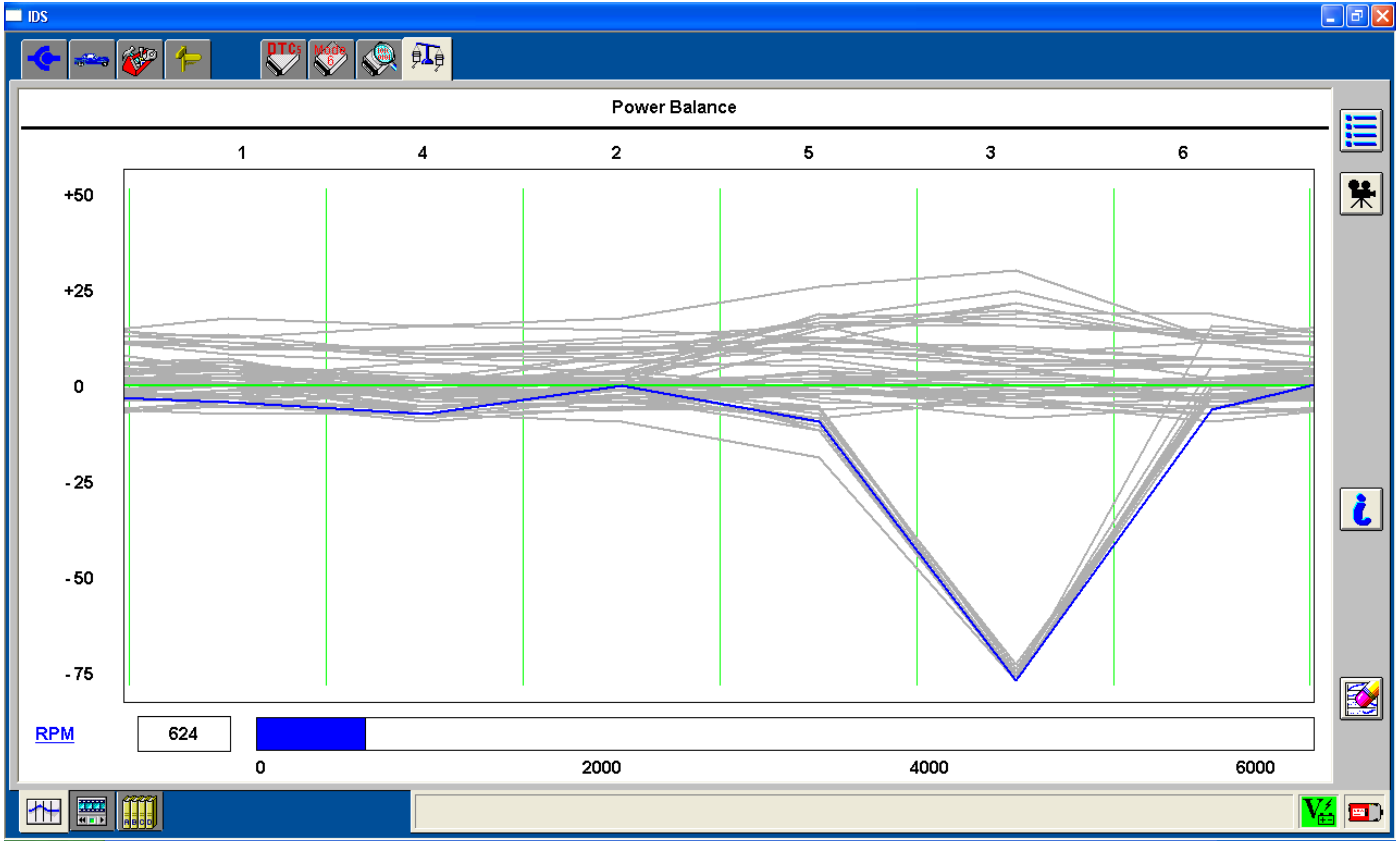

IDS
O2S11 0.75V
O2S12 0.49V
O2S21 0.52V
O2S22 0.01V
15
17.5
20
22.5
25
27.5
30
0s
10s
20s
30s
40s
50s
60s
Zoom to 15s

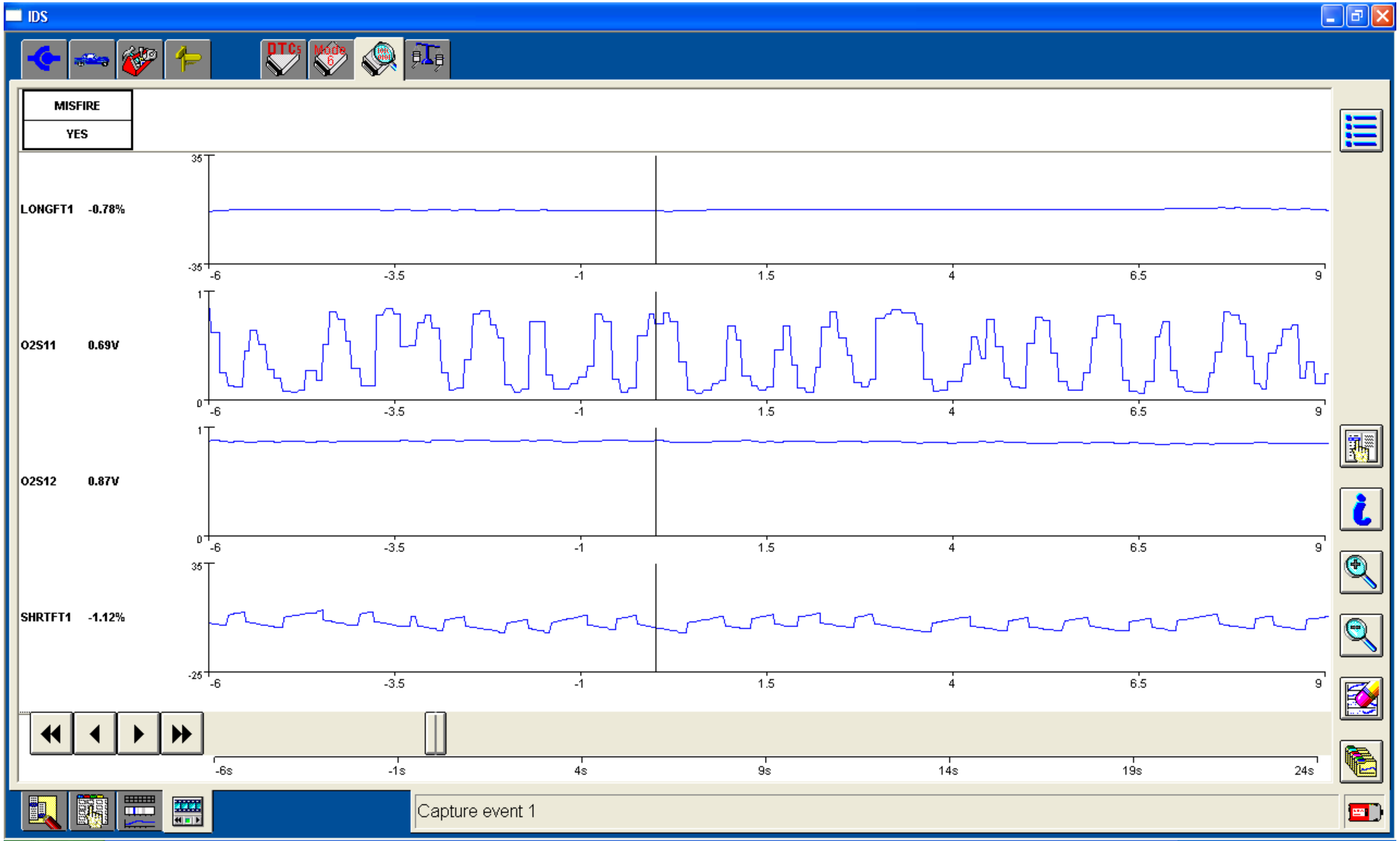
1998 Windstar 3.8 L

Runs Rough

Scan tool: IDS


IDS
DTCs
Mode 6
Select Option
DTC's w/TSB or SSMs Information
P0303 - PCM
Engine CMDTCs
P0303 - PCM
Freeze Frame - Mode 2
P0303 - PCM
Freeze Frame - Mode 2
FUELSYS1 : Closed Loop
FUELSYS2 : ------
LOAD : 62.4%
ECT : 97°C
SFT1 : 7.81%
LFT1 : 2.34%
SFT2 : -0.78%
LFT2 : 2.34%
RPM : 2910RPM
VS : 32KPH
PTS OASIS


IDS
Power Balance
1
4
2
5
3
6
+50
+25
0
-25
-50
-75
RPM
624
0
2000
4000
6000



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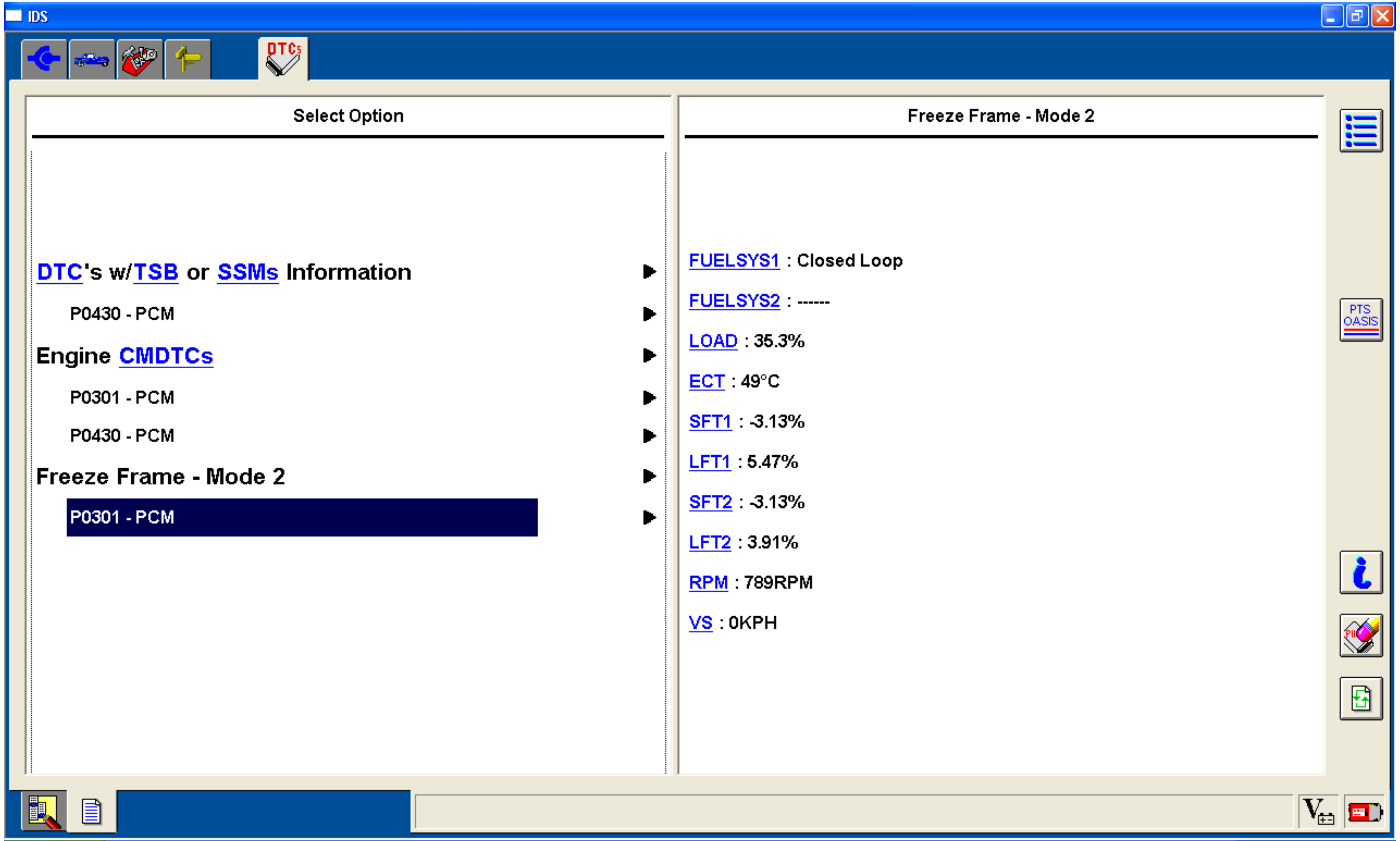
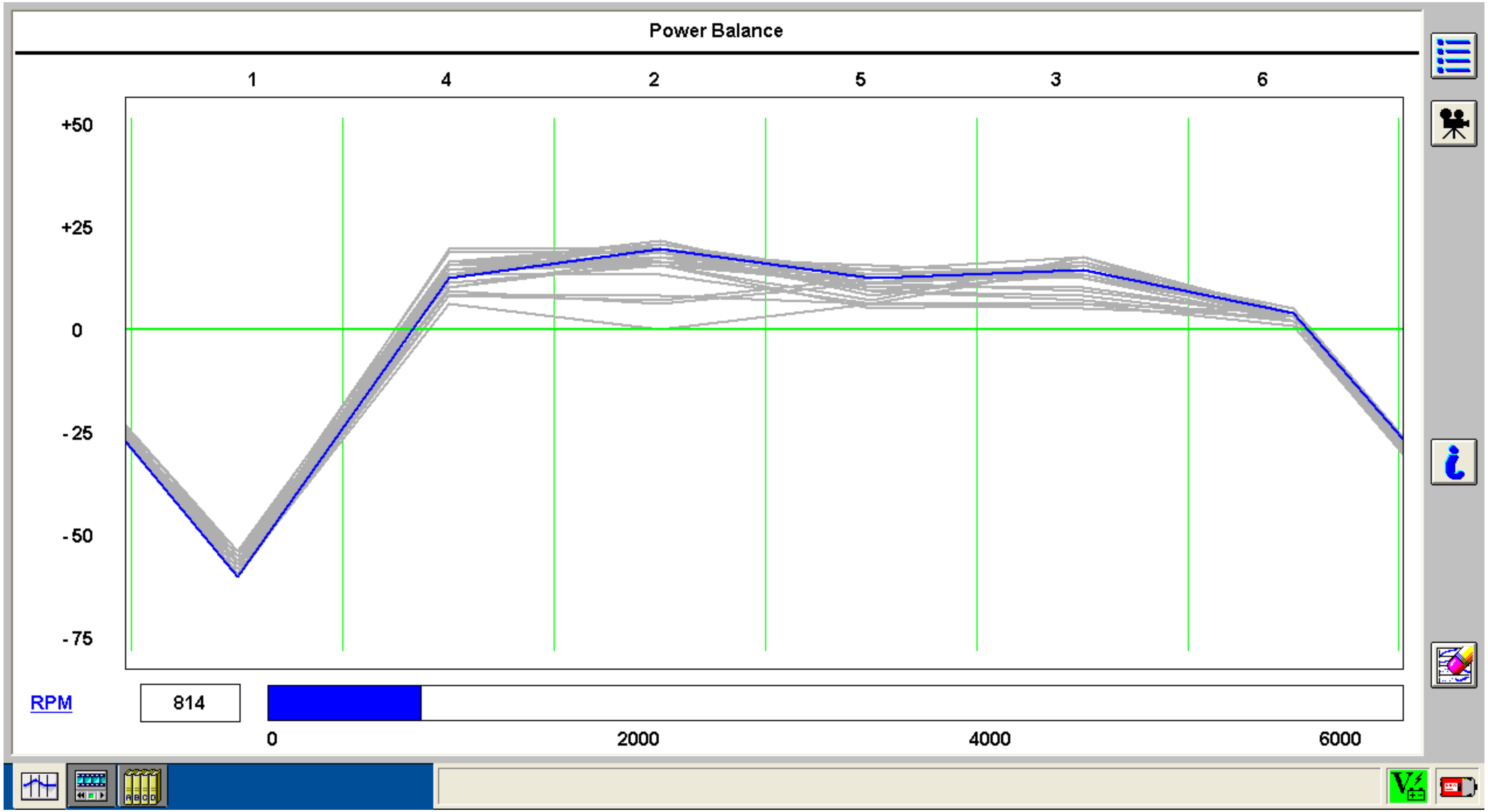
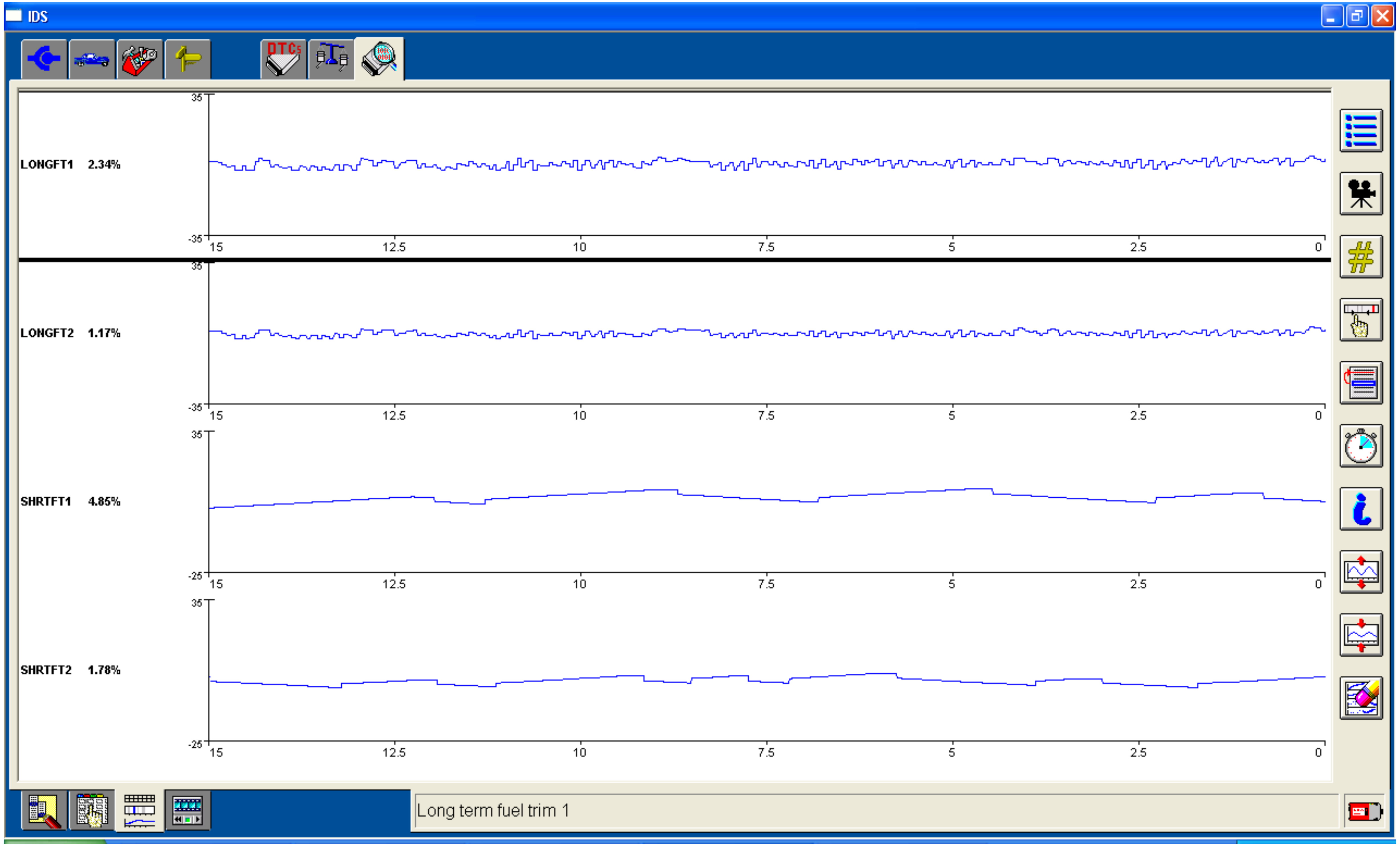
1999 Taurus 3.0 L

Runs Rough / MIL on

Scan tool: IDS


IDS
DTCs
Select Option
DTC's w/TSB or SSMs Information
P0430 - PCM
Engine CMDTCs
P0301 - PCM
P0430 - PCM
Freeze Frame - Mode 2
P0301 - PCM
Freeze Frame - Mode 2
FUELSYS1 : Closed Loop
FUELSYS2 : ------
LOAD : 35.3%
ECT : 49°C
SFT1 : -3.13%
LFT1 : 5.47%
SFT2 : -3.13%
LFT2 : 3.91%
RPM : 789RPM
VS : 0KPH
PTS OASIS


Power Balance
1
4
2
5
3
6
+50
+25
0
-25
-50
-75
RPM
814
0
2000
4000
6000



WTI
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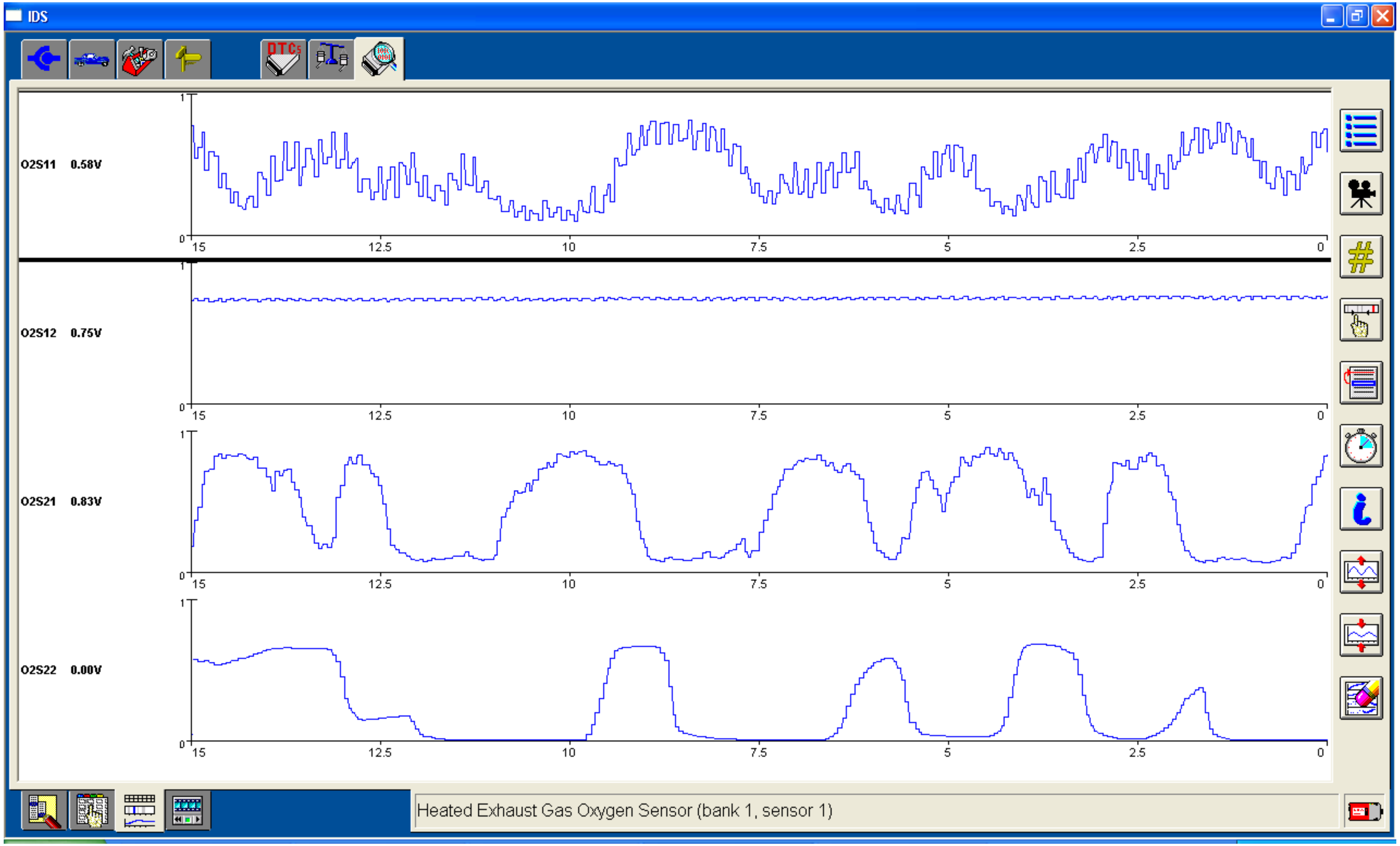
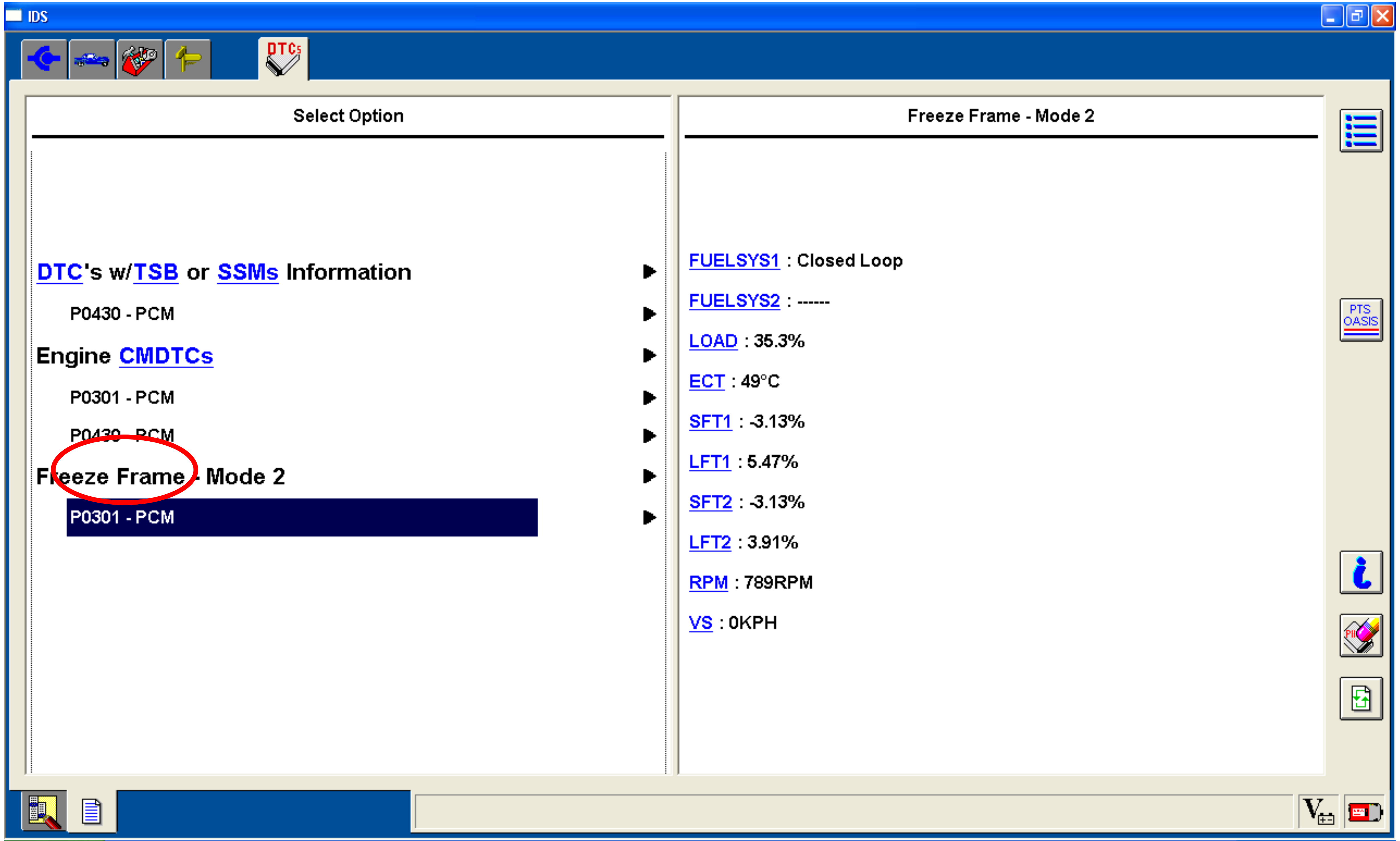

IDS
O2S11 0.58V
O2S12 0.75V
O2S21 0.83V
O2S22 0.00V
Heated Exhaust Gas Oxygen Sensor (bank 1, sensor 1)

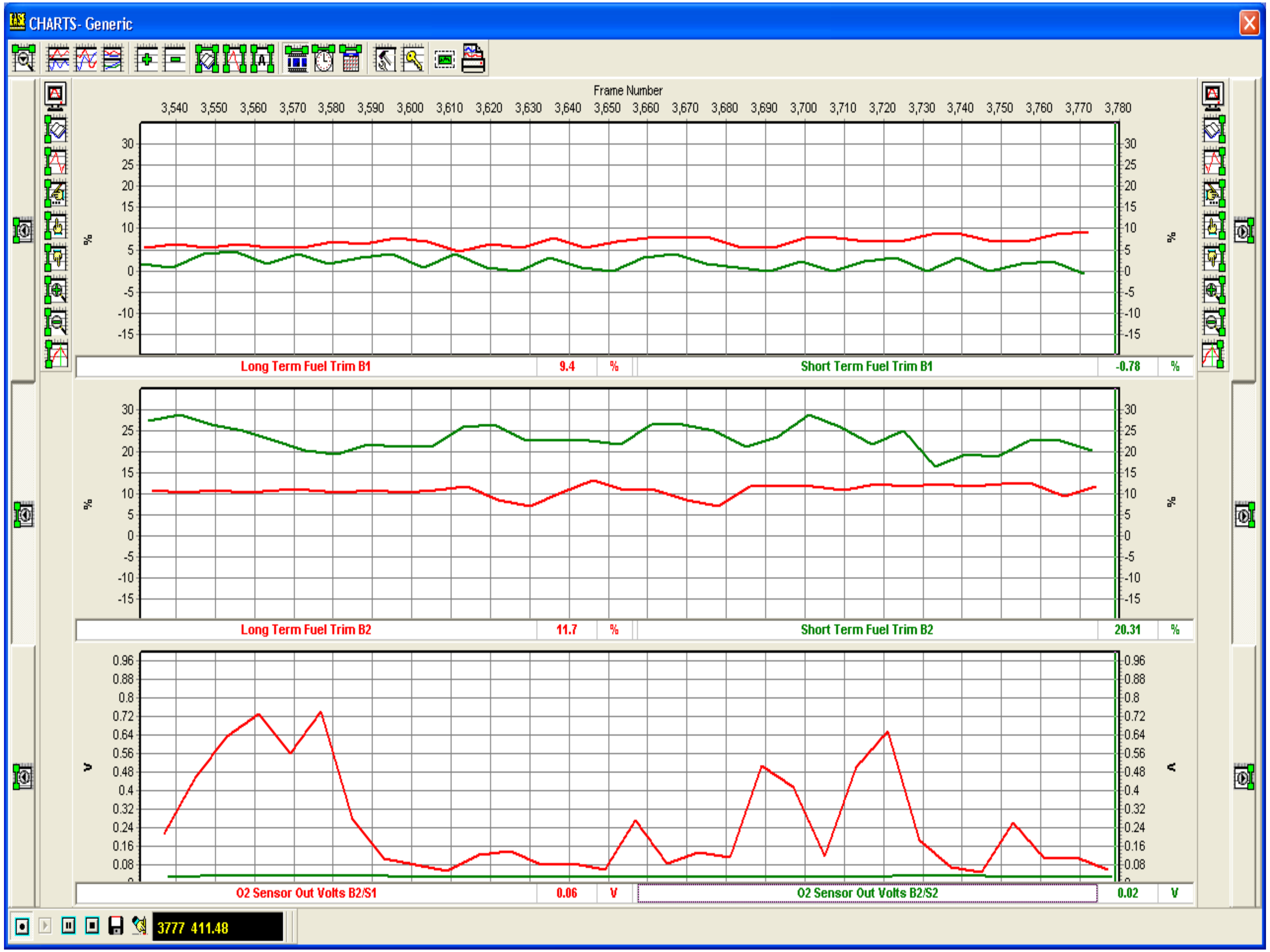

IDS
DTCs
Select Option
DTC's w/TSB or SSMs Information
P0430 - PCM
Engine CMDTCs
P0301 - PCM
P0430 - PCM
Freeze Frame - Mode 2
P0301 - PCM
Freeze Frame - Mode 2
FUELSYS1 : Closed Loop
FUELSYS2 : ------
LOAD : 35.3%
ECT : 49°C
SFT1 : -3.13%
LFT1 : 5.47%
SFT2 : -3.13%
LFT2 : 3.91%
RPM : 789RPM
VS : 0KPH
PTS OASIS

1999 Windstar 3.8 L

Misfire

How quick can you pick it out?

Scan tool: EASE
And Mastertech
Global OBD-II



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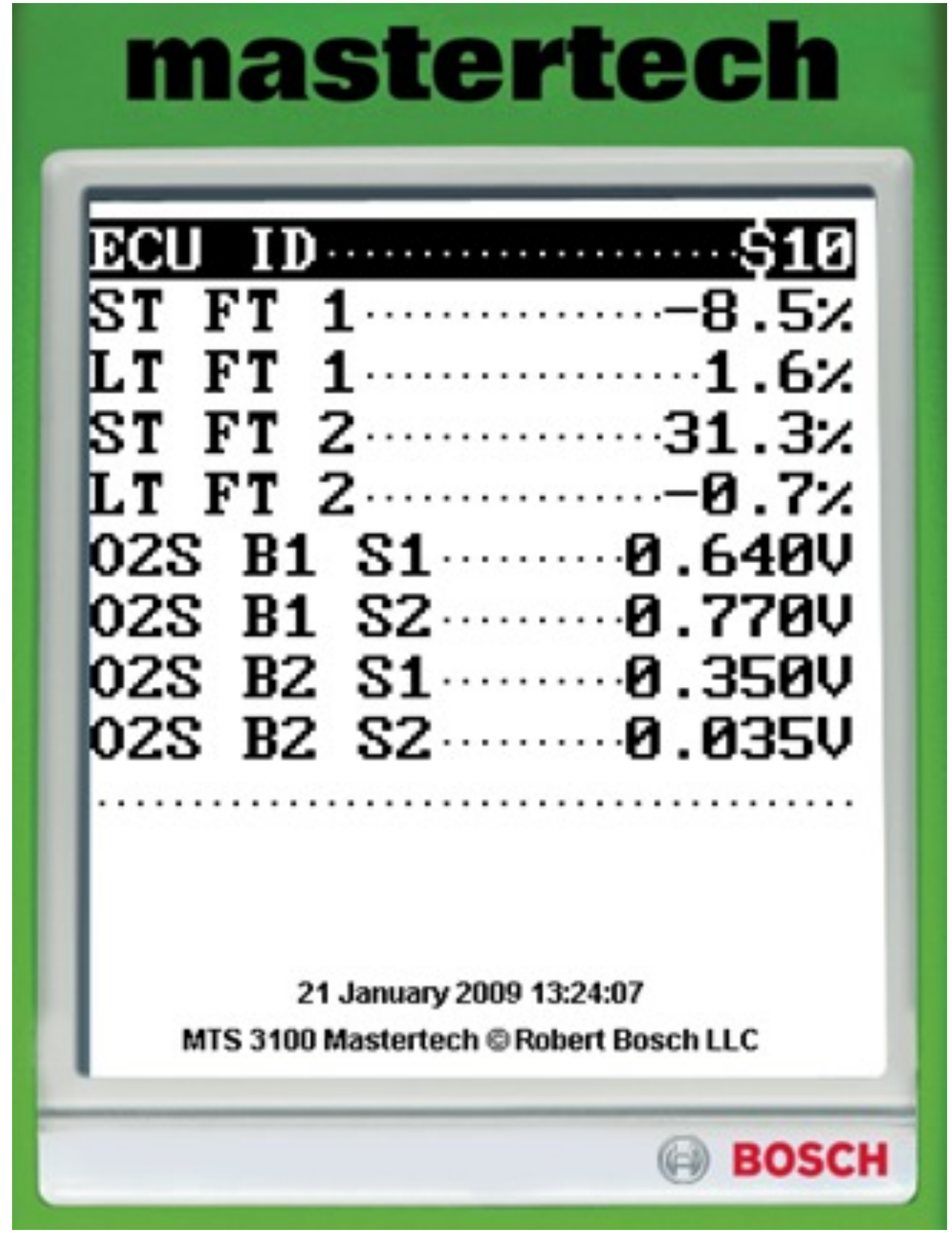
Same Vehicle:

Can we still pick out the likely cause without graphing?



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Misfire without codes

- Some manufacturers have misfire counters that will register even if the failing threshold of the Misfire monitor has not been exceeded.
- What about Ford?

Misfire Data 1

Engine Speed	660 RPM
Desired Idle	649 RPM
Misfire Current Cyl. 1	0
Misfire Current Cyl. 2	130
Misfire Current Cyl. 3	0
Misfire Current Cyl. 4	0
Misfire Current Cyl. 5	0
Misfire Current Cyl. 6	0
Engine Speed	654 RPM

1 / 28

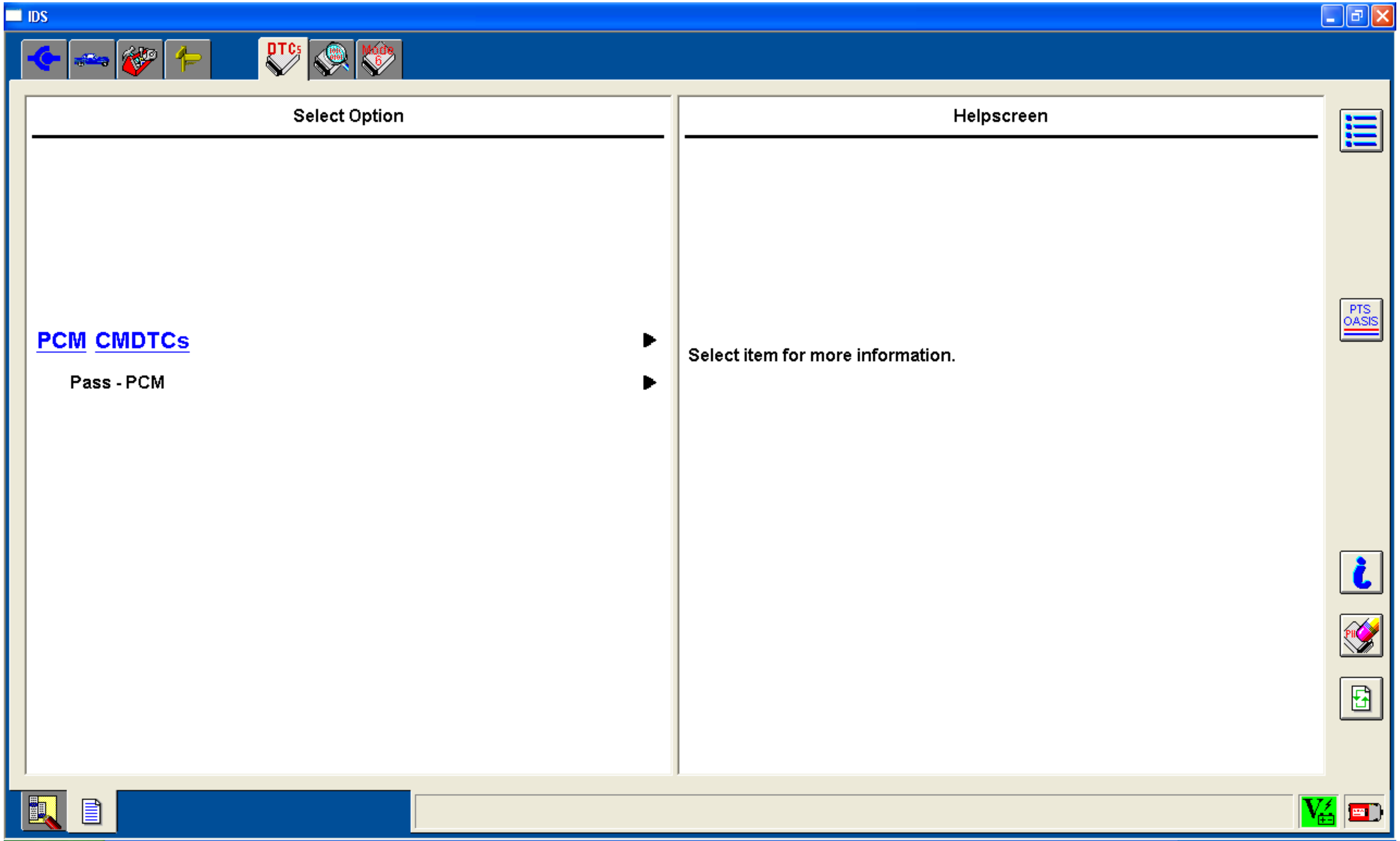
Engine Speed

Select Items	DTC	Quick Snapshot	More

1999 Ford Taurus 3.0 L

Mode $06 no code misfire

Scan tool: IDS


IDS
DTCs
Mode 6
Select Option
PCM CMDTCs
Pass - PCM
Helpscreen
Select item for more information.
PTS OASIS

IDS

Description	Test	Component	Limits	Value
HO2S11 Voltage Amplitude, Bank 1, Sensor 1	1	11	>= 0.52V	0.79V
HO2S21 Voltage Amplitude, Bank 2, Sensor 1	1	21	>= 0.52V	0.83V
Upstream Oxygen Sensor Switchpoint	3	1	>= 0V	0.45V
Downstream Oxygen Sensor Switchpoint	3	2	>= 0V	0.45V
Rear to front Switch Ratio Bank 2	10	21	<= 0.81:1	0:1
Rear to front Switch Ratio Bank 1	10	11	<= 0.81:1	0:1
Initial Tank Vacuum Reading (min limit)	21	0	>= 61.9k	64.8k
Initial Tank Vacuum Reading (max limit)	21	0	<= -6inH2O	-1inH2O
Leak Check Vacuum Bleedup	22	0	<= 3inH2O	3inH2O
Vapor Generation Max Pressure Rise	25	0	>= 2inH2O	-63inH2O
Delta Pressure for Upstream Hose Test	41	11	>= -6inH2O	-1inH2O
Delta Pressure for Downstream Hose Test	41	12	<= 7inH2O	-1inH2O
Delta Pressure for Stuck Open Valve Test	45	20	<= 1.74V	1.16V
Delta Pressure for Low Flow Test	4A	30	>= 6inH2O	17inH2O
Commanded EGR Dutycycle for Low Flow Test	4B	30	<= 80%	38.6%
Total Engine Misfire Rate & Type B Threshold	50	0	<= 3.93%	0%
Cylinder 1 Misfire Rate & Type A Threshold	53	1	<= 16.1%	0.49%
Cylinder 2 Misfire Rate & Type A Threshold	53	2	<= 16.1%	0%
Cylinder 3 Misfire Rate & Type A Threshold	53	3	<= 16.1%	0%
Cylinder 4 Misfire Rate & Type A Threshold	53	4	<= 16.1%	0%
Cylinder 5 Misfire Rate & Type A Threshold	53	5	<= 16.1%	0%
Cylinder 6 Misfire Rate & Type A Threshold	53	6	<= 16.1%	0%
Highest Type A Misfire Rate & Threshold	54	0	<= 16.1%	0.98%
Highest Type B Misfire Rate & Threshold	55	0	<= 2.46%	0.2%
Cylinder Events Tested	56	0	<= 3k	2.6k

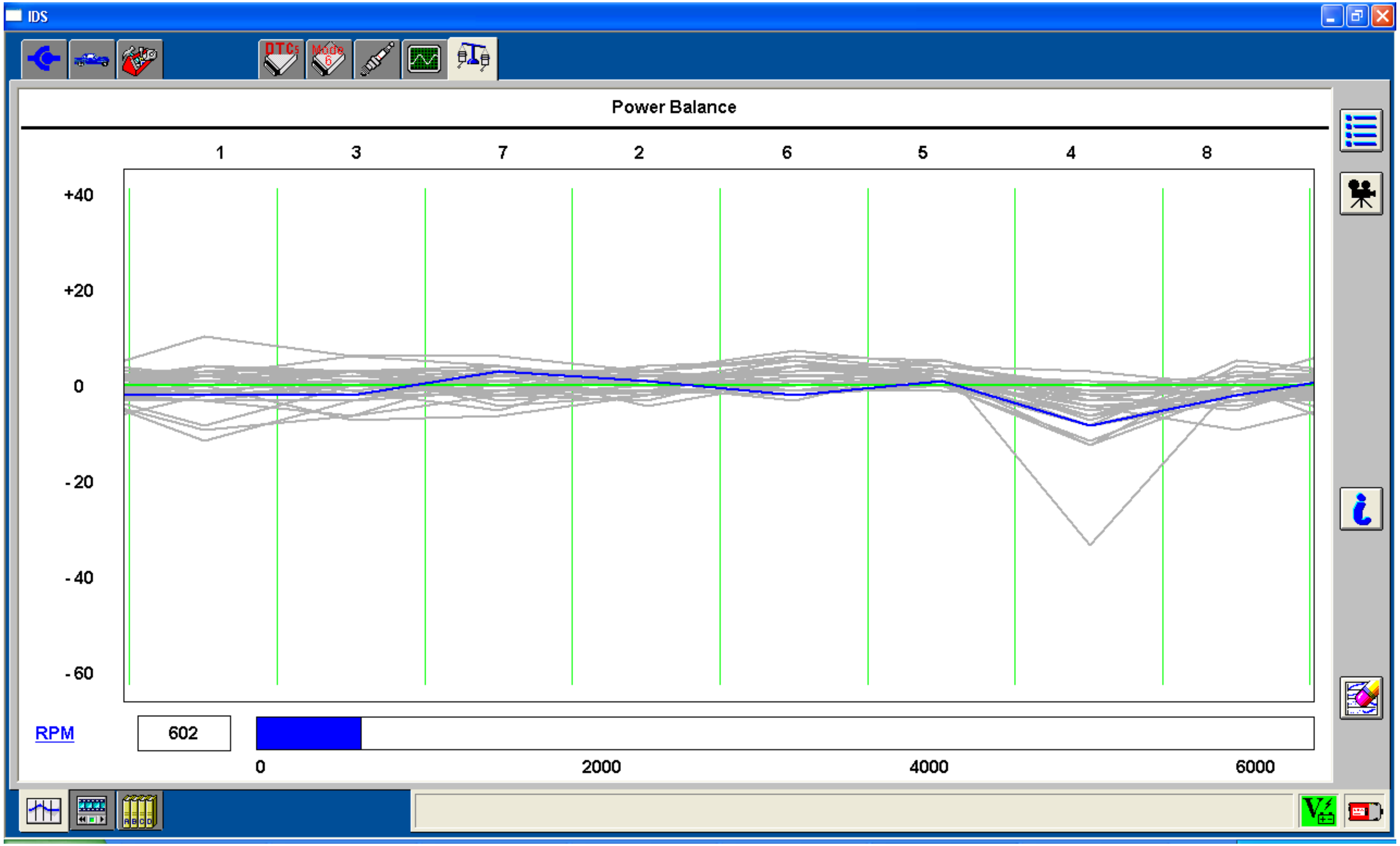
Complete

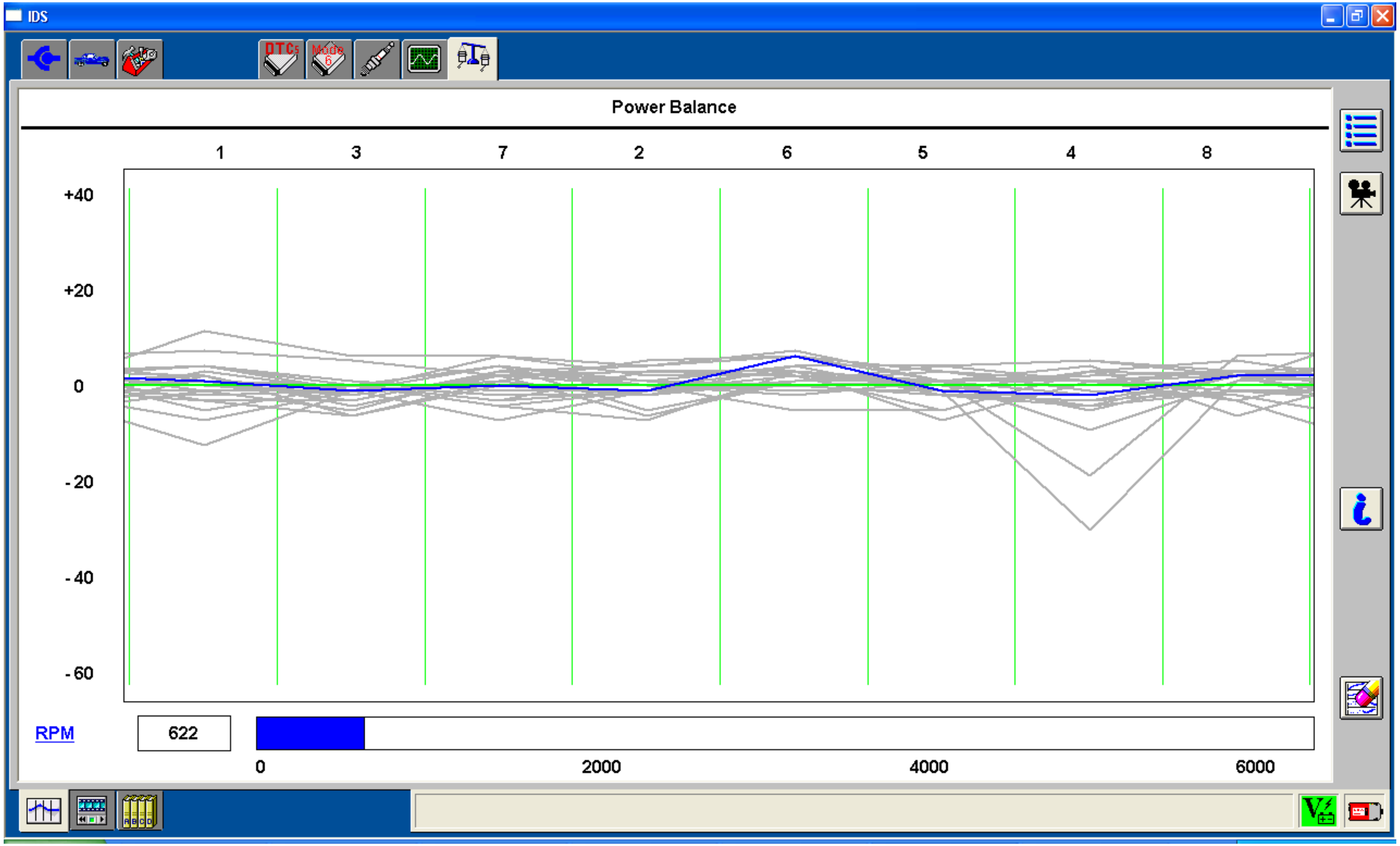
Total Engine Misfire Rate & Type B Threshold	50	0	<= 3.93%	0%
Cylinder 1 Misfire Rate & Type A Threshold	53	1	<= 16.1%	0.49%
Cylinder 2 Misfire Rate & Type A Threshold	53	2	<= 16.1%	0%
Cylinder 3 Misfire Rate & Type A Threshold	53	3	<= 16.1%	0%
Cylinder 4 Misfire Rate & Type A Threshold	53	4	<= 16.1%	0%
Cylinder 5 Misfire Rate & Type A Threshold	53	5	<= 16.1%	0%
Cylinder 6 Misfire Rate & Type A Threshold	53	6	<= 16.1%	0%
Highest Type A Misfire Rate & Threshold	54	0	<= 16.1%	0.98%
Highest Type B Misfire Rate & Threshold	55	0	<= 2.46%	0.2%
Cylinder Events Tested	56	0	<= 3k	2.6k

2006 Ford F150 5.4 L

No MIL, miss sometimes

Scan tool: IDS


IDS
Power Balance
1
3
7
2
6
5
4
8
+40
+20
0
- 20
- 40
- 60
RPM
602
0
2000
4000
6000



IDS
Power Balance
1
3
7
2
6
5
4
8
+40
+20
0
- 20
- 40
- 60
RPM
622
0
2000
4000
6000

Description	OBDMID	Test ID	Min	Max	Value
Cylinder 1 and Catalyst Damage Misfire Rate	A2	80	0%	24.49%	0%
Cylinder 1 and Emission Threshold Misfire Rate	A2	81	0%	0.99%	0%
Misfire Cylinder 2 Data	A3				
EWMA misfire counts for last 10 drive cycles	A3	B	0	65535	0
Misfire counts for last/current drive cycle	A3	C	0	65535	2
Cylinder 2 and Catalyst Damage Misfire Rate	A3	80	0%	24.49%	0%
Cylinder 2 and Emission Threshold Misfire Rate	A3	81	0%	0.99%	0%
Misfire Cylinder 3 Data	A4				
EWMA misfire counts for last 10 drive cycles	A4	B	0	65535	0
Misfire counts for last/current drive cycle	A4	C	0	65535	0
Cylinder 3 and Catalyst Damage Misfire Rate	A4	80	0%	24.49%	0%
Cylinder 3 and Emission Threshold Misfire Rate	A4	81	0%	0.99%	0%
Misfire Cylinder 4 Data	A5				
EWMA misfire counts for last 10 drive cycles	A5	B	0	65535	5
Misfire counts for last/current drive cycle	A5	C	0	65535	50
Cylinder 4 and Catalyst Damage Misfire Rate	A5	80	0%	24.49%	0%
Cylinder 4 and Emission Threshold Misfire Rate	A5	81	0%	0.99%	0%
Misfire Cylinder 5 Data	A6				
EWMA misfire counts for last 10 drive cycles	A6	B	0	65535	0
Misfire counts for last/current drive cycle	A6	C	0	65535	0
Cylinder 5 and Catalyst Damage Misfire Rate	A6	80	0%	24.49%	0%
Cylinder 5 and Emission Threshold Misfire Rate	A6	81	0%	0.99%	0%
Misfire Cylinder 6 Data	A7				
EWMA misfire counts for last 10 drive cycles	A7	B	0	65535	0
Misfire counts for last/current drive cycle	A7	C	0	65535	0
Cylinder 6 and Catalyst Damage Misfire Rate	A7	80	0%	24.49%	0%
Cylinder 6 and Emission Threshold Misfire Rate	A7	81	0%	0.99%	0%
Misfire Cylinder 7 Data	A8				
EWMA misfire counts for last 10 drive cycles	A8	B	0	65535	0
Misfire counts for last/current drive cycle	A8	C	0	65535	0
Cylinder 7 and Catalyst Damage Misfire Rate	A8	80	0%	24.49%	0%

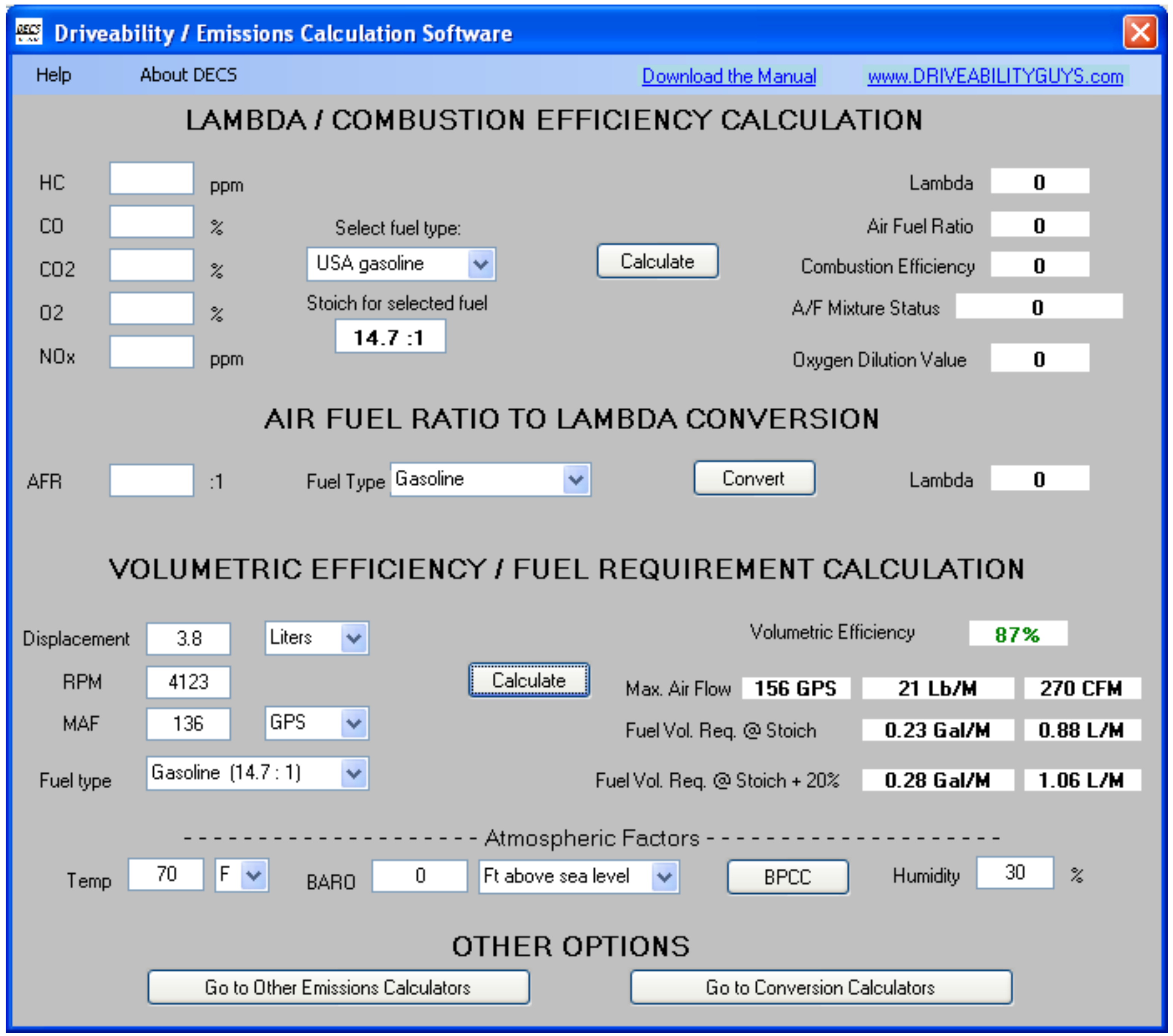
No power

- MIL or not, no (or low) power issues can be approached in the same manner
- What could cause a low power complaint?
  - Bad fuel pump
  - Plugged exhaust
  - Bad MAF sensor

Volumetric Efficiency

What is it?

Calculators



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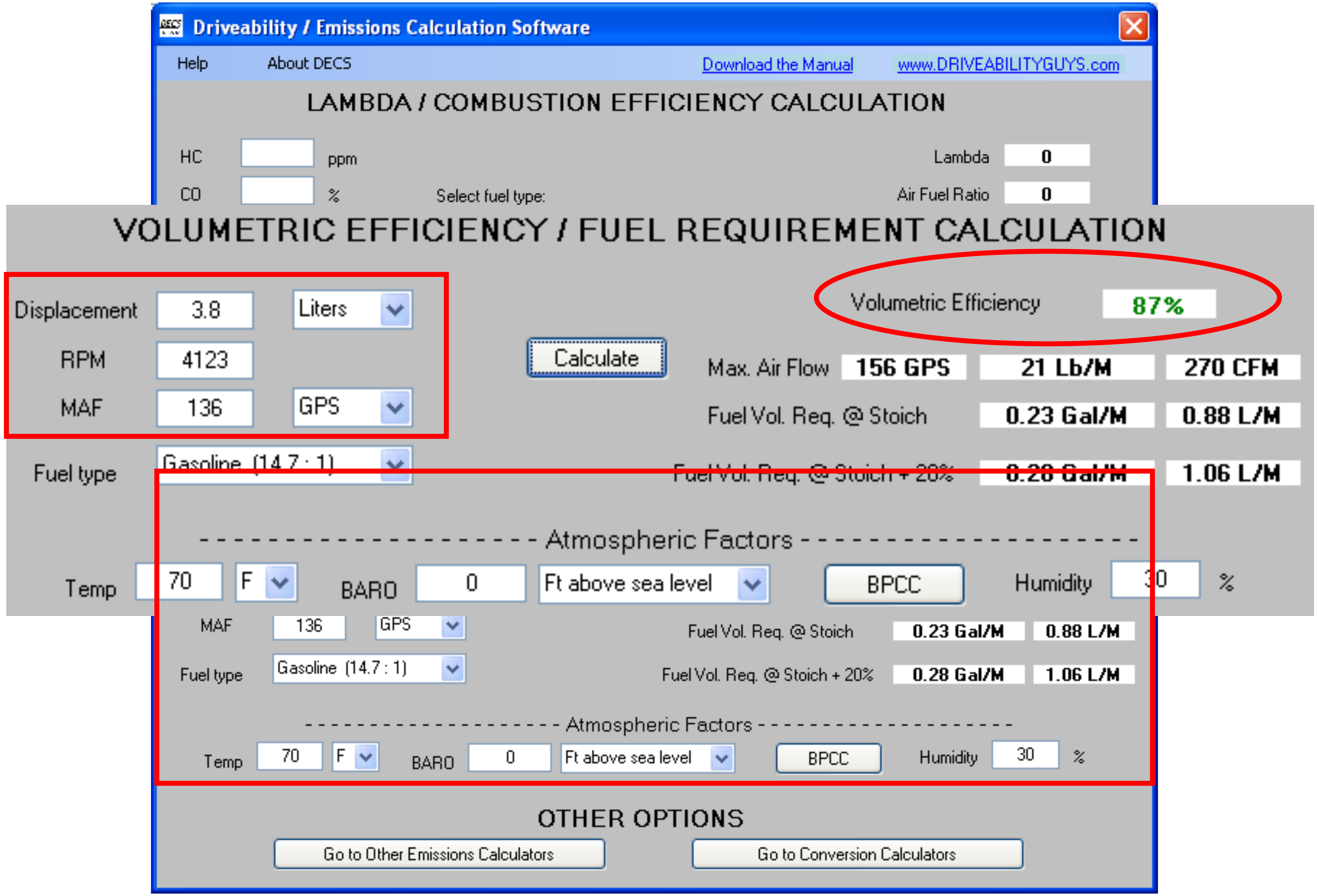

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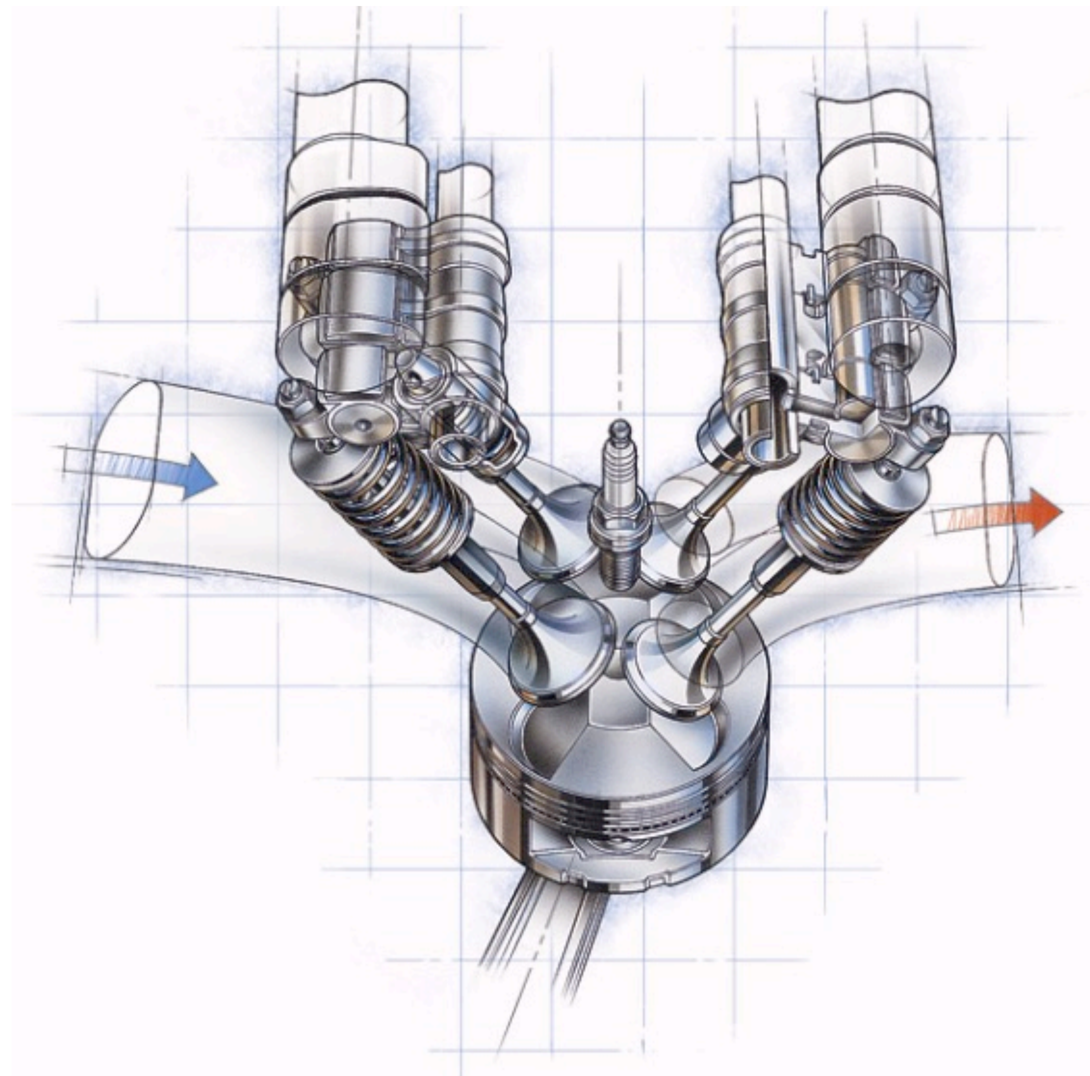
So… if there are variables… why use VE?

- Indication of a problem
- Data to analyze
- Understanding of Load PID
- Repair verification

So how do we test drive?

- WOT run until 1-2 or 2-3 shift
- 3 times
- Pay attention to what you feel..
- Let’s address each of these points individually

1: Why wide-open throttle?



...and why the up shift?

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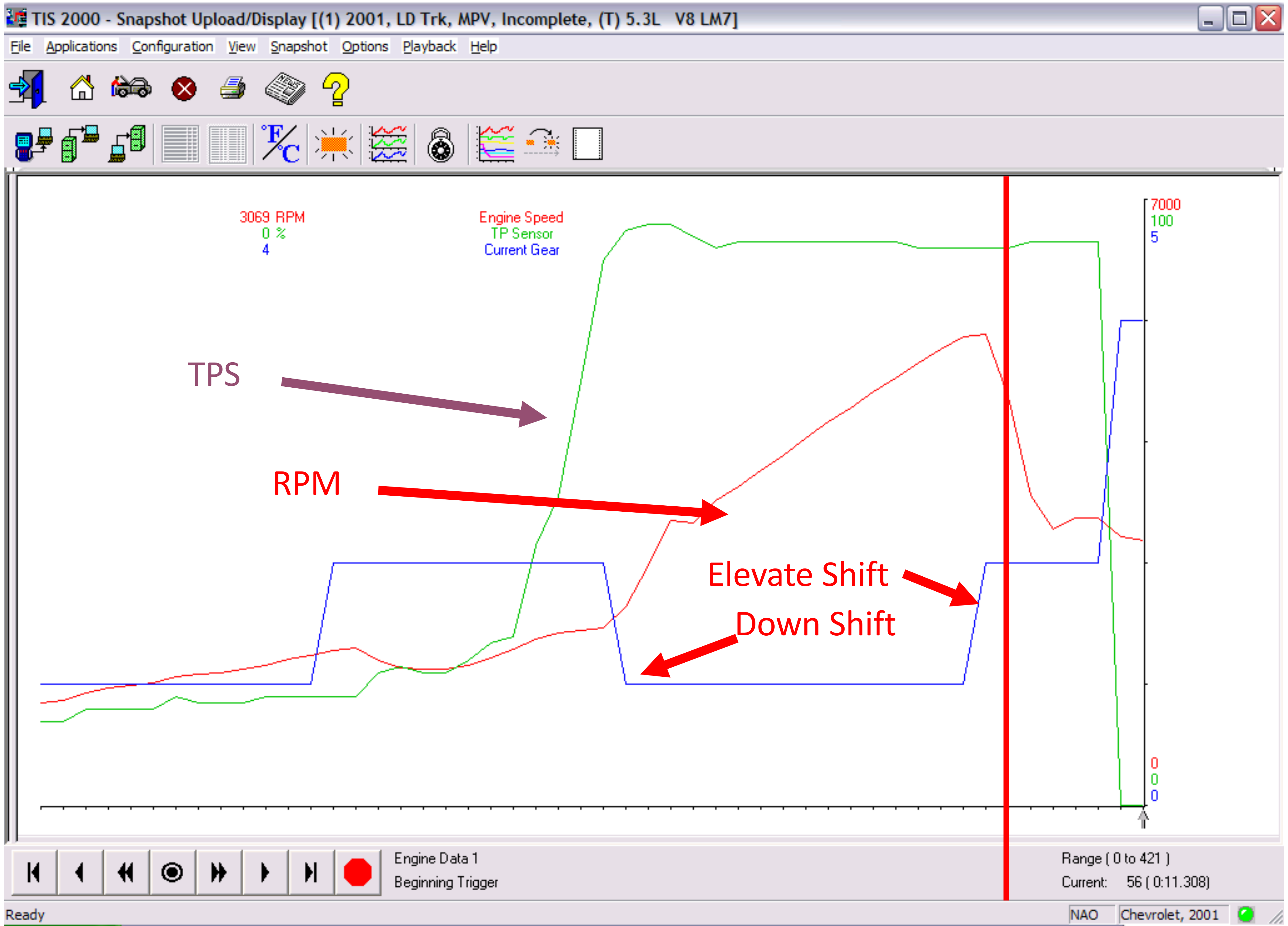
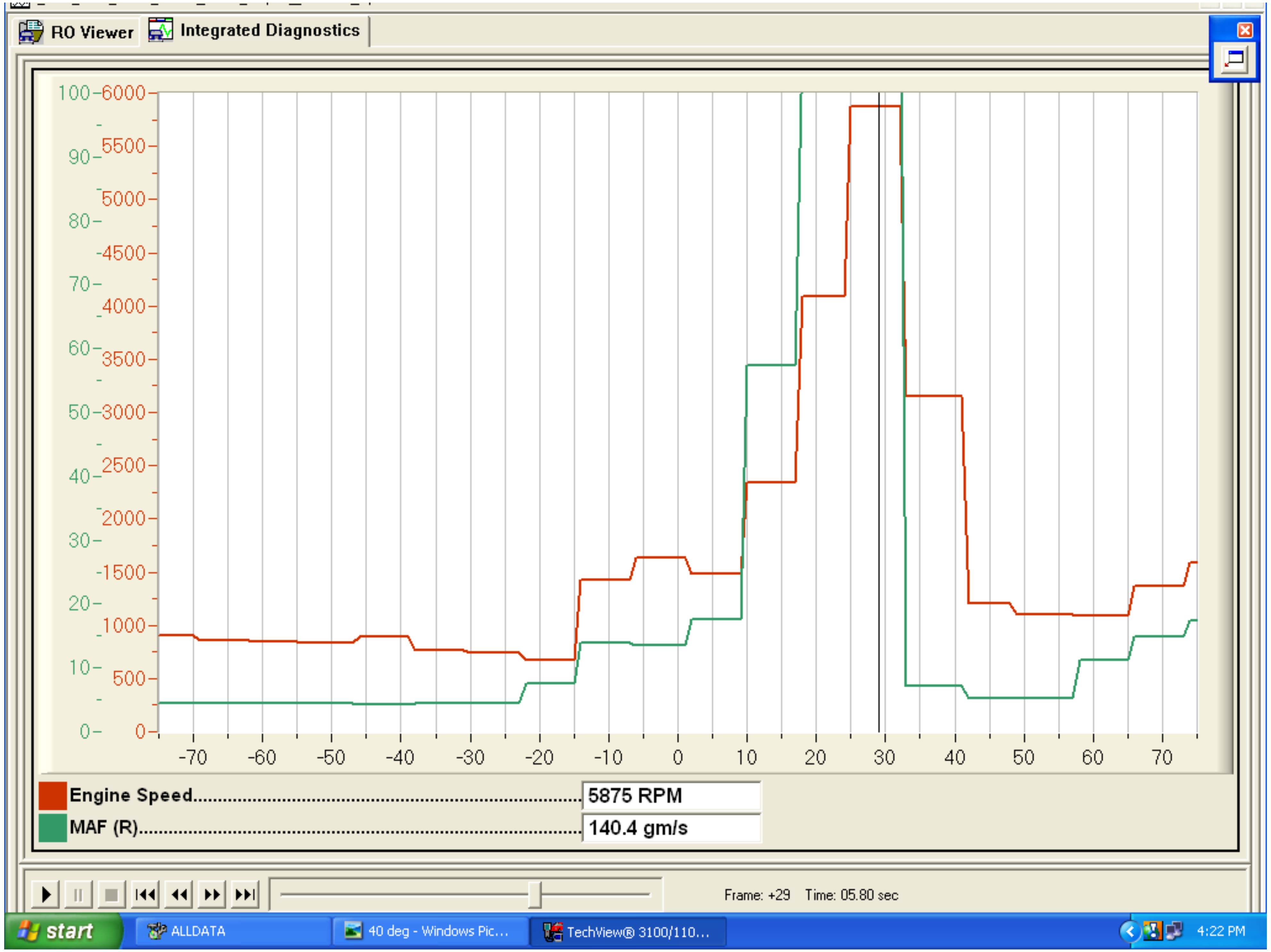

TIS 2000 - Snapshot Upload/Display [(1) 2001, LD Trk, MPV, Incomplete, (T) 5.3L V8 LM7]
File Applications Configuration View Snapshot Options Playback Help
3069 RPM
0 %
4
Engine Speed
TP Sensor
Current Gear
7000
100
5
TPS
RPM
Elevate Shift
Down Shift
0
0
0
Engine Data 1
Beginning Trigger
Range (0 to 421)
Current: 56 (0:11.308)
Ready
NAO
Chevrolet, 2001

2: Why 3 times?

- Depending on equipment information could be sketchy
- Scanner refresh rate could yield skewed results
- Averaging 3 runs increases the accuracy of the calculation
- Example…


RO Viewer
Integrated Diagnostics
100 90 80 70 60 50 40 30 20 10 0
6000 5500 5000 4500 4000 3500 3000 2500 2000 1500 1000 500 0
-70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70
Engine Speed
5875 RPM
MAF (R)
140.4 gm/s
Frame: +29 Time: 05.80 sec
start
ALLDATA
40 deg - Windows Pic...
TechView® 3100/110...
4:22 PM

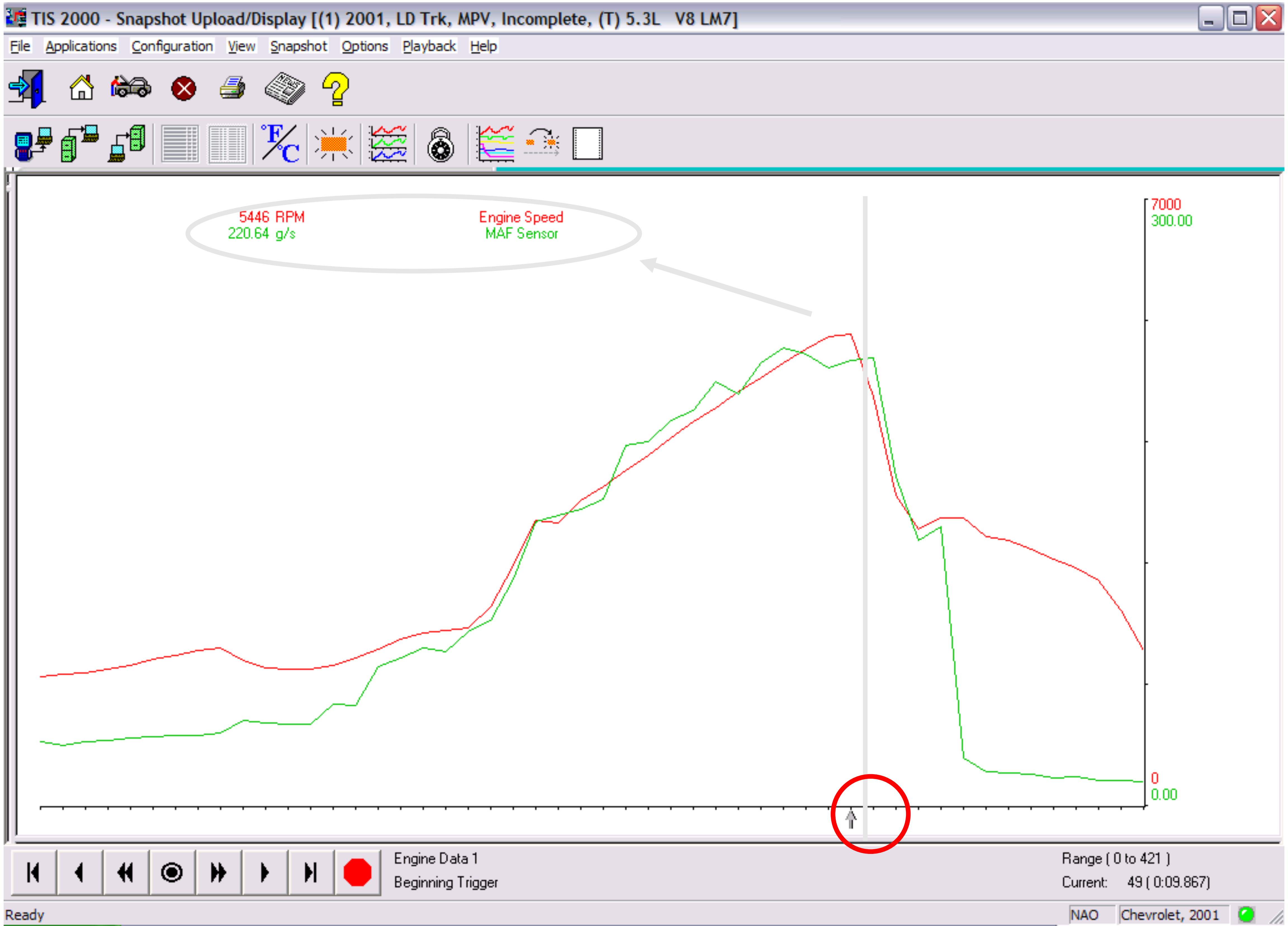
3: Pay attention to what you feel

- A secondary ignition misfire may be evident under certain driving conditions

- Don’t forget to take the “seat of your pants” information into account… but still do the scan tool recording

So what data do we need to calculate VE?

- TPS and current gear are not required
- Displacement
- RPM
- MAF



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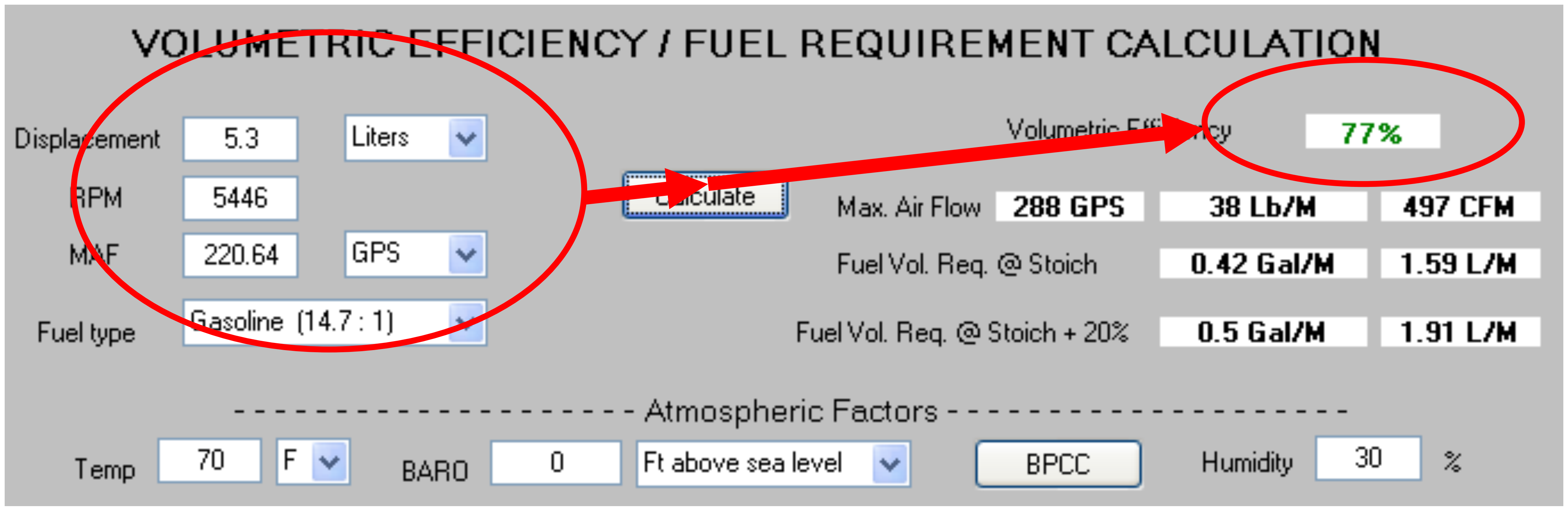
VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
5.3
Liters
RPM
5446
MAF
220.64
GPS
Fuel type
Gasoline (14.7 : 1)
Volumetric Effi
77%
Max. Air Flow
288 GPS
38 Lb/M
497 CFM
Fuel Vol. Req. @ Stoich
0.42 Gal/M
1.59 L/M
Fuel Vol. Req. @ Stoich + 20%
0.5 Gal/M
1.91 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%

Now that we know our VE…

- What additional data can we analyze?
- Can it point us in a diagnostic direction?
- How far (and quickly) can we progress in our diagnosis before getting our hands dirty?
- We need to know what is good first…

What can we expect from a known good?

- Naturally aspirated engines usually range from about 75% to 85% VE
- Forced induction engines usually exceed 100%
- For our “Red Flag” purposes today, 75% or higher will be considered acceptable
- However, when you apply these techniques at your shop, make adjustments as you see fit based on your atmospheric conditions, calculator choice, and experience.

What can we expect from a known good?

- O2 sensor reports…
- MAP sensor reports…
- How do fuel trims behave?

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The O2 sensor

- Normal driving conditions
- WOT

Condition	VE	O2	MAP	Trims
Good	Good	Rich		

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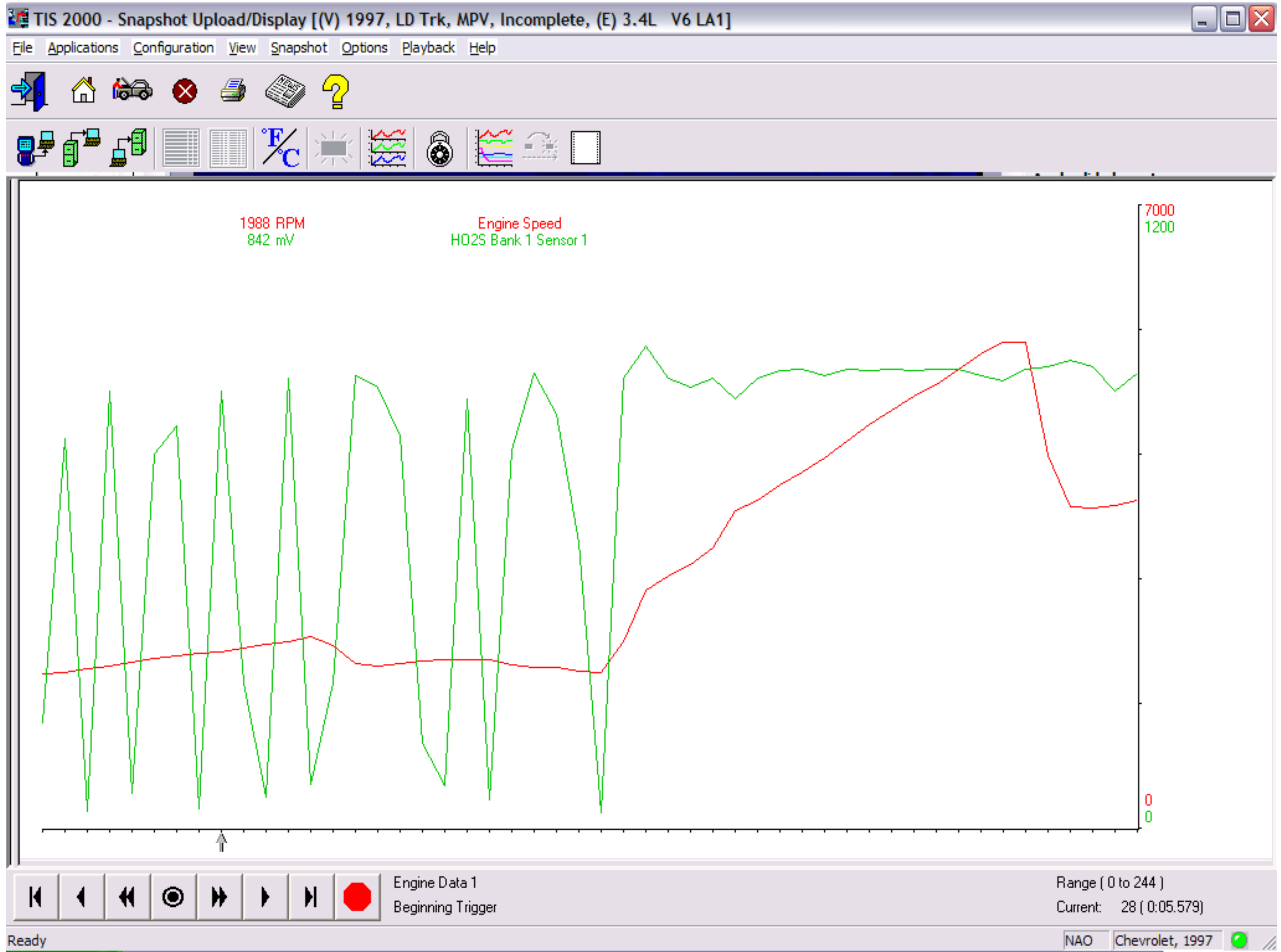
O2 sensor



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MAP sensor

- Normal driving conditions

- WOT

Condition	VE	O2	MAP	Trims
Good	Good	Rich	Near BARO	

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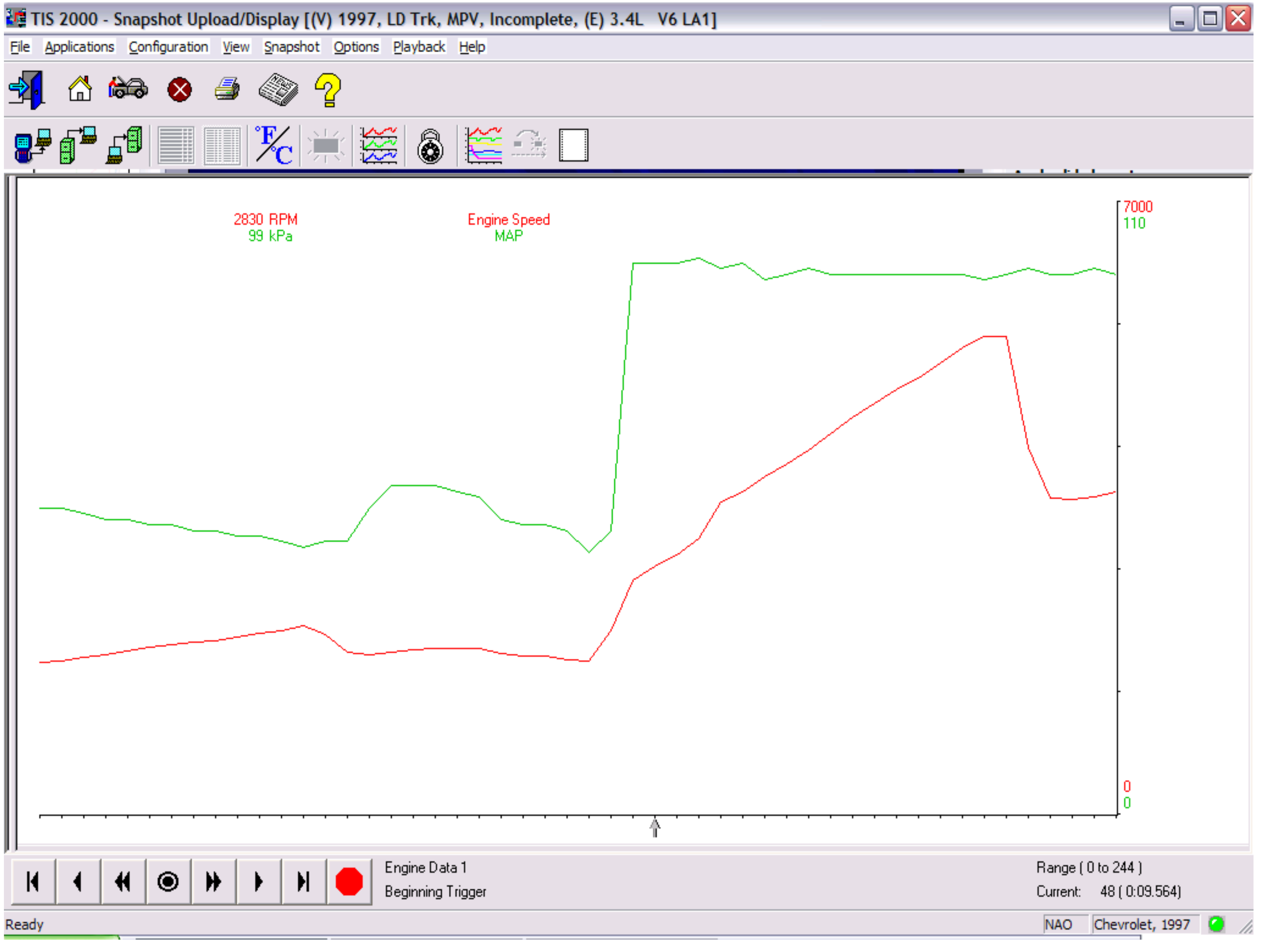
MAP sensor



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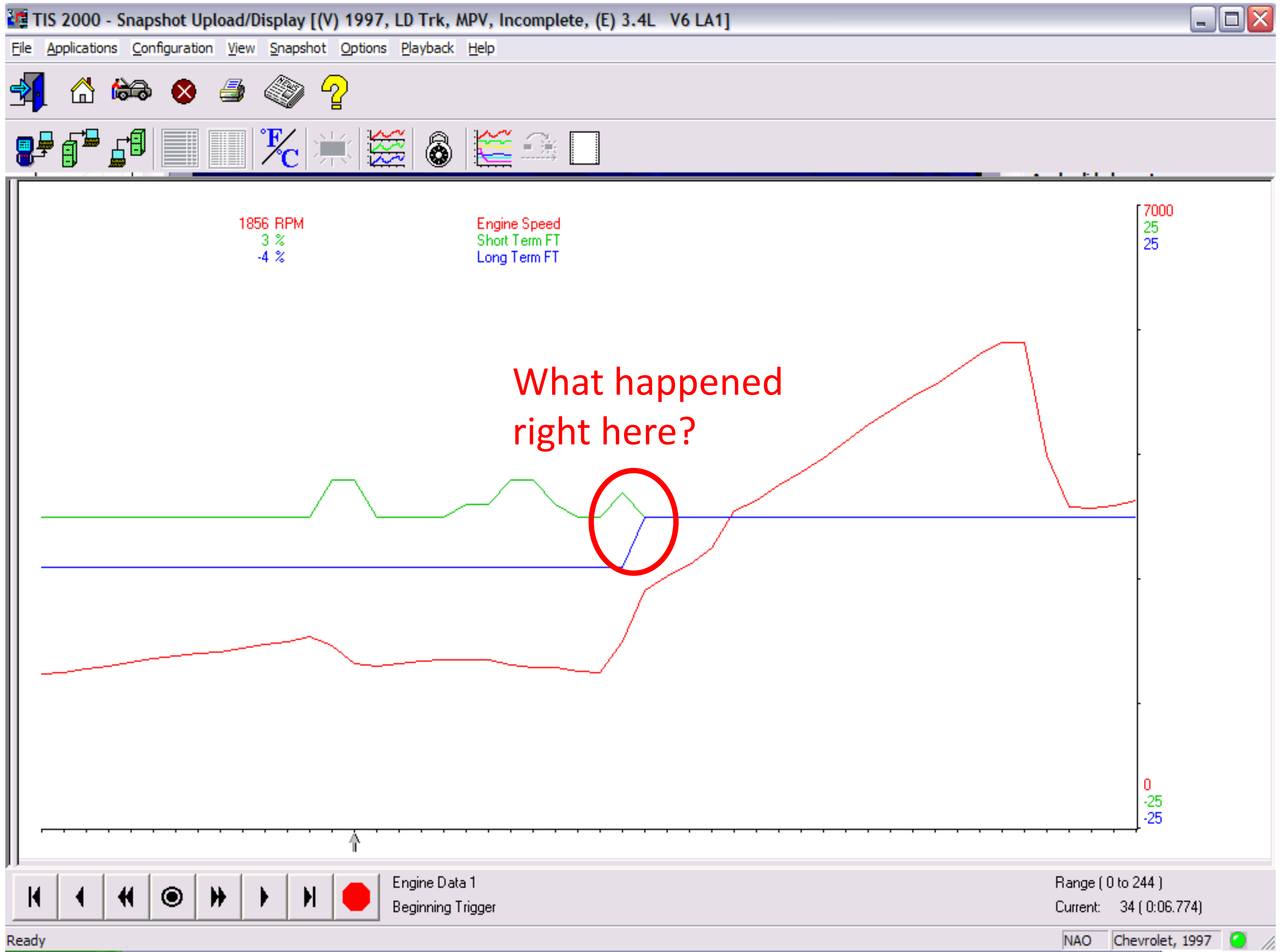
Fuel Trims

- Normal driving conditions
- WOT

Condition	VE	O2	MAP	Trims
Good	Good	Rich	Near BARO	Good **w/o** WOT

Fuel Trims



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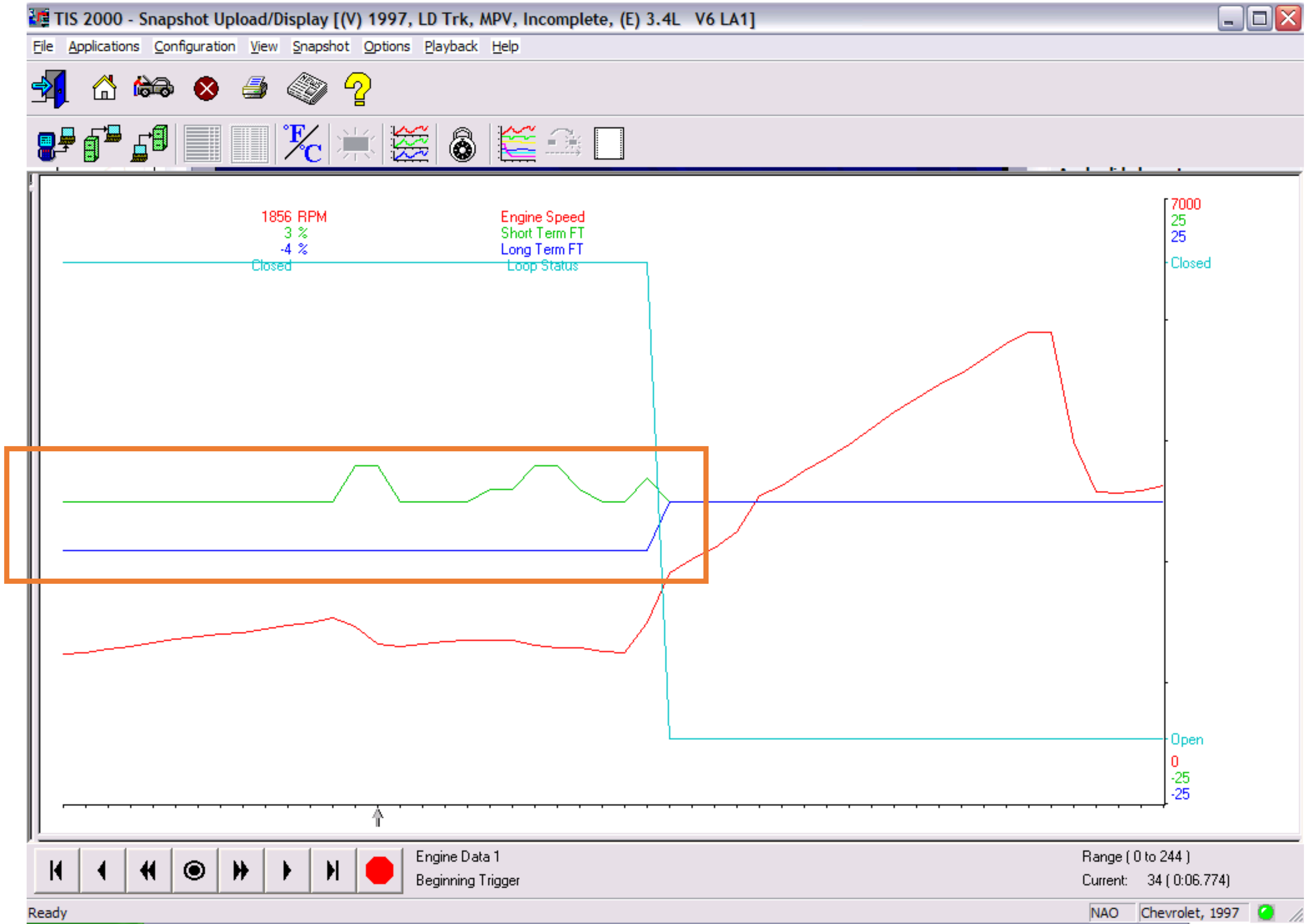

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All of the PID’s we discuss pertain to the WOT condition except…

Fuel trim numbers need to be observed during normal operating conditions.

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Now that we know what good looks like…

How can we use this information?

The Plan:

4 low power case studies

Let's look for trends that stand out

RED FLAGS!

Fill out your "Cheat Sheets"

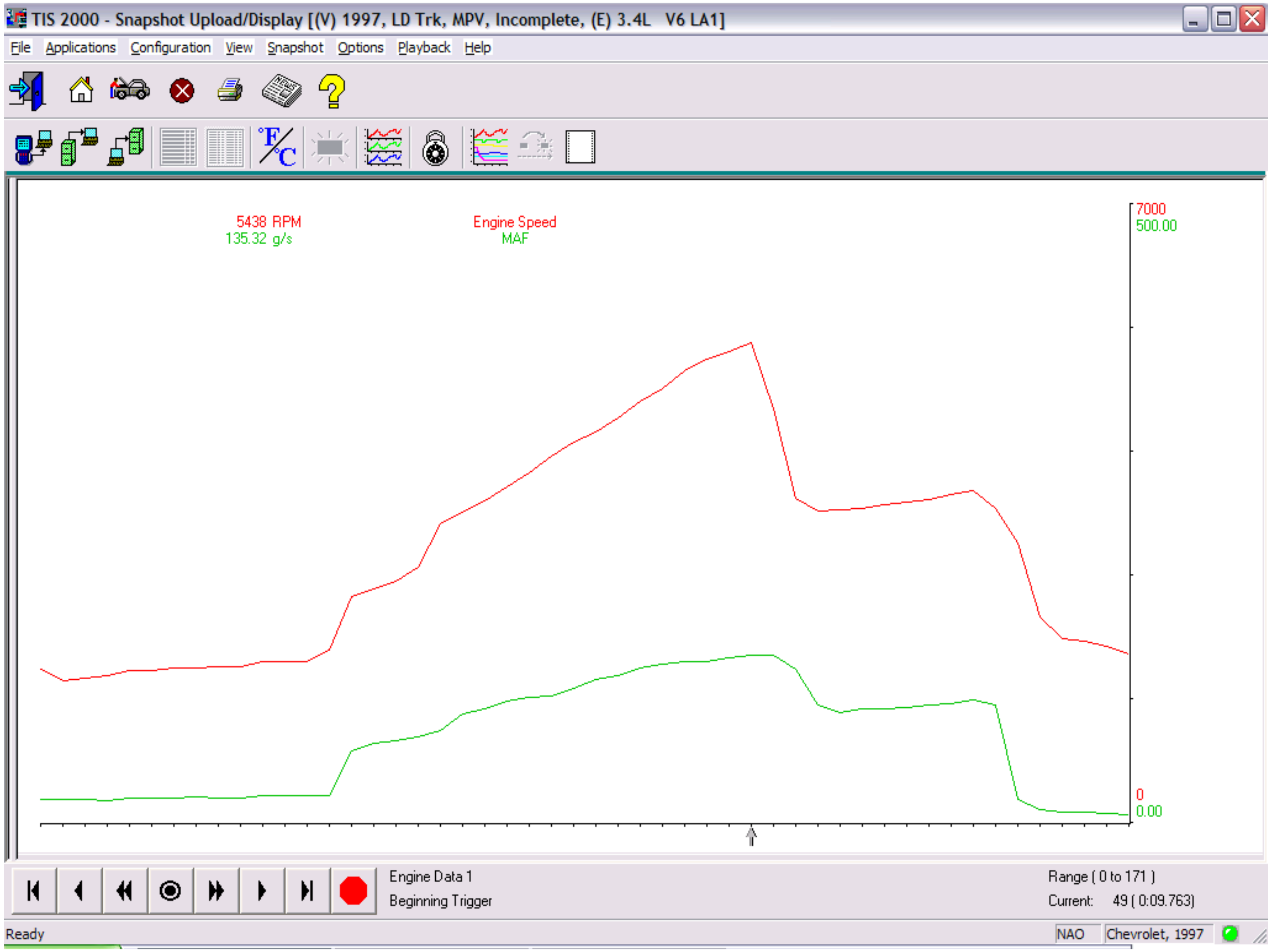
Let’s look at our first problem…

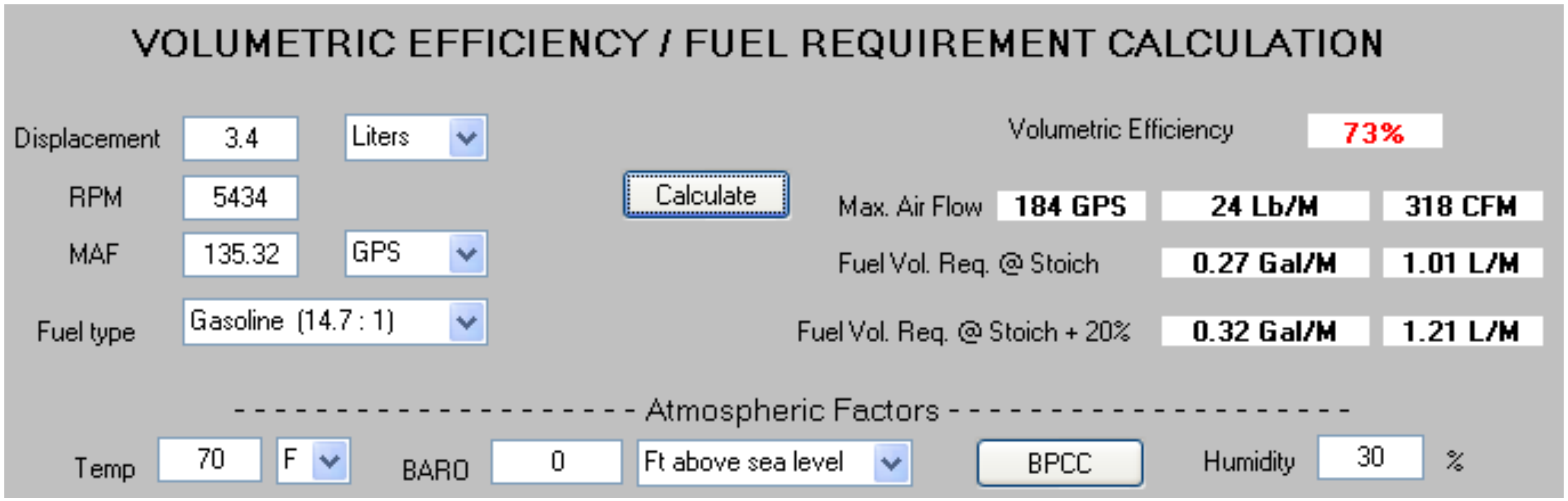
1997 Transport 3.4L

Complaint: sometimes lacks power on harder acceleration.

Today… the vehicle exhibits no driveability complaint.

Fp reg drive


TIS 2000 - Snapshot Upload/Display [(V) 1997, LD Trk, MPV, Incomplete, (E) 3.4L V6 LA1]
File Applications Configuration View Snapshot Options Playback Help
5438 RPM
135.32 g/s
Engine Speed
MAF
7000
500.00
0
0.00
Engine Data 1
Beginning Trigger
Range (0 to 171)
Current: 49 (0:09.763)
Ready
NAO
Chevrolet, 1997



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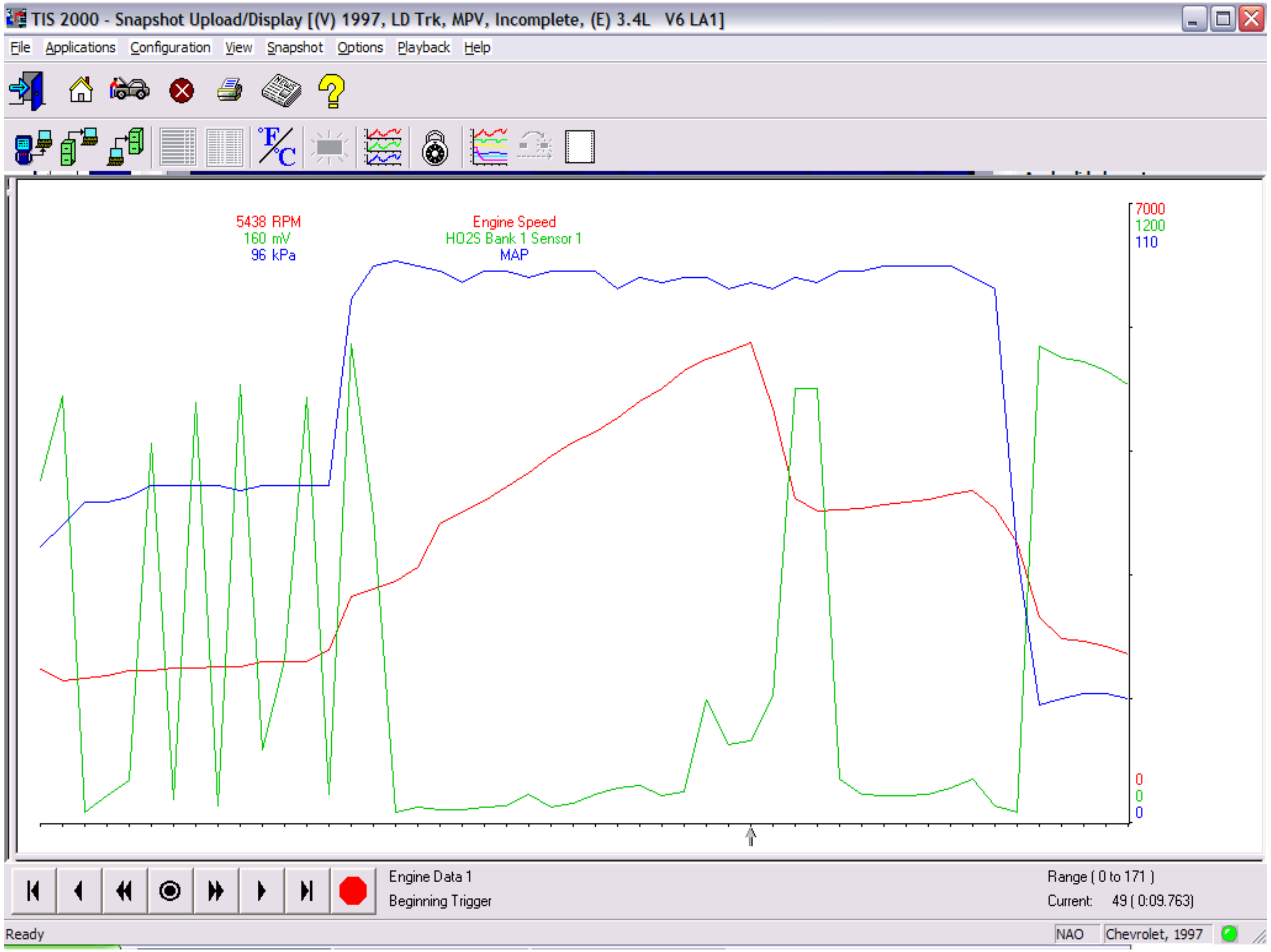
O2 and MAP



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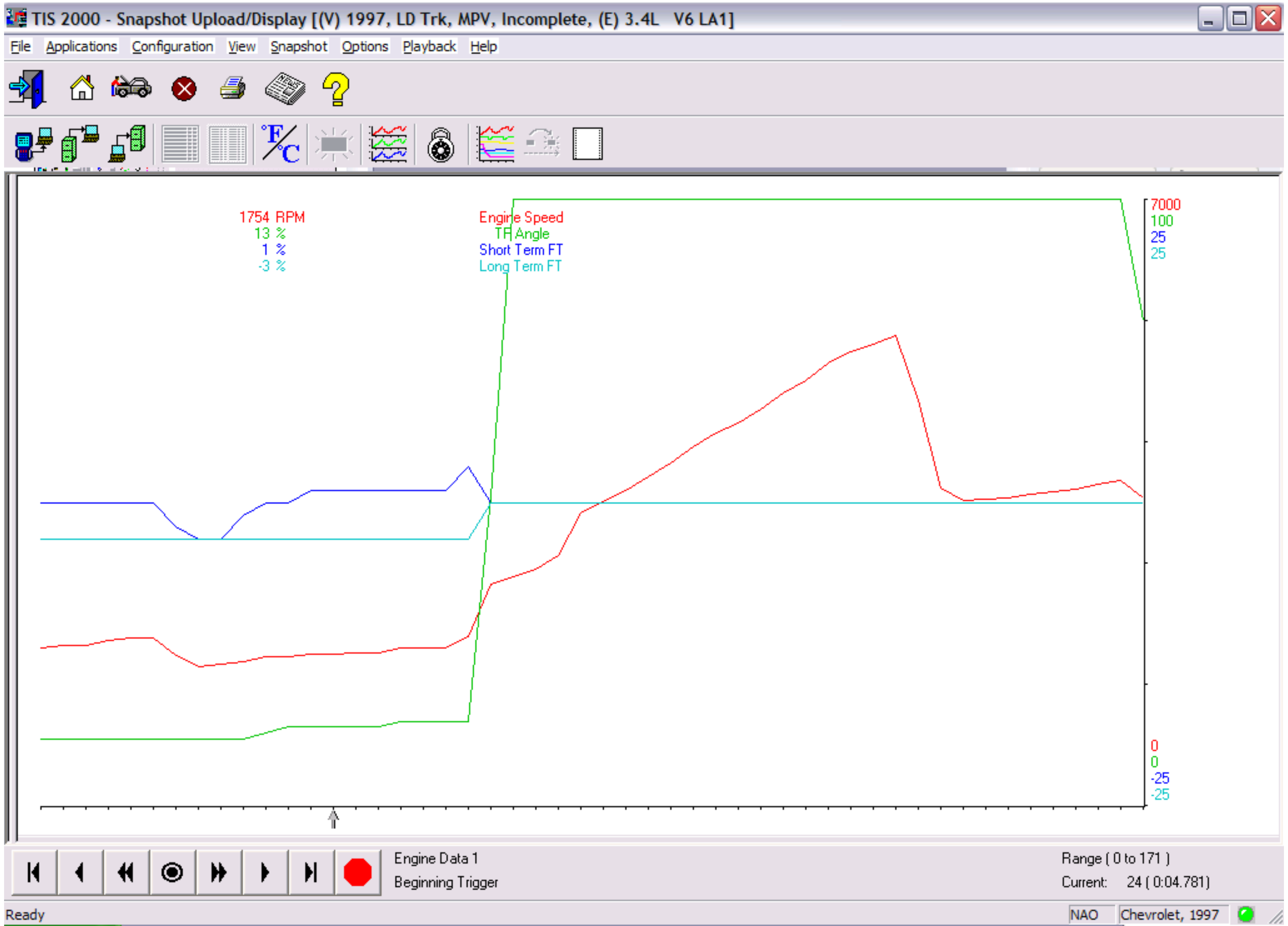

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Fuel delivery results

- VE relatively unaffected
- 02 sensor reads lean
- MAP sensor reads normal
- STFT and LTFT numbers during closed loop depend on the level of fuel delivery deterioration.
  - Usually positive to compensate for lean condition

Fuel delivery cheat sheet

Condition	VE	O2	MAP	Trims
Poor fuel delivery	OK	Lean	Normal	Positive- To varying degrees

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Next complaint…

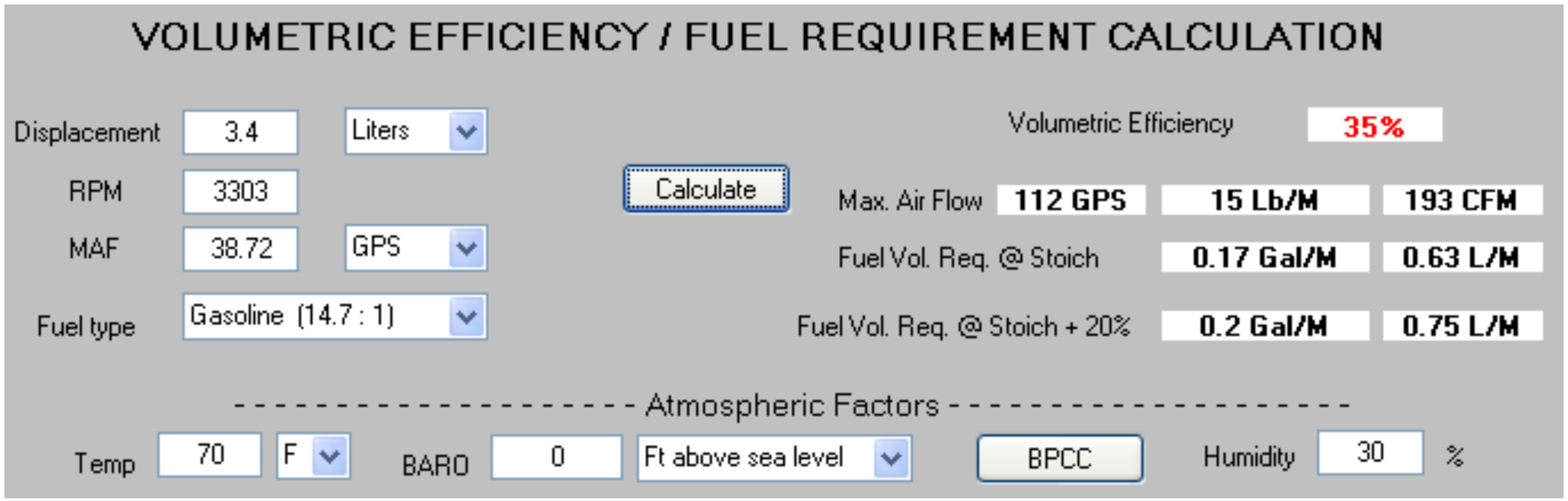
No power, stumble, and hesitation.

Transport again.

Trust me… this car had NO power!

MAF drive


TIS 2000 - Snapshot Upload/Display [(V) 1997, LD Trk, MPV, Incomplete, (E) 3.4L V6 LA1]
File Applications Configuration View Snapshot Options Playback Help
3033 RPM
38.72 g/s
100 %
Engine Speed
MAF
TP Angle
7000
500.00
100
0
0.00
0
Notice the extra trace?
Engine Data 1
Beginning Trigger
Range (0 to 219)
Current: 40 (0:07.969)
Ready
NAO
Chevrolet, 1997


VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement 3.4 Liters
RPM 3303
MAF 38.72 GPS
Fuel type Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency 35%
Max. Air Flow 112 GPS 15 Lb/M 193 CFM
Fuel Vol. Req. @ Stoich 0.17 Gal/M 0.63 L/M
Fuel Vol. Req. @ Stoich + 20% 0.2 Gal/M 0.75 L/M
Atmospheric Factors
Temp 70 F
BARO 0 Ft above sea level
BPCC
Humidity 30 %

O2 and MAP

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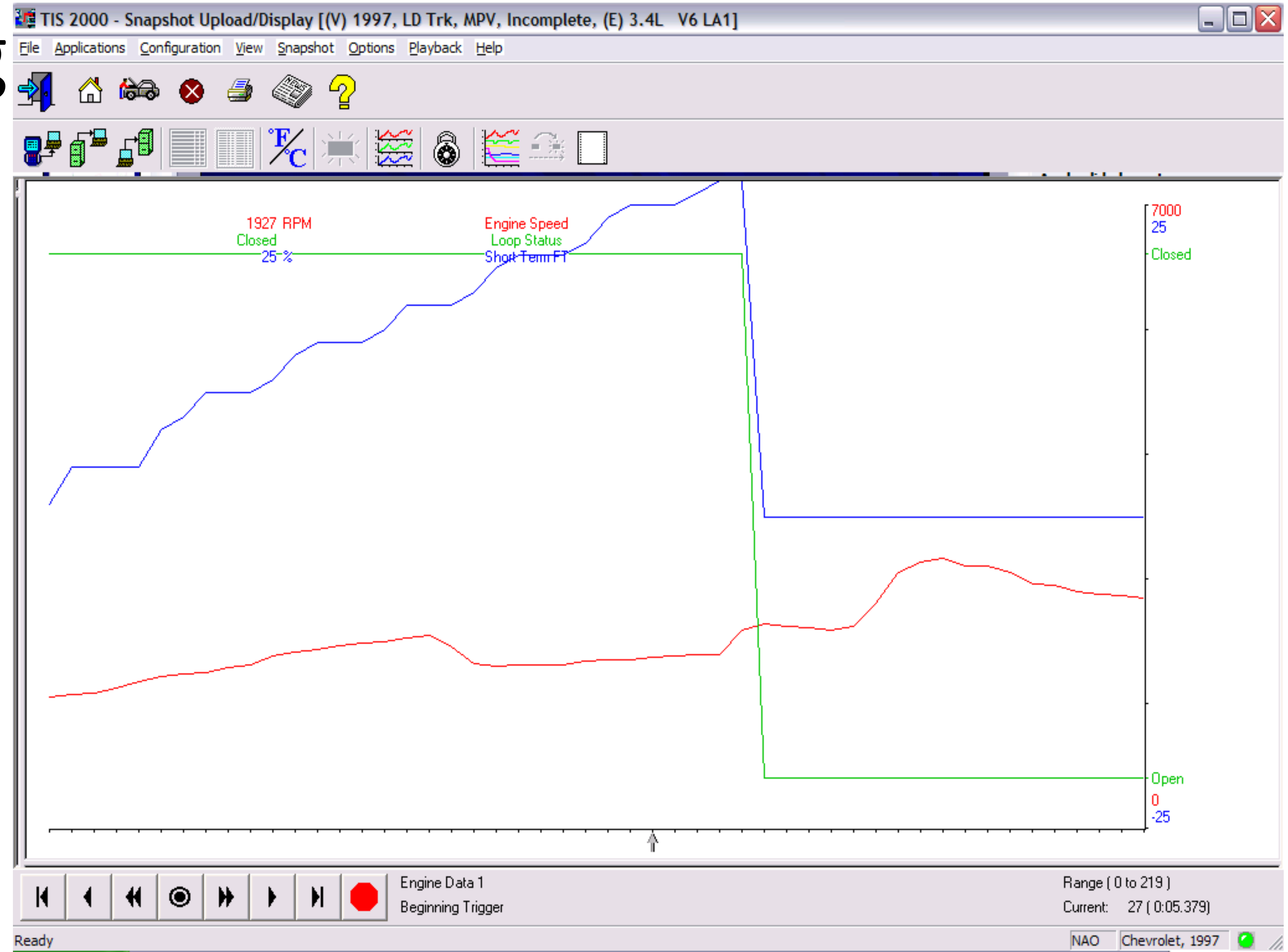
ST trim tracking



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Air metering results

- VE poor (Calculation!)
- 02 sensor reads lean
- MAP sensor reads normal
- STFT and LTFT numbers erratic, and often track RPM, <u>during closed loop</u>

Condition	VE	O2	MAP	Trims
Air Metering	Poor	Lean	Normal	Erratic

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~~Air metering tip…~~

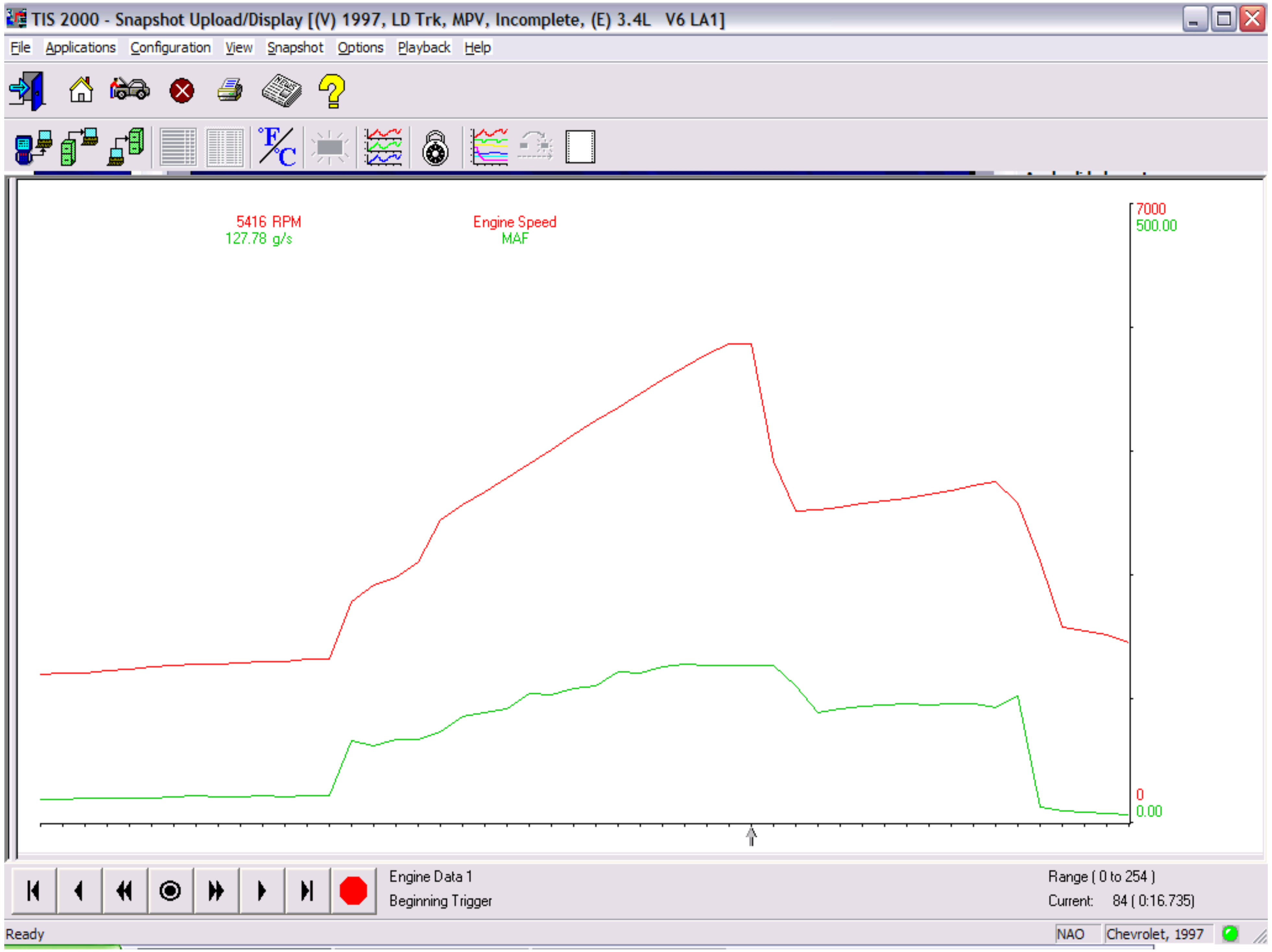
CAUTION!

- Un-plug MAF and re-test drive
- Do driveability issues go away?
- Works on some vehicles
  - Use caution

Problem child #3…

Compliant: Car isn't as "peppy" as it used to be.

Exhaust drive



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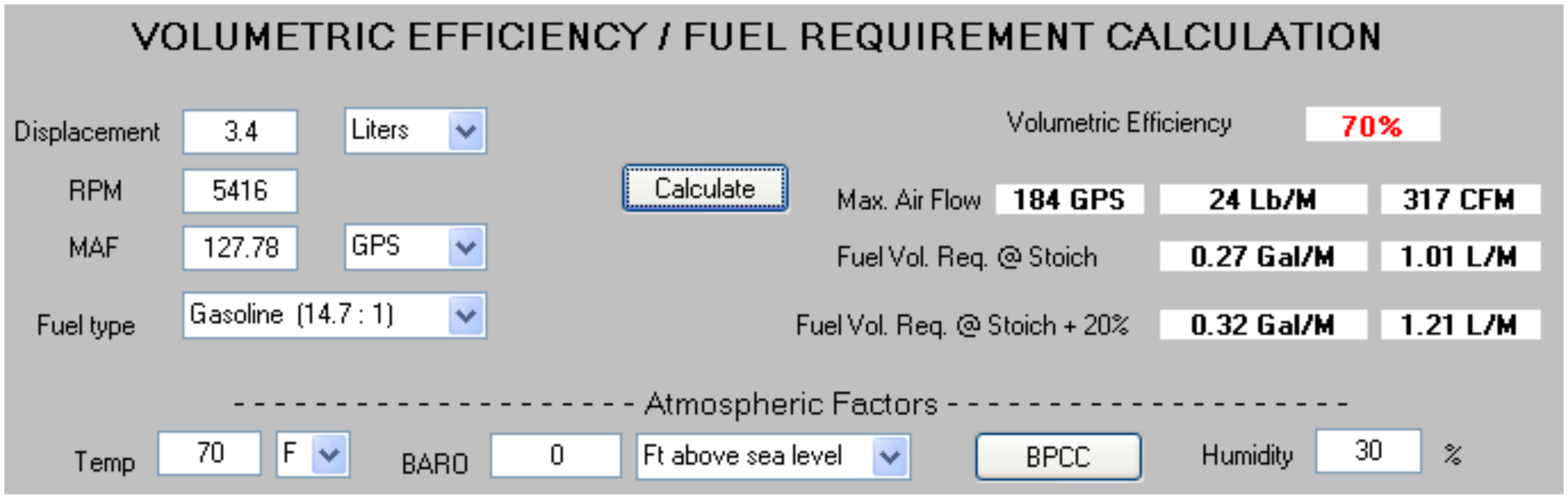
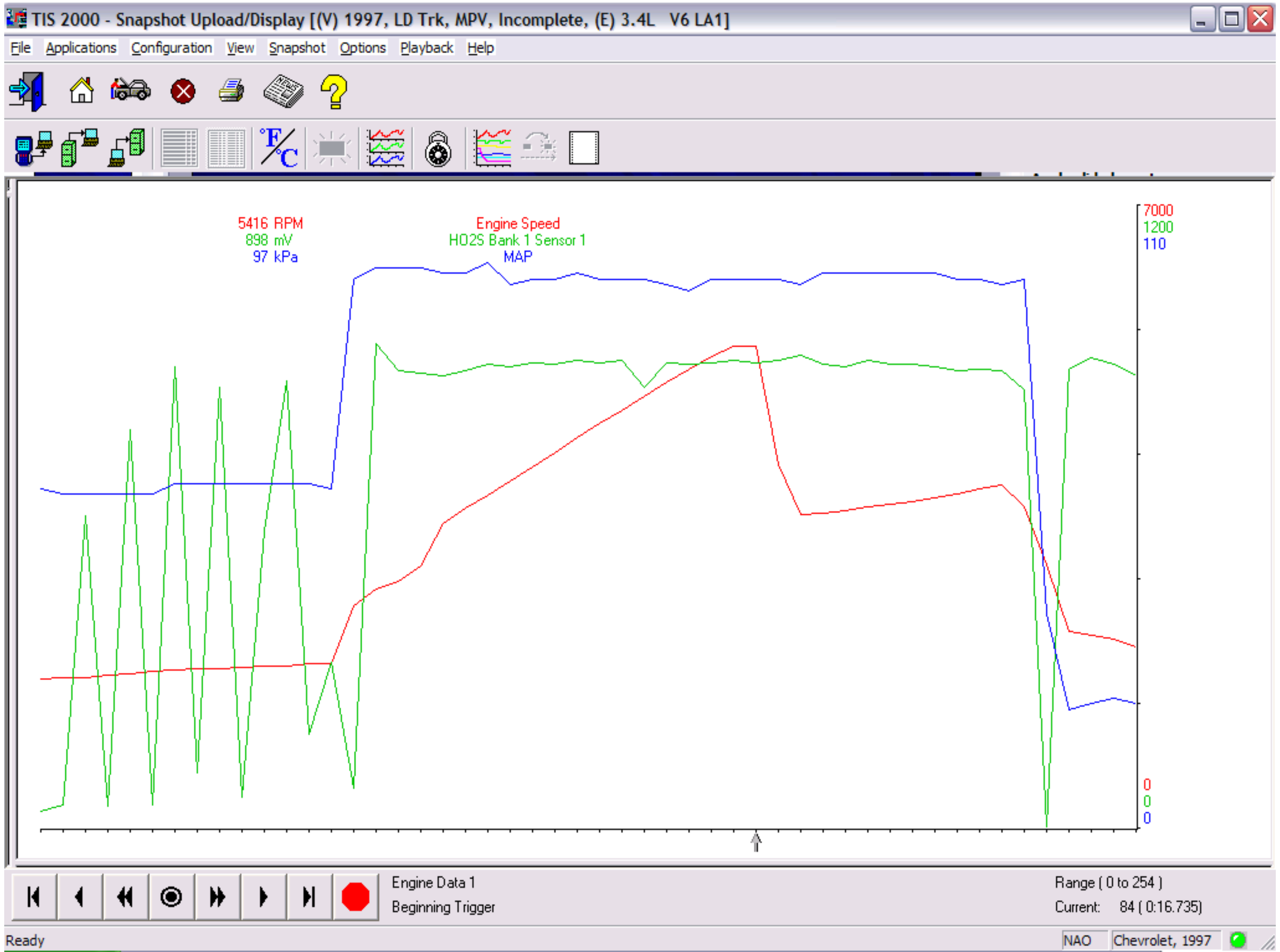

VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
3.4
Liters
RPM
5416
MAF
127.78
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
70%
Max. Air Flow
184 GPS
24 Lb/M
317 CFM
Fuel Vol. Req. @ Stoich
0.27 Gal/M
1.01 L/M
Fuel Vol. Req. @ Stoich + 20%
0.32 Gal/M
1.21 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%

O2 and MAP


TIS 2000 - Snapshot Upload/Display [(V) 1997, LD Trk, MPV, Incomplete, (E) 3.4L V6 LA1]
File Applications Configuration View Snapshot Options Playback Help
5416 RPM
898 mV
97 kPa
Engine Speed
HO2S Bank 1 Sensor 1
MAP
7000
1200
110
0
0
0
Engine Data 1
Beginning Trigger
Range (0 to 254)
Current: 84 (0:16.735)
Ready
NAO
Chevrolet, 1997

Trims

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Restricted exhaust results

- VE poor
- 02 sensor reads rich
- MAP sensor reads normal
- STFT and LTFT tend to go negative
  - But not always. Toughest to spot on scantool

Condition	VE	O2	MAP	Trims
Restricted Exhaust	Poor	Rich	Normal	Trend Negative / Less irregular than Air metering issue

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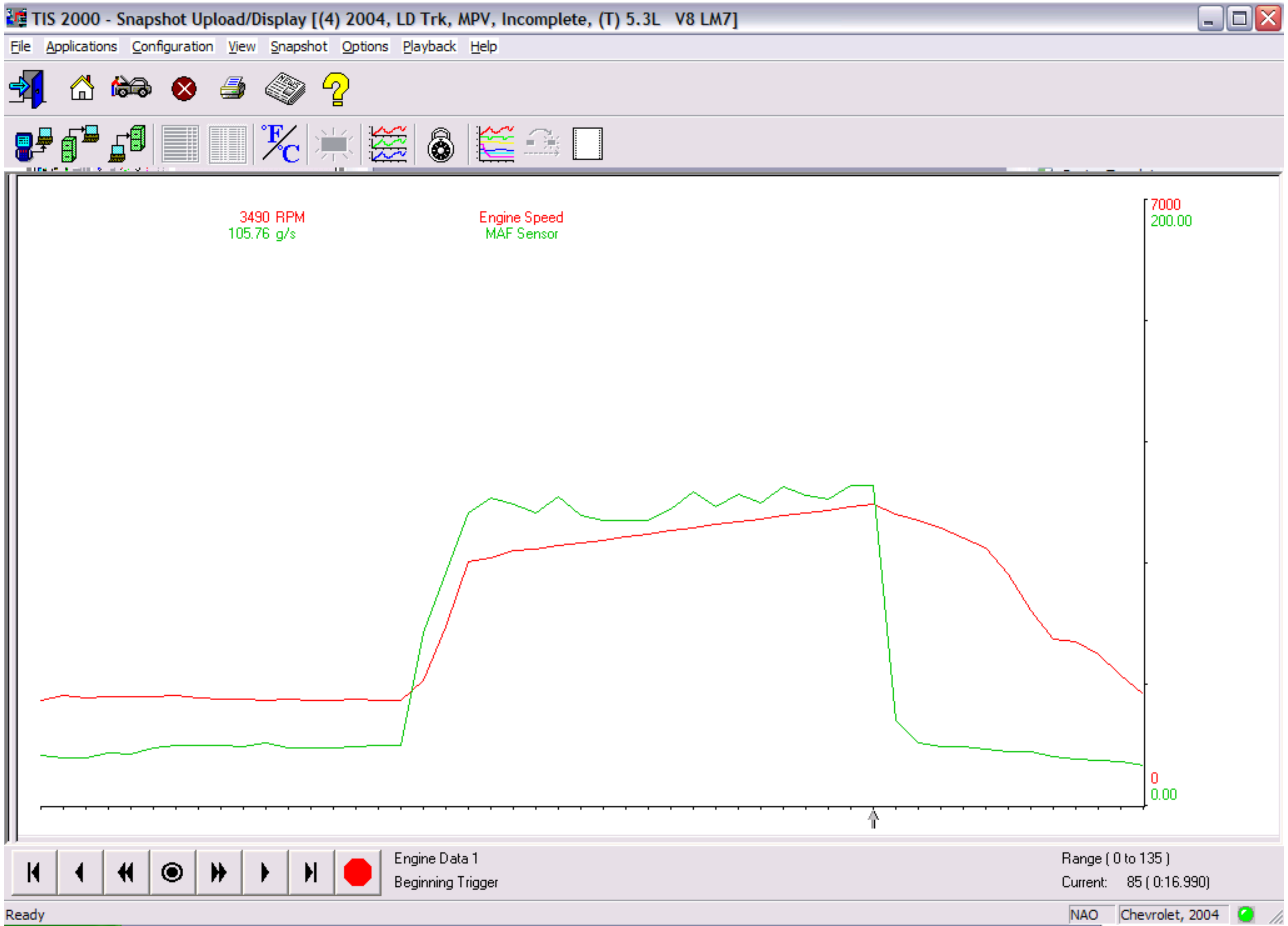
Example #4…

Compliant: Absolutely no power.

Our friend John Thornton gave us this example.

A contractor’s truck that sees a rough life.



TIS 2000 - Snapshot Upload/Display [(4) 2004, LD Trk, MPV, Incomplete, (T) 5.3L V8 LM7]
File Applications Configuration View Snapshot Options Playback Help
3490 RPM
105.76 g/s
Engine Speed
MAF Sensor
7000
200.00
0
0.00
Engine Data 1
Beginning Trigger
Range (0 to 135)
Current: 85 (0:16.990)
Ready
NAO
Chevrolet, 2004

VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION

Displacement 5.3 Liters

RPM 3490

MAF 105.76 GPS

Fuel type Gasoline (14.7 : 1)

Calculate

Volumetric Efficiency **57%**

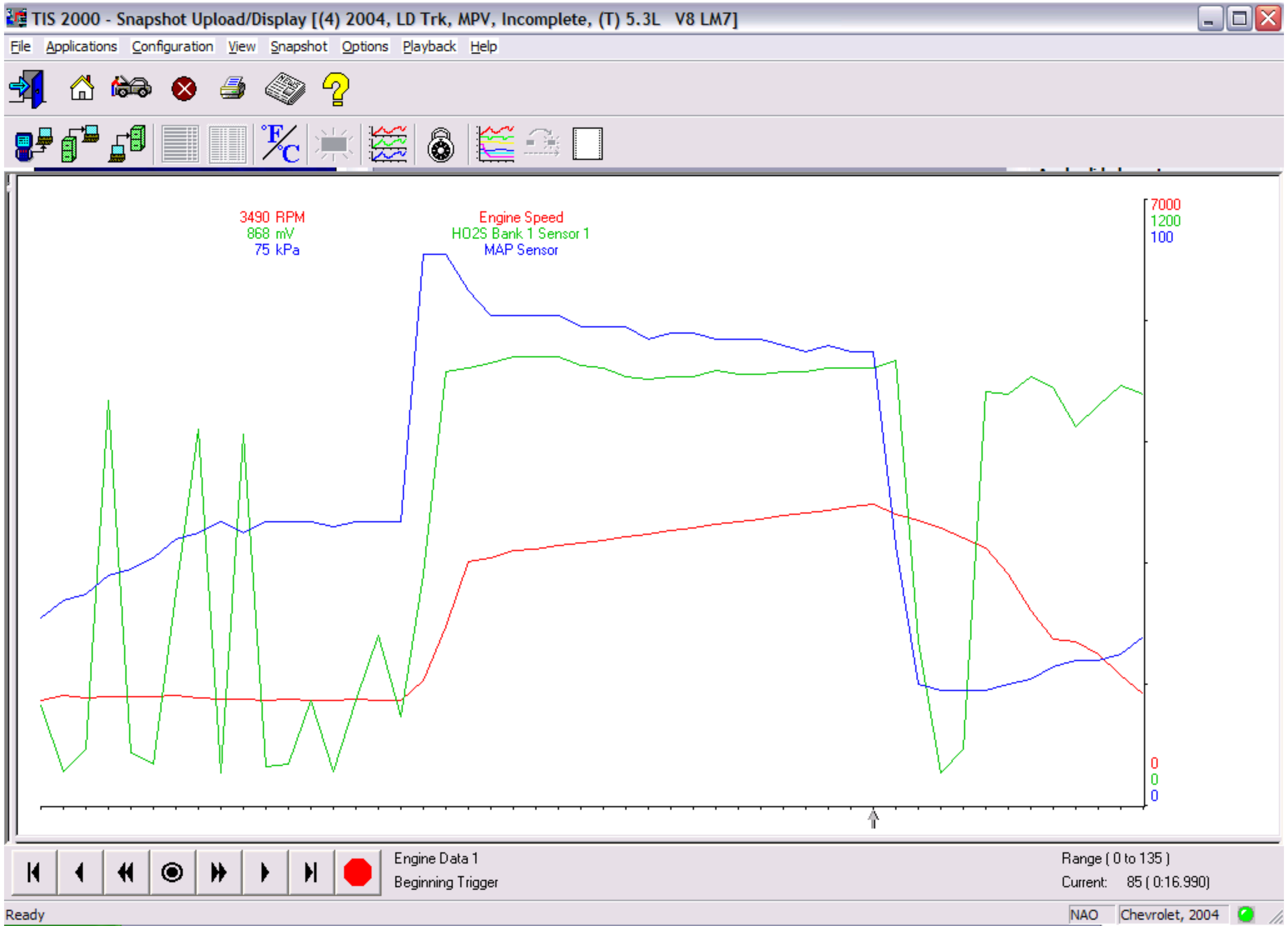
Max. Air Flow **184 GPS** **24 Lb/M** **318 CFM**

Fuel Vol. Req. @ Stoich **0.27 Gal/M** **1.01 L/M**

Fuel Vol. Req. @ Stoich + 20% **0.32 Gal/M** **1.21 L/M**

- Atmospheric Factors -

Temp 70 F BARO 0 Ft above sea level BPCC Humidity 30 %



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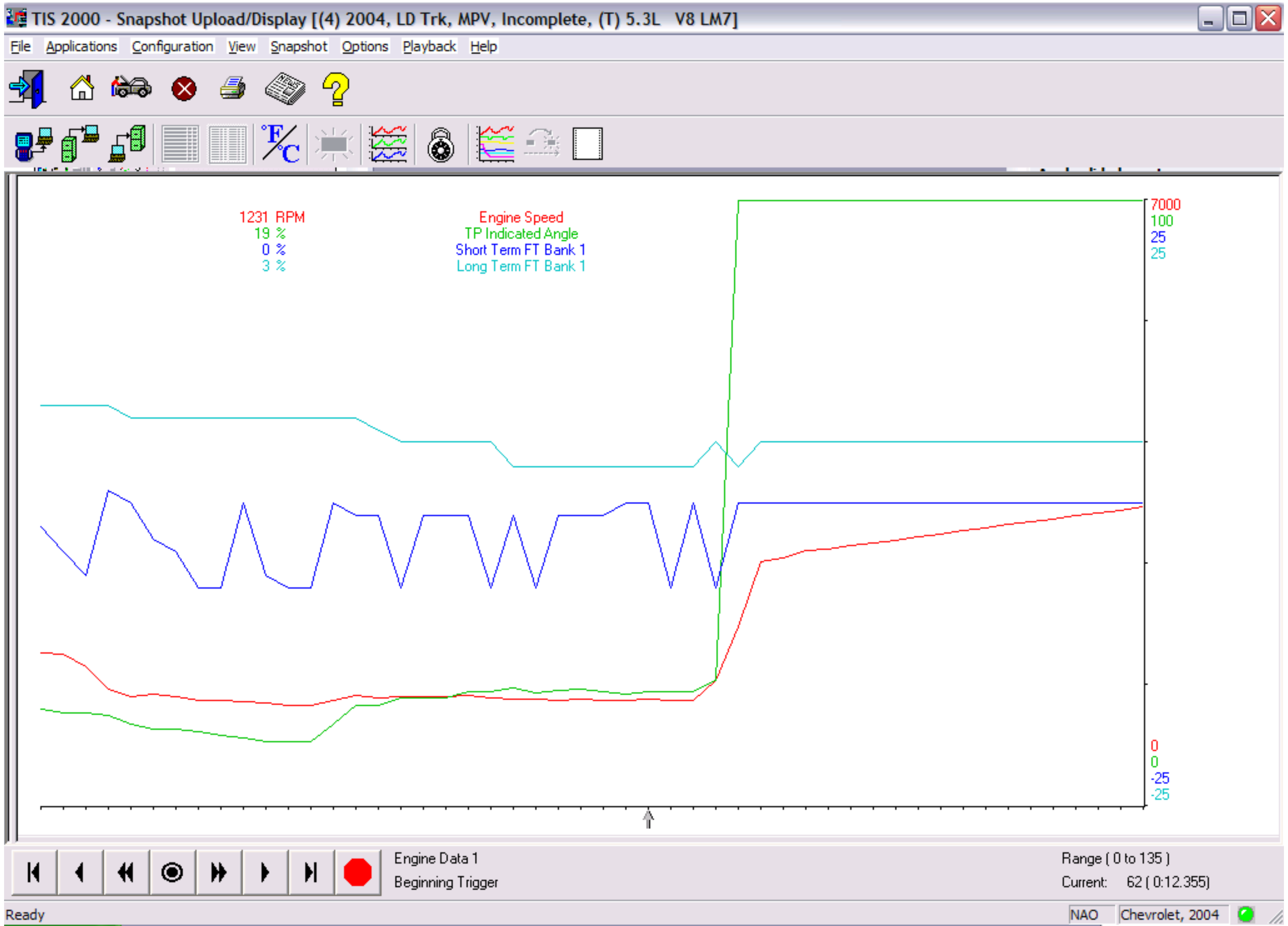
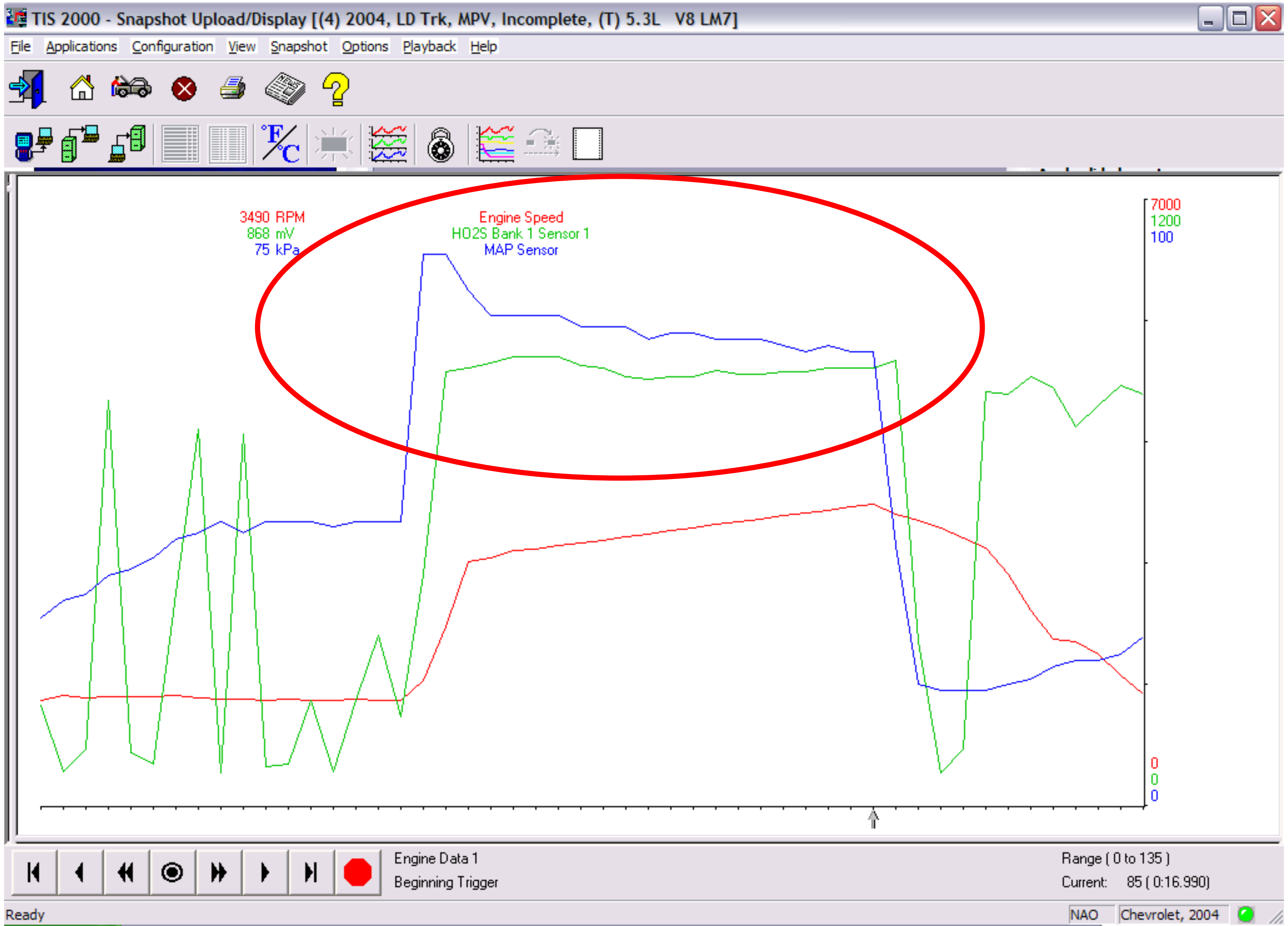


TIS 2000 - Snapshot Upload/Display [(4) 2004, LD Trk, MPV, Incomplete, (T) 5.3L V8 LM7]
File Applications Configuration View Snapshot Options Playback Help
1231 RPM
19 %
0 %
3 %
Engine Speed
TP Indicated Angle
Short Term FT Bank 1
Long Term FT Bank 1
7000
100
25
25
0
0
-25
-25
Engine Data 1
Beginning Trigger
Range (0 to 135)
Current: 62 (0:12.355)
Ready
NAO
Chevrolet, 2004



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Restricted intake results

- VE poor
- 02 sensor reads normal
- MAP sensor ratchets away from barometric pressure
- STFT and LTFT numbers are normal

Condition	VE	O2	MAP	Trims
Restricted Intake	Poor	Rich	Ratchets away from BARO	Normal

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What next?

- Cheat sheets filled out
- Red Flags in order
- By now, your cheat sheets should look something like this…

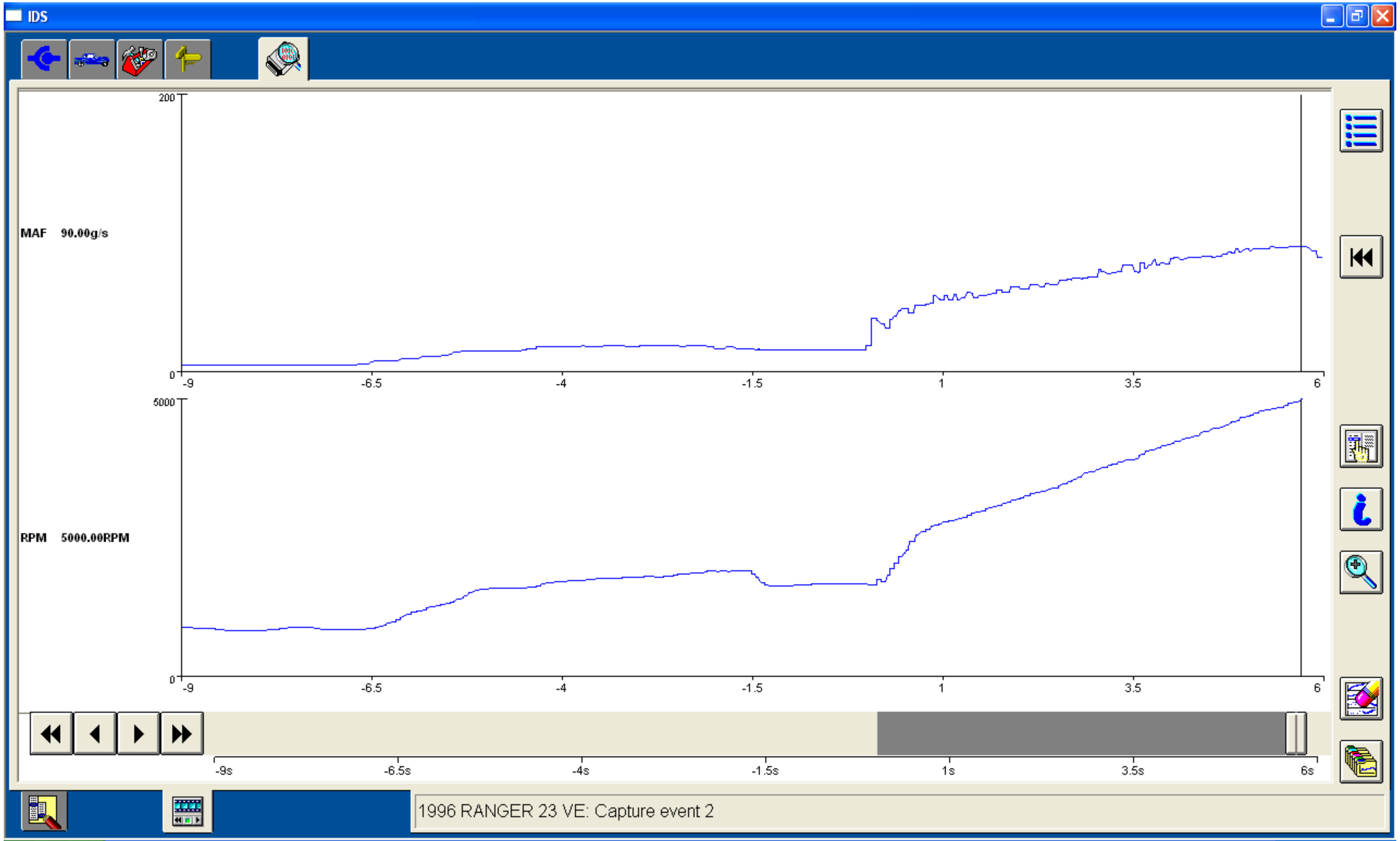
Condition	VE	O2	MAP	Trims
Good	Good	Rich	Normal	Normal
Fuel Delivery	OK	Lean	Normal	Positive #'s
Air Metering	Poor	Lean	Normal	Erratic
Rest. Exh.	Poor	Rich	Normal	Negative #'s
Rest. Int.	Poor	Rich	Ratchets	Normal

Let’s Expand…

- To this point we have only used GM vehicles
- And we have only used the Tech 2
- How about some Ford vehicles
- Scan tool is the IDS
- And we’ll start with a known good

1996 Ford Ranger 2.3 L

Known Good



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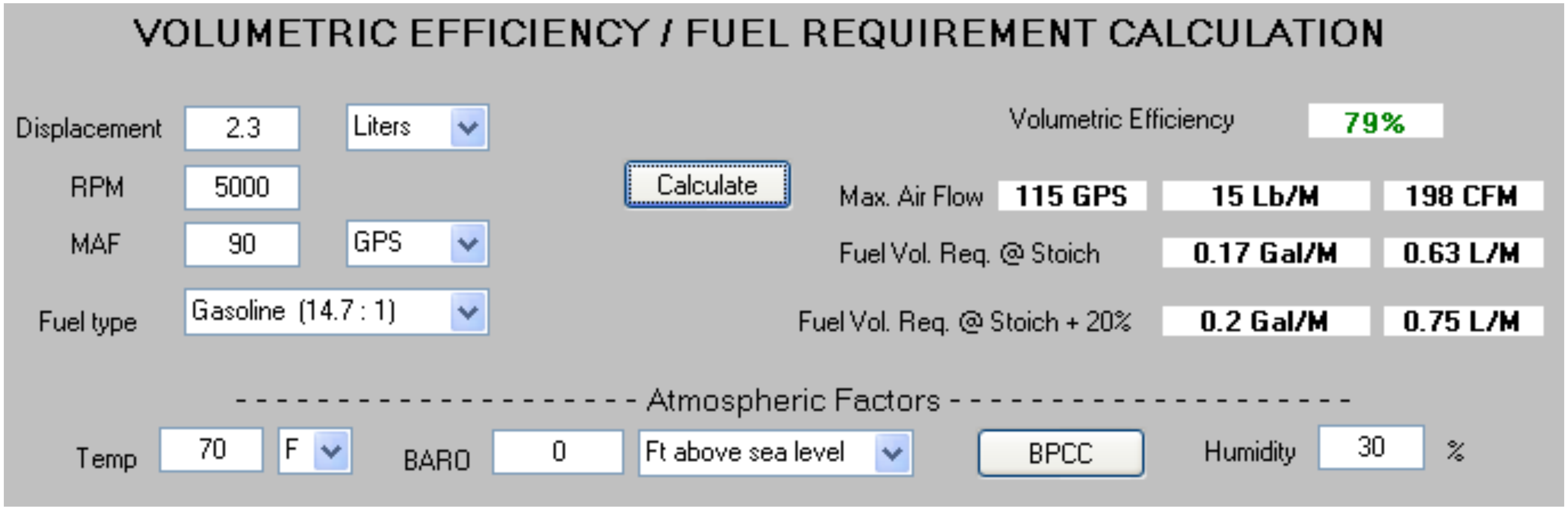
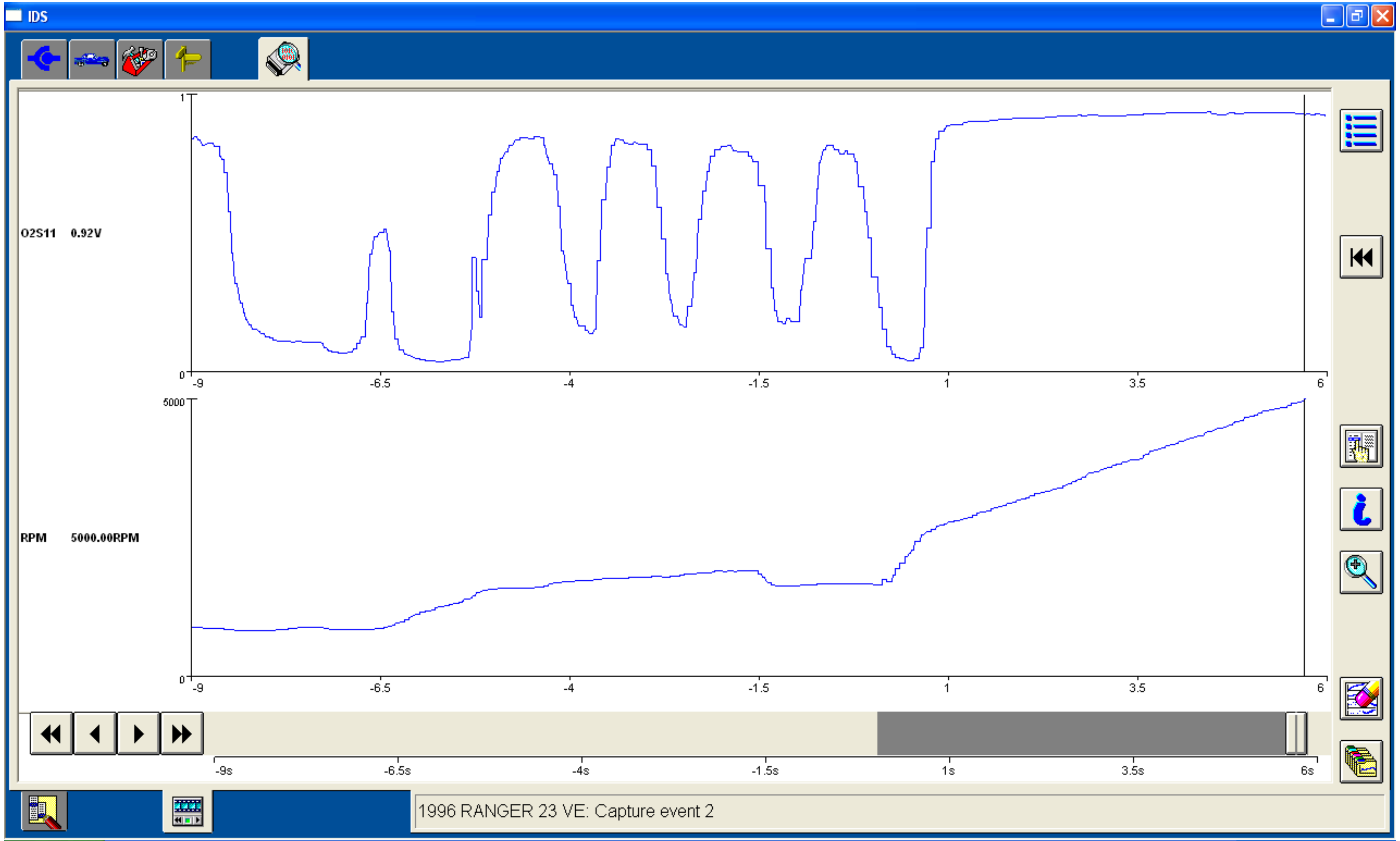
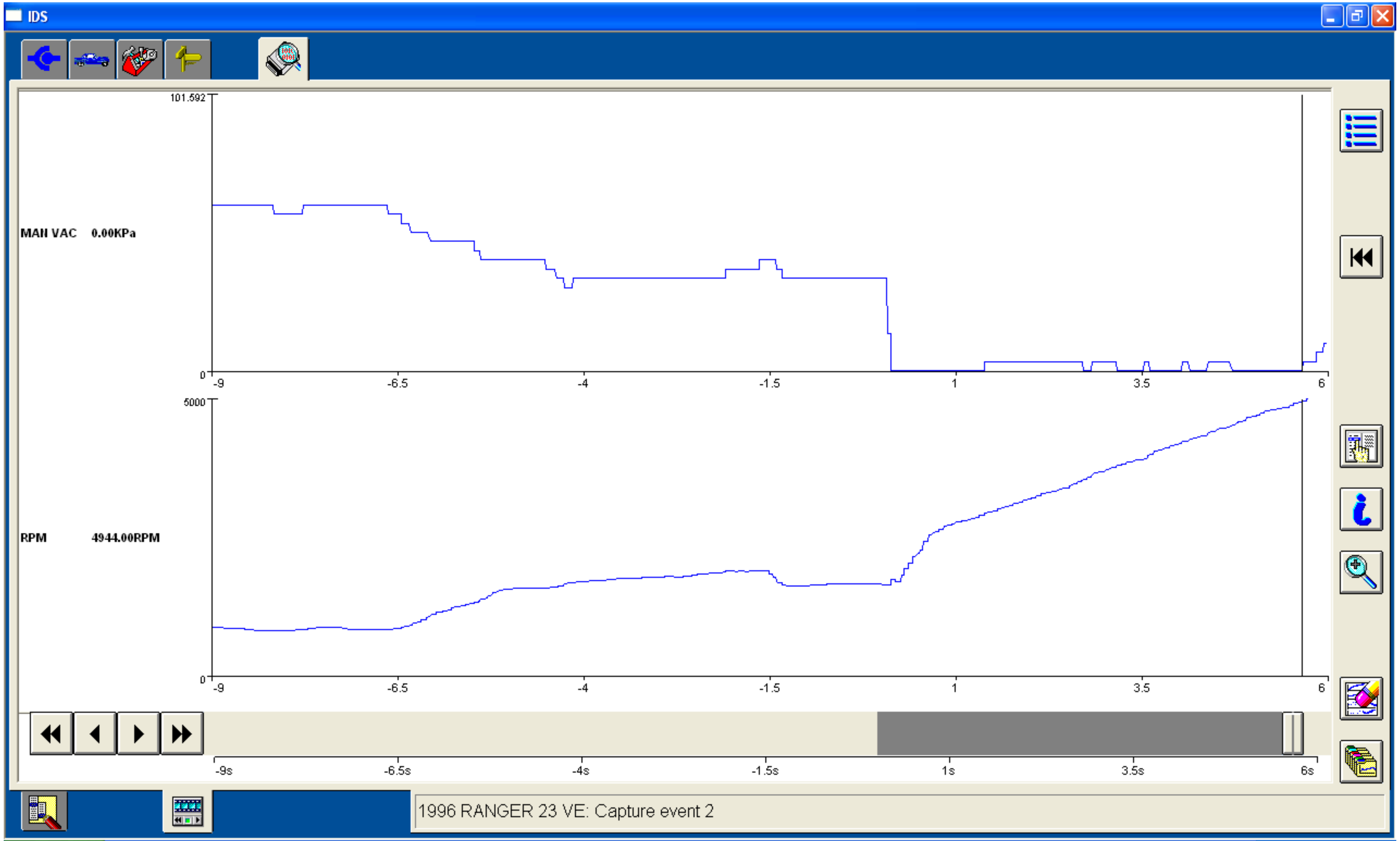

VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
2.3
Liters
RPM
5000
MAF
90
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
79%
Max. Air Flow
115 GPS
15 Lb/M
198 CFM
Fuel Vol. Req. @ Stoich
0.17 Gal/M
0.63 L/M
Fuel Vol. Req. @ Stoich + 20%
0.2 Gal/M
0.75 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%



IDS
O2S11 0.92V
RPM 5000.00RPM
1996 RANGER 23 VE: Capture event 2



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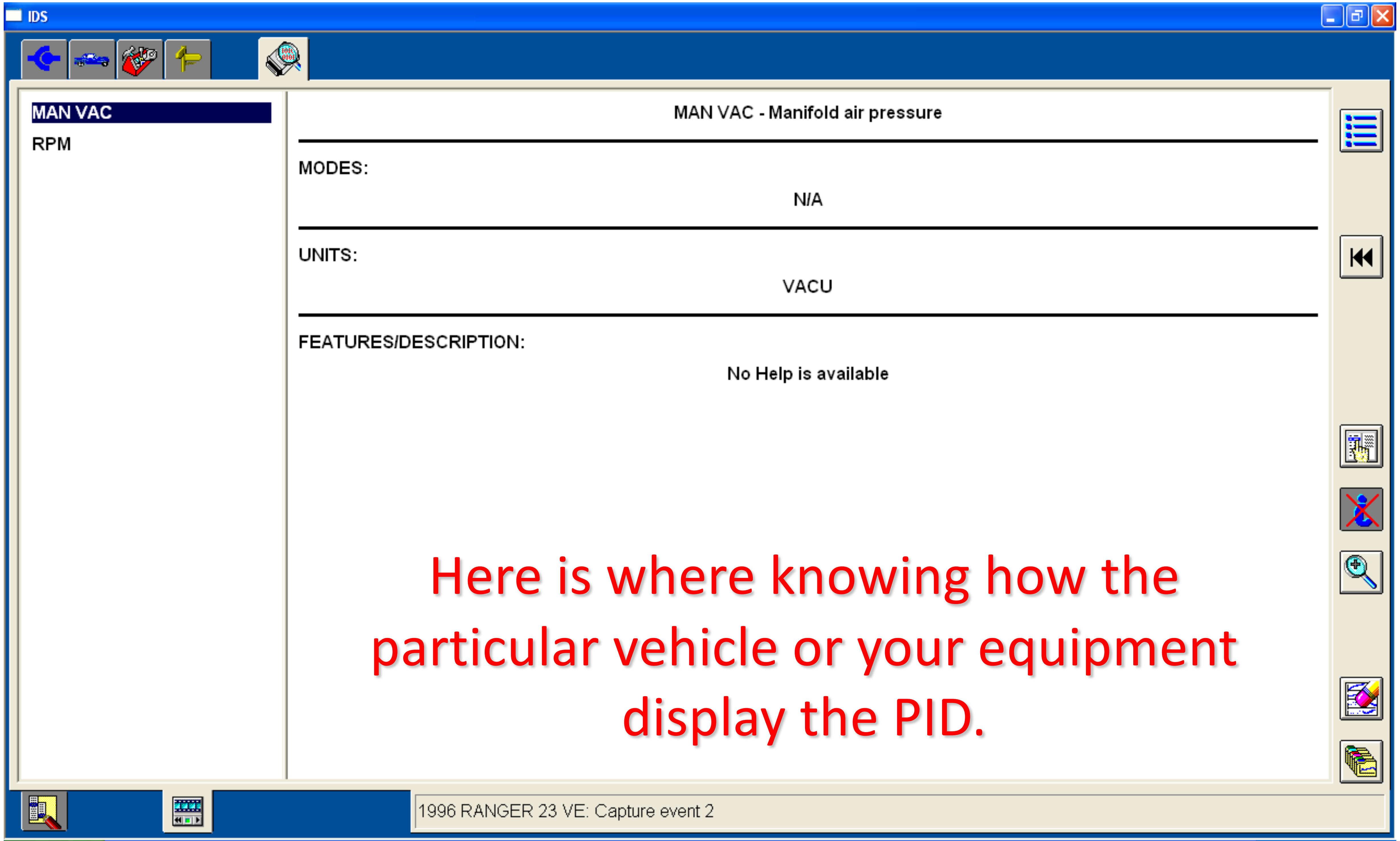
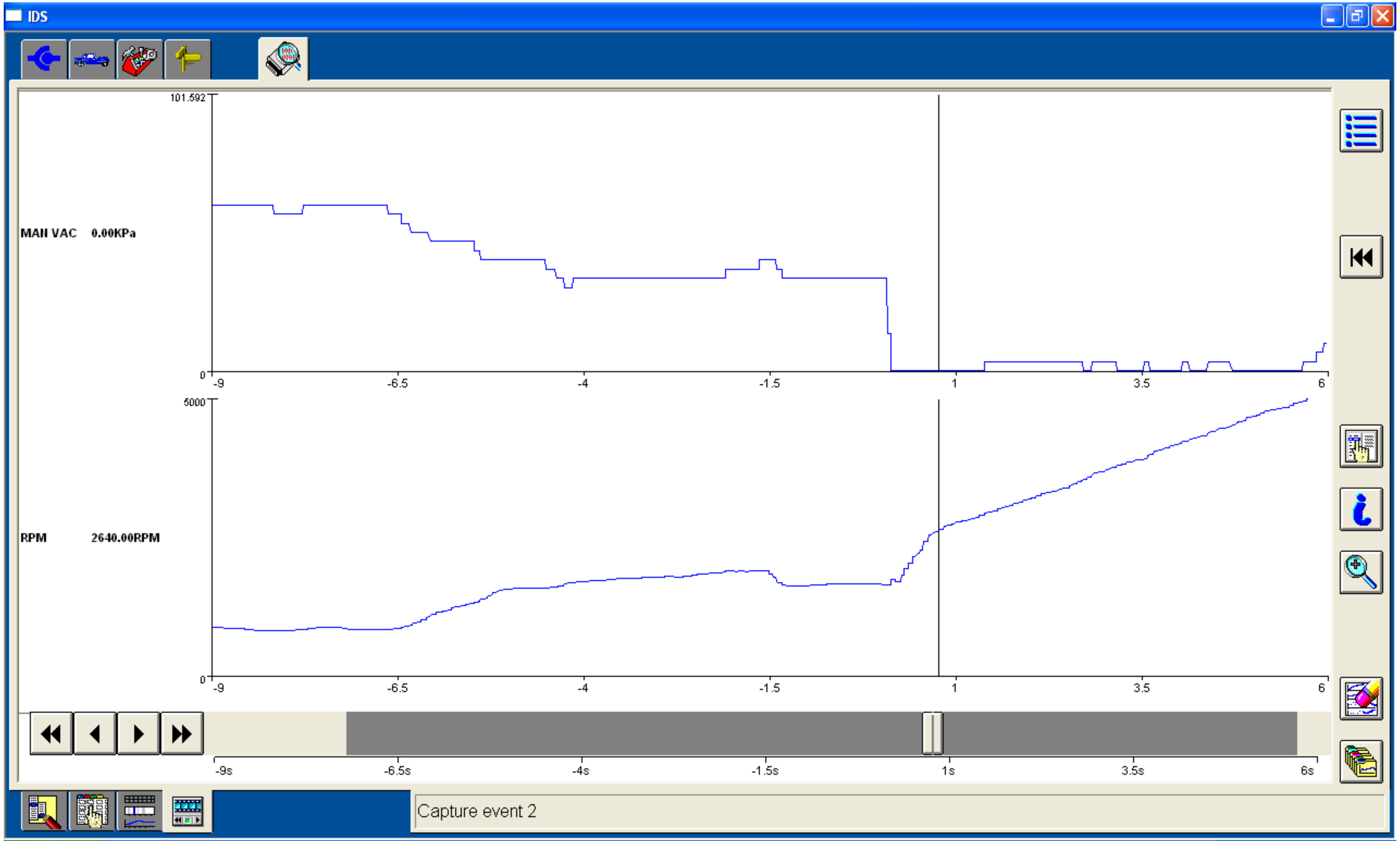
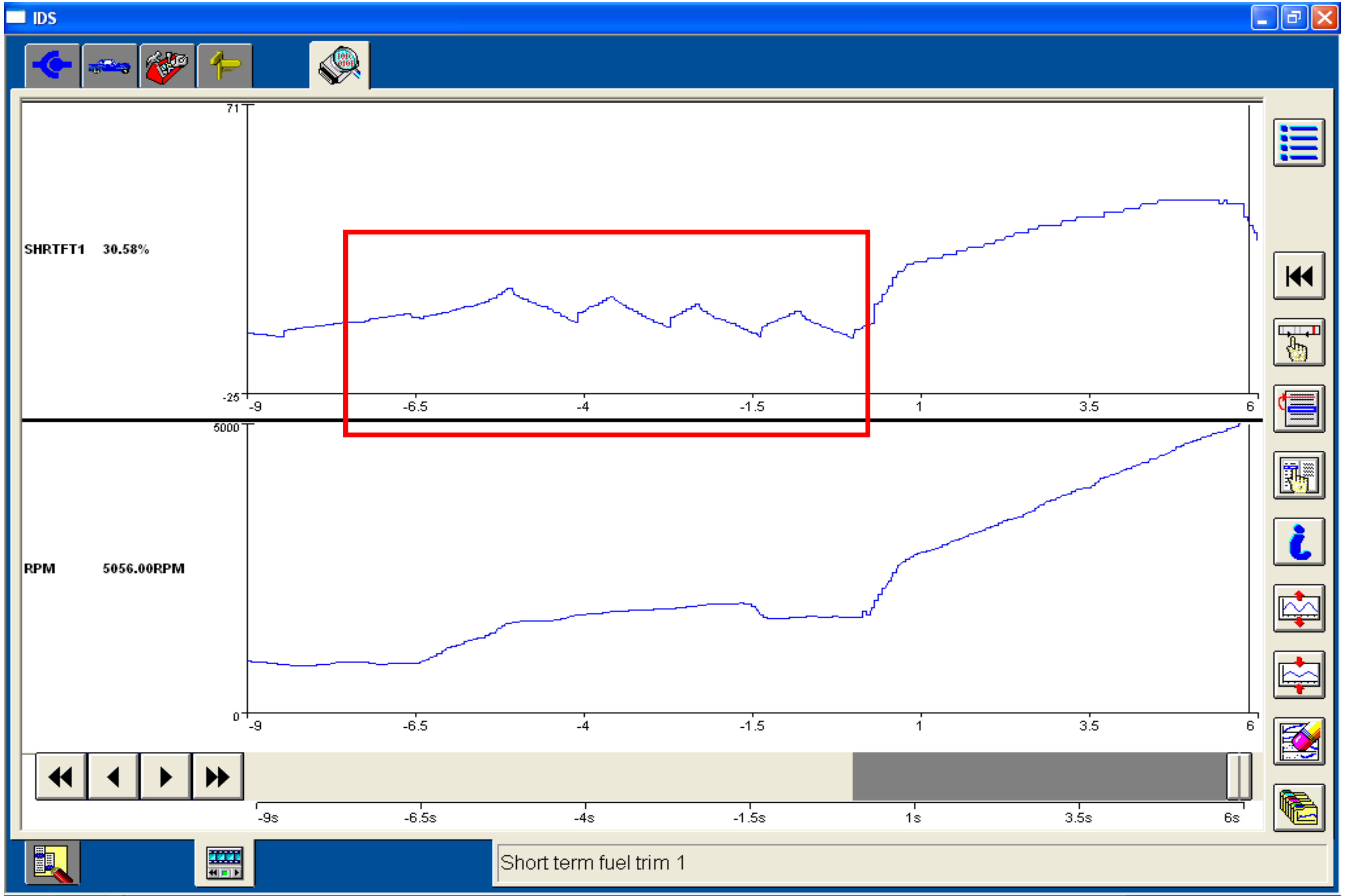


Here is where knowing how the particular vehicle or your equipment display the PID.



WTI WORLDPAC Training Institute.

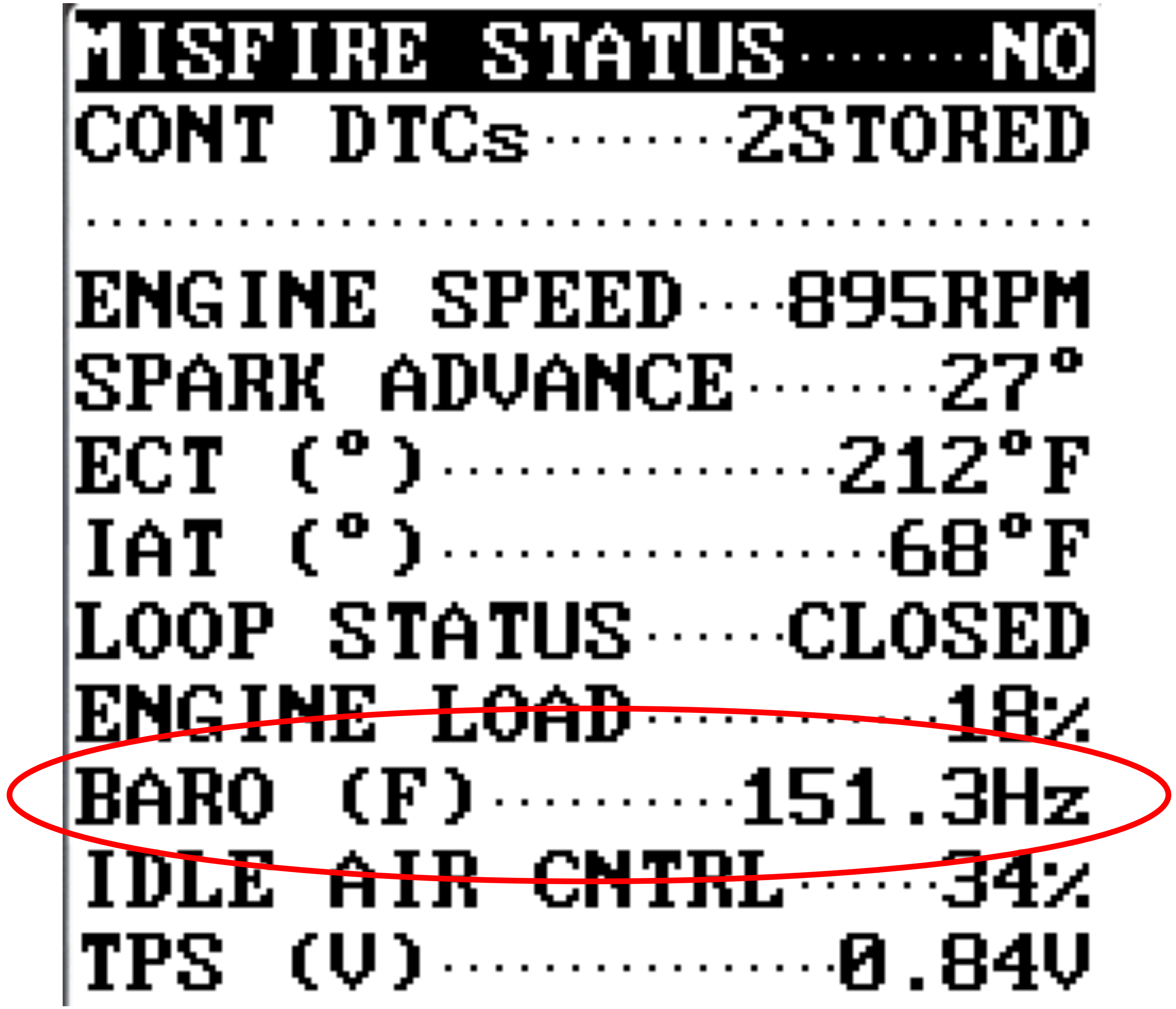

IDS
SHRTFT1 30.58%
RPM 5056.00RPM
71
-25
5000
0
-9
-6.5
-4
-1.5
1
3.5
6
-9s
-6.5s
-4s
-1.5s
1s
3.5s
6s
Short term fuel trim 1

Is our Cheat Sheet still correct?

- Is VE still the same
- Is O2 still the same
- Is MAP, or Manifold Vacuum, still the same (it may be calculated)
- **CLOSED LOOP** fuel trims are the same

Ford side bar…

- Ford uses the MAF to determine BARO
- Incorrect BARO is an indication of a VE issue
  - Actual or
  - Calculated
- Do you know the BARO reading for your altitude?


MISFIRE STATUS.......NO
CONT DTCs.......2STORED
ENGINE SPEED....895RPM
SPARK ADVANCE.......27°
ECT (°)...............212°F
IAT (°)..................68°F
LOOP STATUS.....CLOSED
ENGINE LOAD..........18%
BARO (F)..........151.3Hz
IDLE AIR CNTRL.......34%
TPS (V)..............0.84V

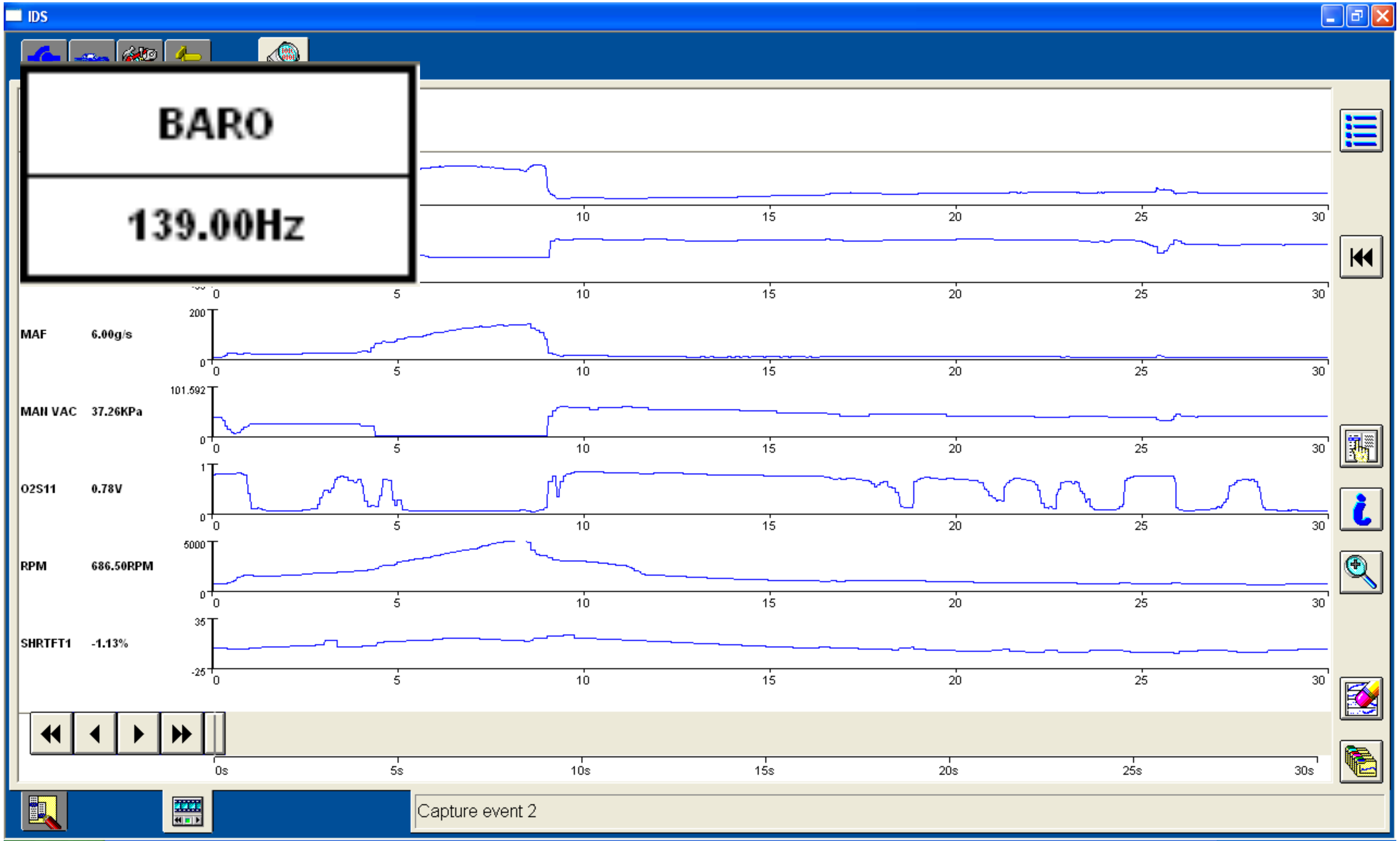
BAROMETRIC PRESSURE REFERENCE			
Barometric Pressure (in. Hg.)	Barometric Pressure (kPa)	BARO/MAP PID (Hz)	Altitude above sea level (ft)
3.5	11.8	89.3	
5	16.9	92.8	
10	33.8	104.6	
15	50.7	117.0	14,000
20	67.5	129.6	10,000
21	70.9	132.5	9,000
22	74.3	135.4	8,000
23	77.7	138.3	7,000
24	81.1	141.1	6,000
25	84.4	144.0	5,000
26	87.8	146.9	4,000
27	91.2	149.8	3,000
28	94.6	152.8	2,000
29	97.9	155.8	1,000
30	101.3	158.9	0 (sea level)
31	104.7	162.0	
31.875	107.7	164.7	

1999 Ford Windstar 3.8 L

P0171/P0174

VE test drive…

What do you see?



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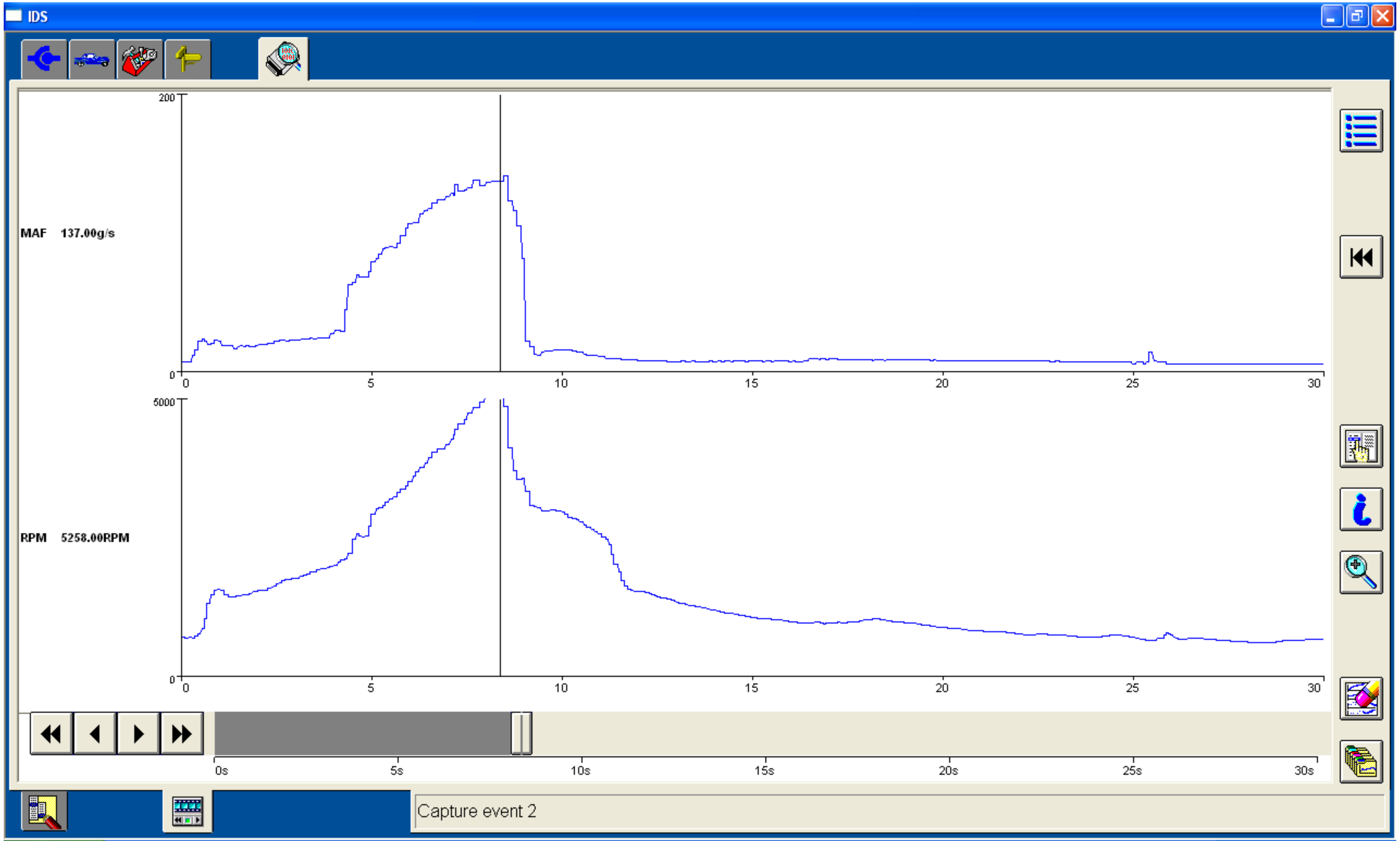
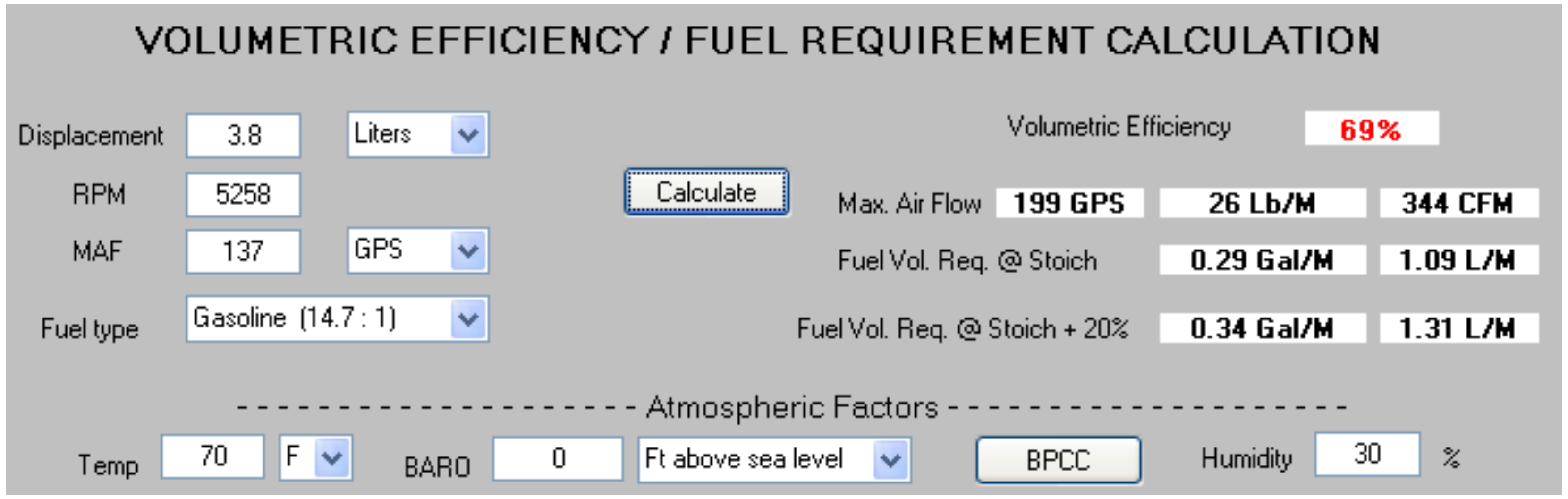
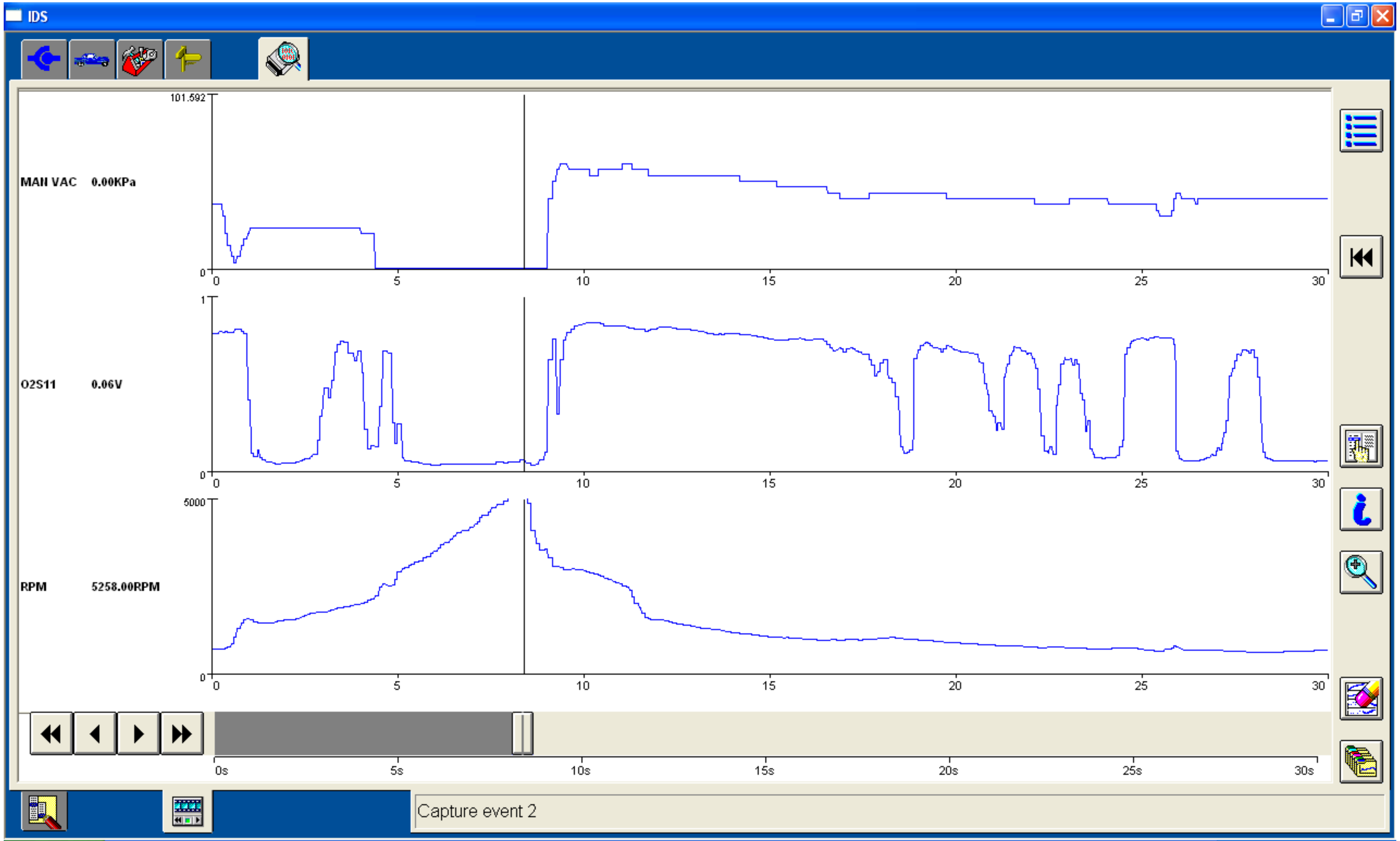
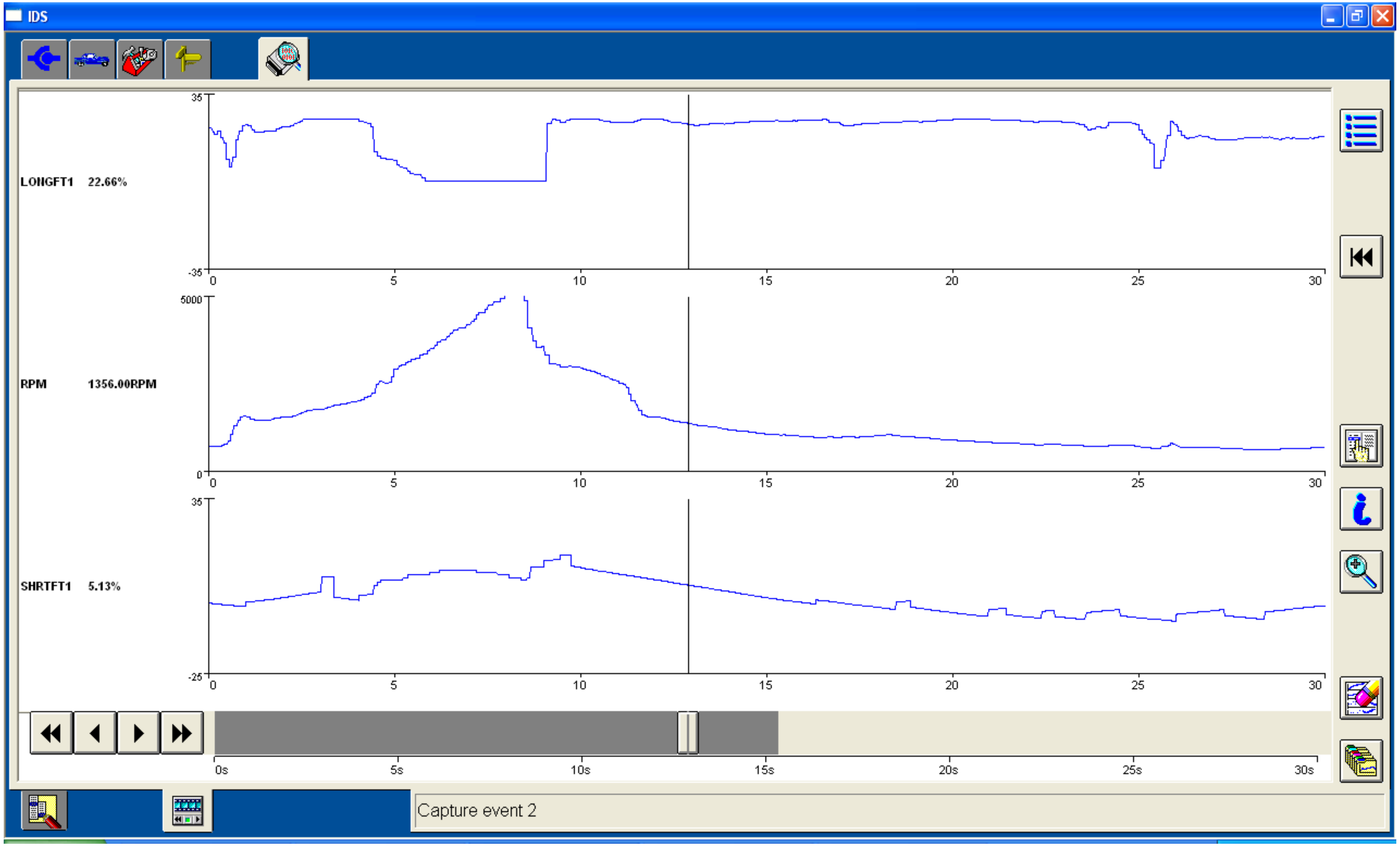


WTI WORLDPAC Training Institute.


VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
3.8
Liters
RPM
5258
MAF
137
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
69%
Max. Air Flow
199 GPS
26 Lb/M
344 CFM
Fuel Vol. Req. @ Stoich
0.29 Gal/M
1.09 L/M
Fuel Vol. Req. @ Stoich + 20%
0.34 Gal/M
1.31 L/M
- - - - - - - - - - - - - - - - - - - Atmospheric Factors - - - - - - - - - - - - - - - - - - -
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%


IDS
MAN VAC 0.00KPa
O2S11 0.06V
RPM 5258.00RPM
101.592
5000
0s
5s
10s
15s
20s
25s
30s
Capture event 2

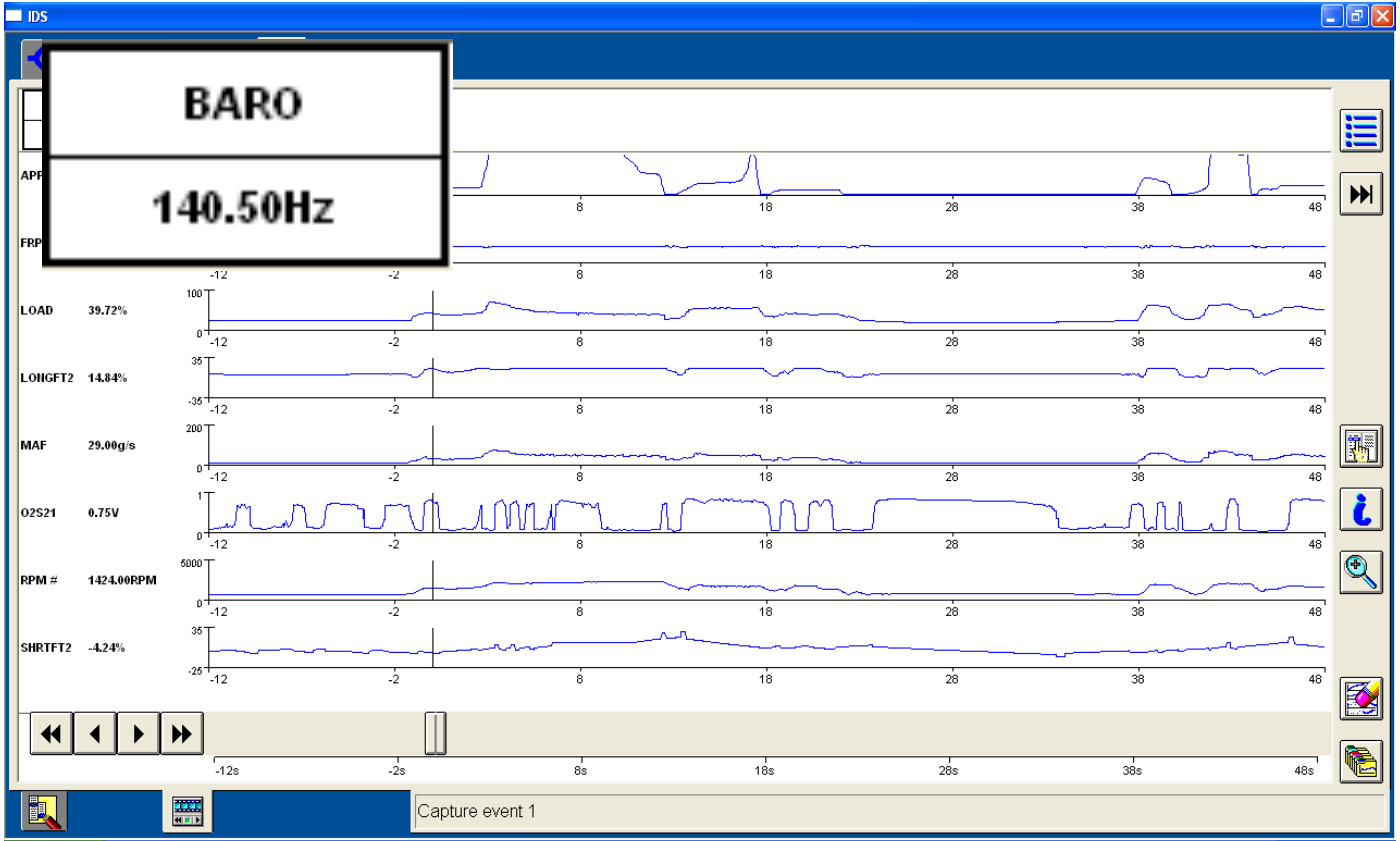

IDS
LONGFT1 22.66%
RPM 1356.00RPM
SHRTFT1 5.13%
Capture event 2

Diagnostic decision?

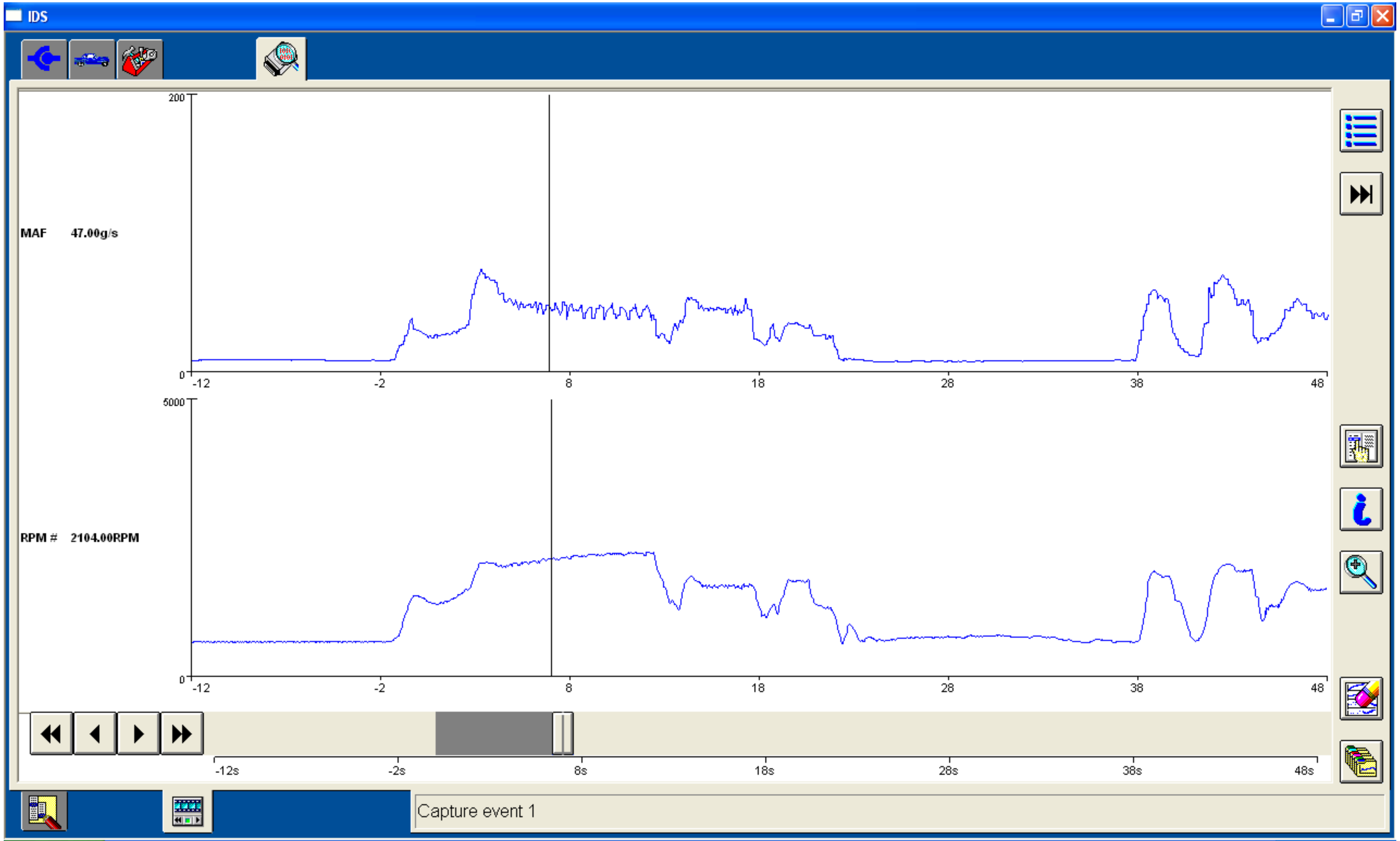
- BARO indicates a VE issue, physical or calculated
- VE calculation confirms a VE issue
  - Again, physical or calculated?
- O2 PID is Lean - cannot be blamed on a fuel delivery issue because of poor VE
- MAP?
- Closed loop fuel trim?

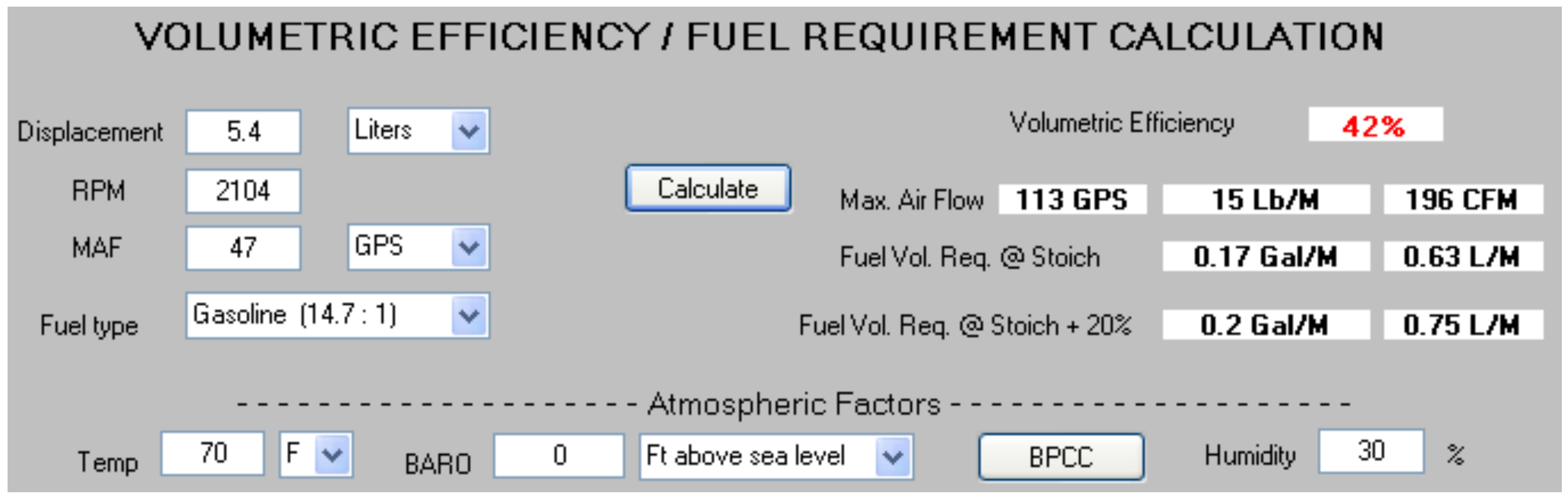
Next example…

An Expedition with low power



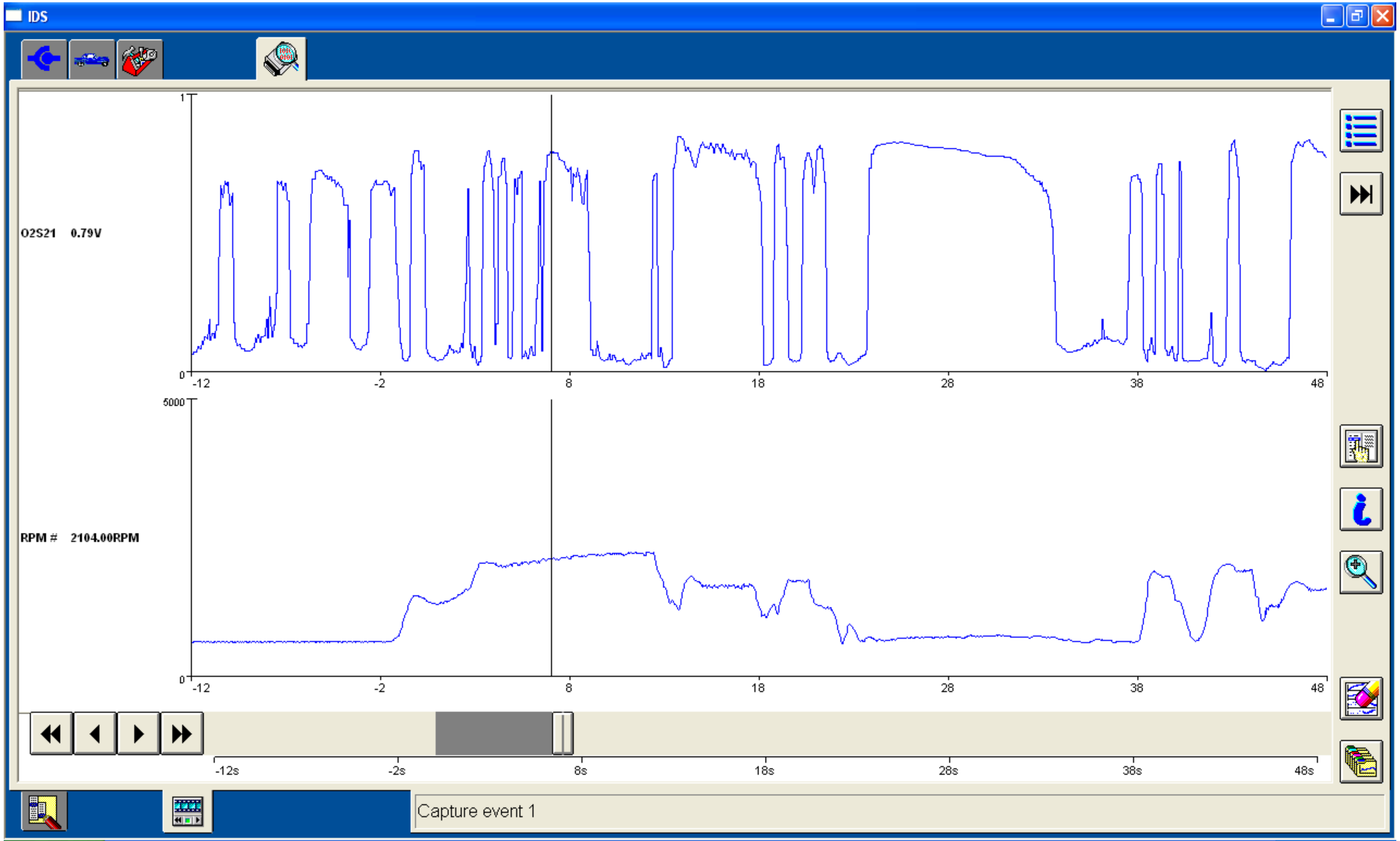
IDS
BARO
140.50Hz
APP
FRP
LOAD 39.72%
LONGFT2 14.84%
MAF 29.00g/s
O2S21 0.75V
RPM # 1424.00RPM
SHRTFT2 -4.24%
-12s -2s 8s 18s 28s 38s 48s
Capture event 1


IDS
MAF 47.00g/s
200
0
-12
-2
8
18
28
38
48
RPM # 2104.00RPM
5000
0
-12
-2
8
18
28
38
48
-12s
-2s
8s
18s
28s
38s
48s
Capture event 1


VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
5.4
Liters
RPM
2104
MAF
47
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
42%
Max. Air Flow
113 GPS
15 Lb/M
196 CFM
Fuel Vol. Req. @ Stoich
0.17 Gal/M
0.63 L/M
Fuel Vol. Req. @ Stoich + 20%
0.2 Gal/M
0.75 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%

No Manifold Vacuum PID

Move on to O2 and fuel trim



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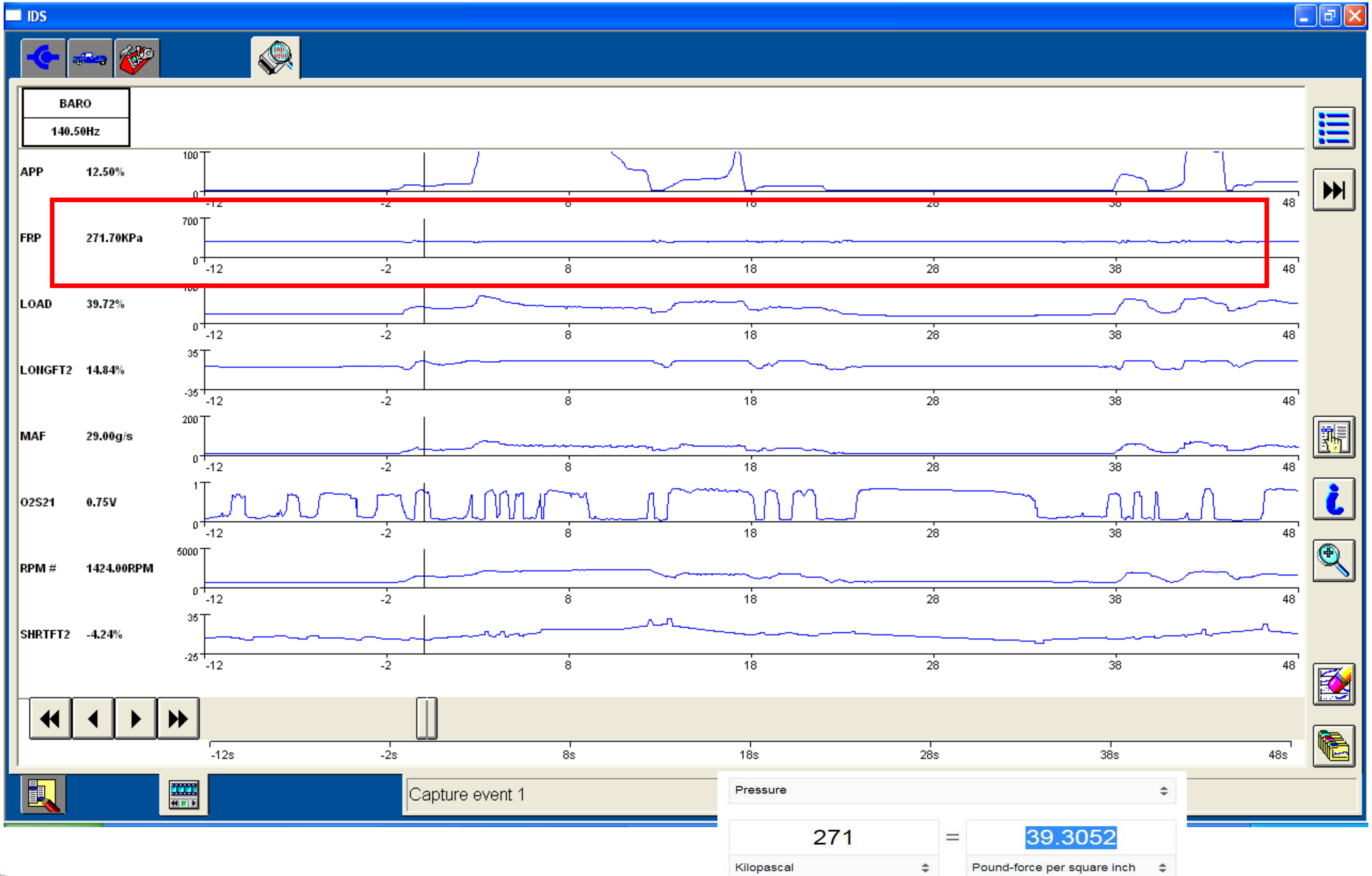
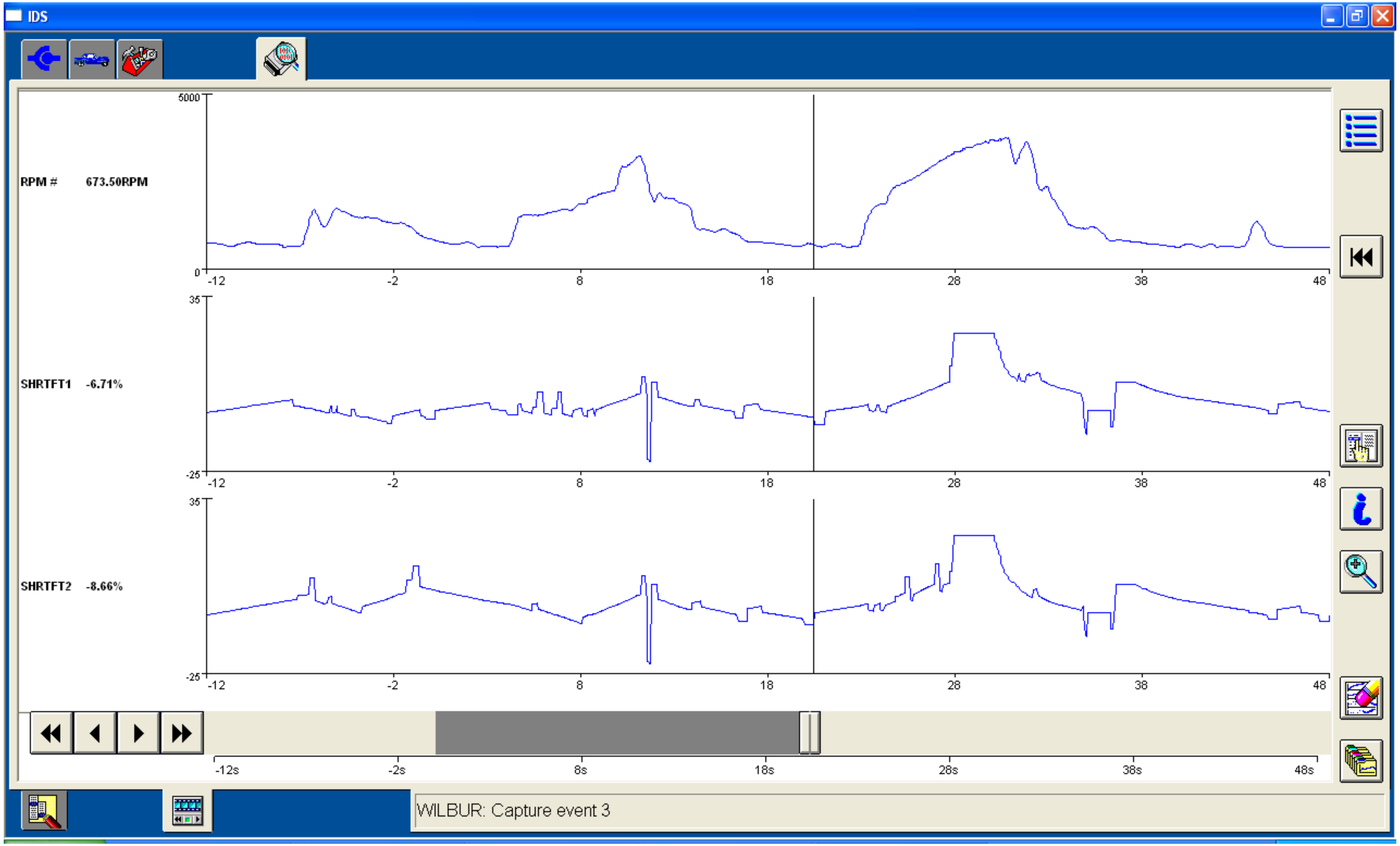


WTI WORLDPAC Training Institute.



IDS
RPM # 673.50RPM
SHRTFT1 -6.71%
SHRTFT2 -8.66%
5000
0
35
-25
-12
-2
8
18
28
38
48
-12s
-2s
8s
18s
28s
38s
48s
WILBUR: Capture event 3

Diagnostic decision?

- BARO indicates a VE issue, physical or calculated
- VE calculation confirms a VE issue
- Rich O2, poor VE and FRP exclude fuel delivery
- No MAP available…
- Closed loop fuel trim numbers are negative… What do you think?

Where does a VE calculation come in next?

Repair verification.

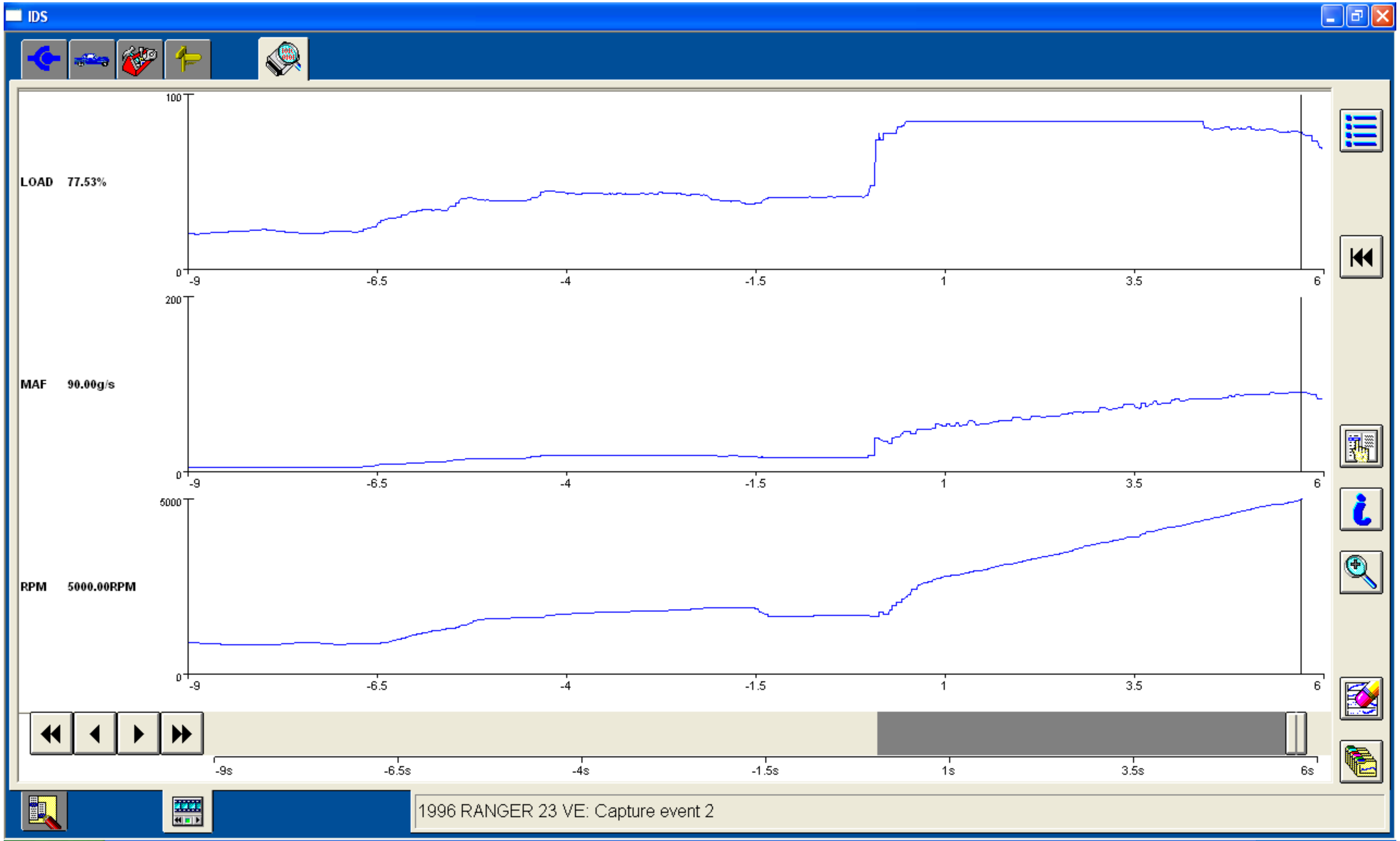
The Load PID…

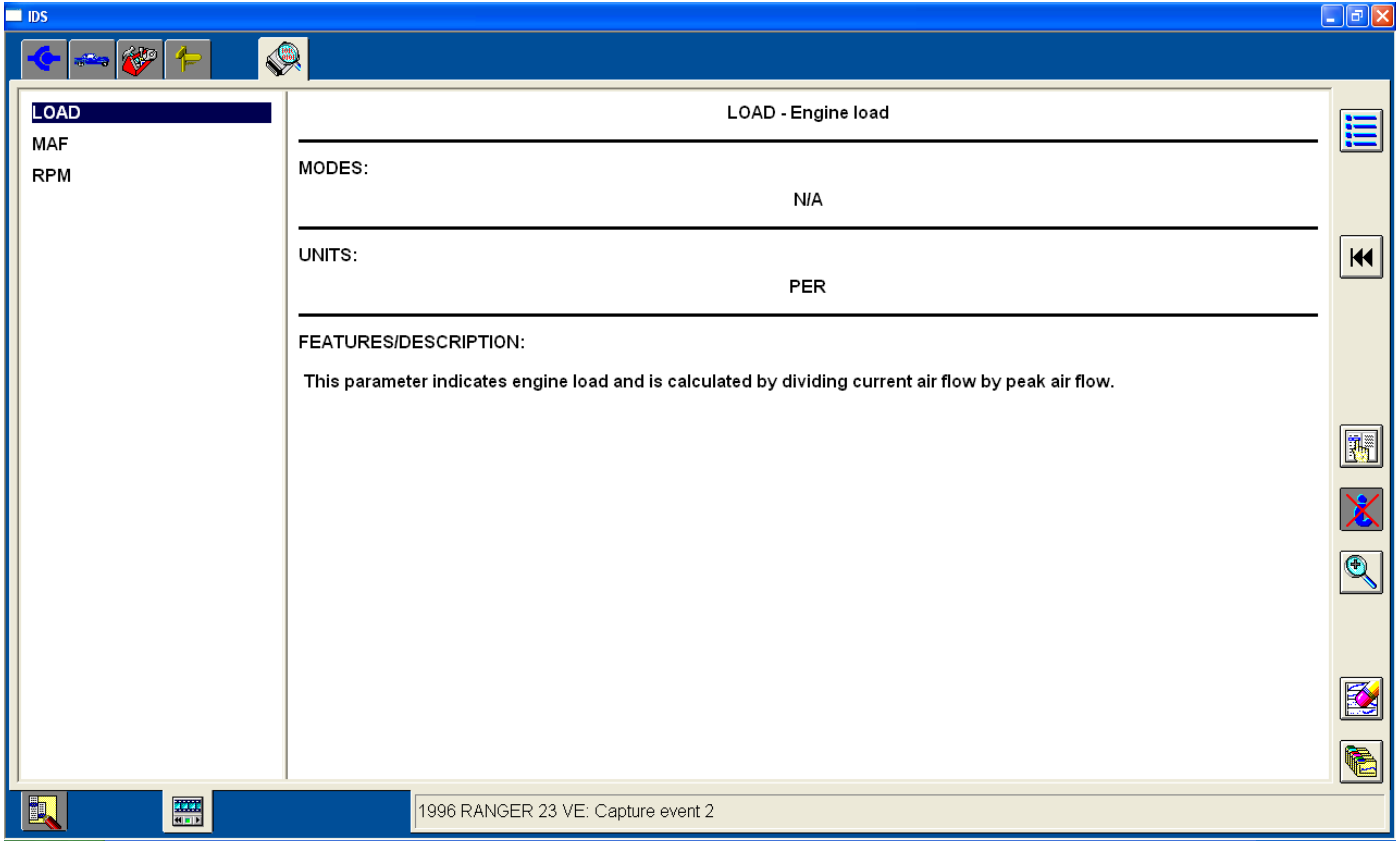
- Definitions
- Load
- Calculated Load
- Absolute Load
- Where is it derived from?
- Not always, but most are calculated much (or exactly) like VE

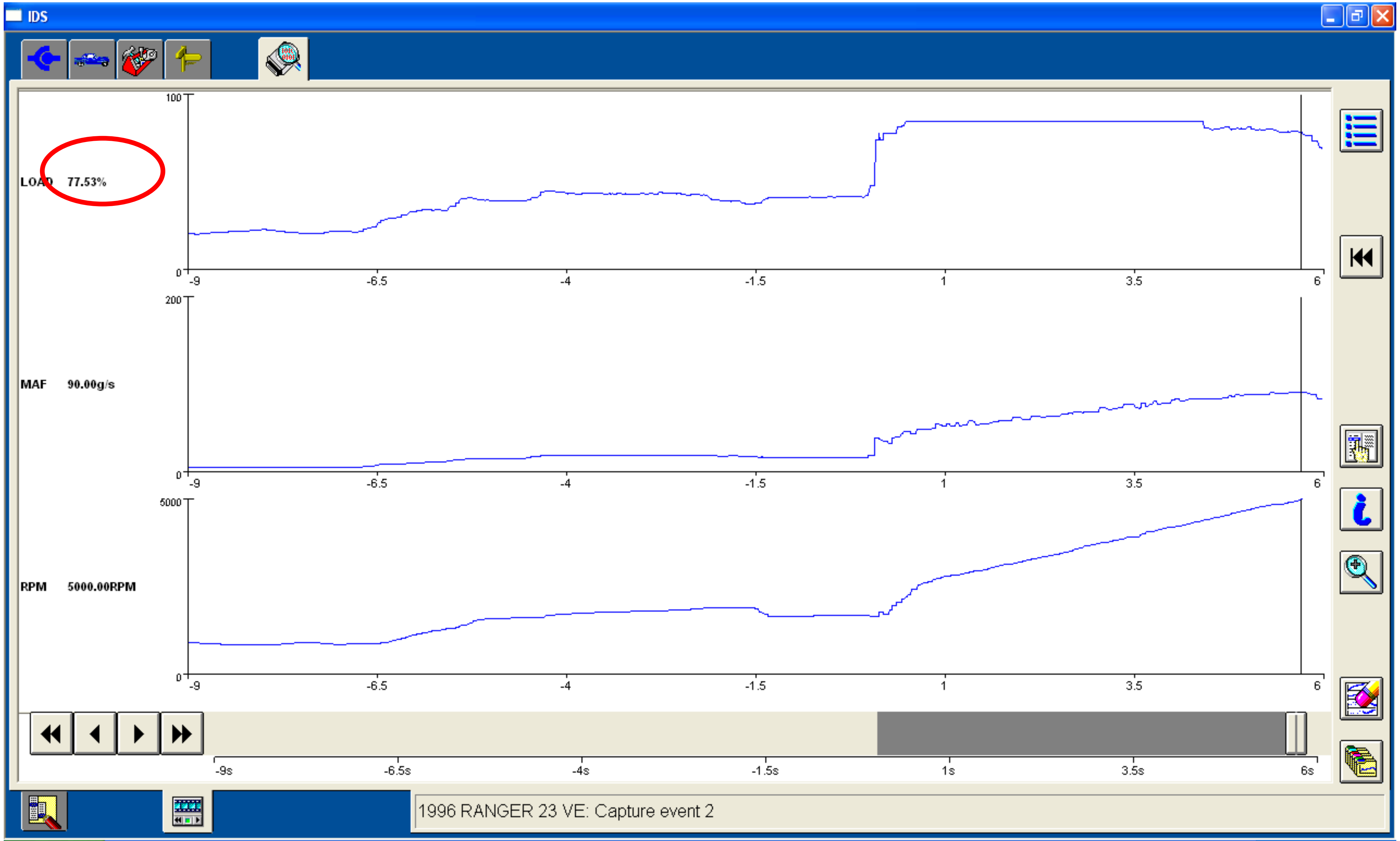
Load PID

- Required PID for OBDII
- Defined in SAE J1979
- Redefined more recently so all manufactures would report the PID the same
- LOAD_PCT = [current airflow] / [(peak airflow at WOT@STP as a function of rpm) * (BARO/29.92) * SQRT(298/(AAT+273))]

Let’s take a look at Load on our previous Ranger example…


IDS
LOAD 77.53%
100
0
-9
-6.5
-4
-1.5
1
3.5
6
MAF 90.00g/s
200
0
-9
-6.5
-4
-1.5
1
3.5
6
RPM 5000.00RPM
5000
0
-9
-6.5
-4
-1.5
1
3.5
6
-9s
-6.5s
-4s
-1.5s
1s
3.5s
6s
1996 RANGER 23 VE: Capture event 2


IDS
LOAD
MAF
RPM
LOAD - Engine load
MODES:
N/A
UNITS:
PER
FEATURES/DESCRIPTION:
This parameter indicates engine load and is calculated by dividing current air flow by peak air flow.
1996 RANGER 23 VE: Capture event 2



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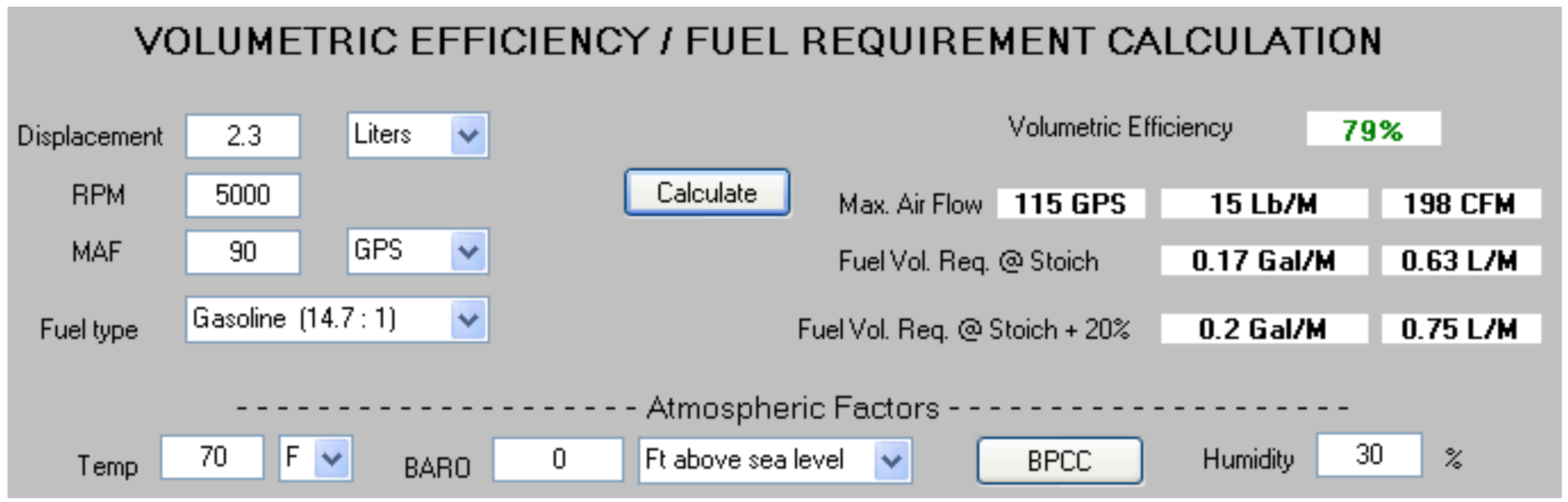
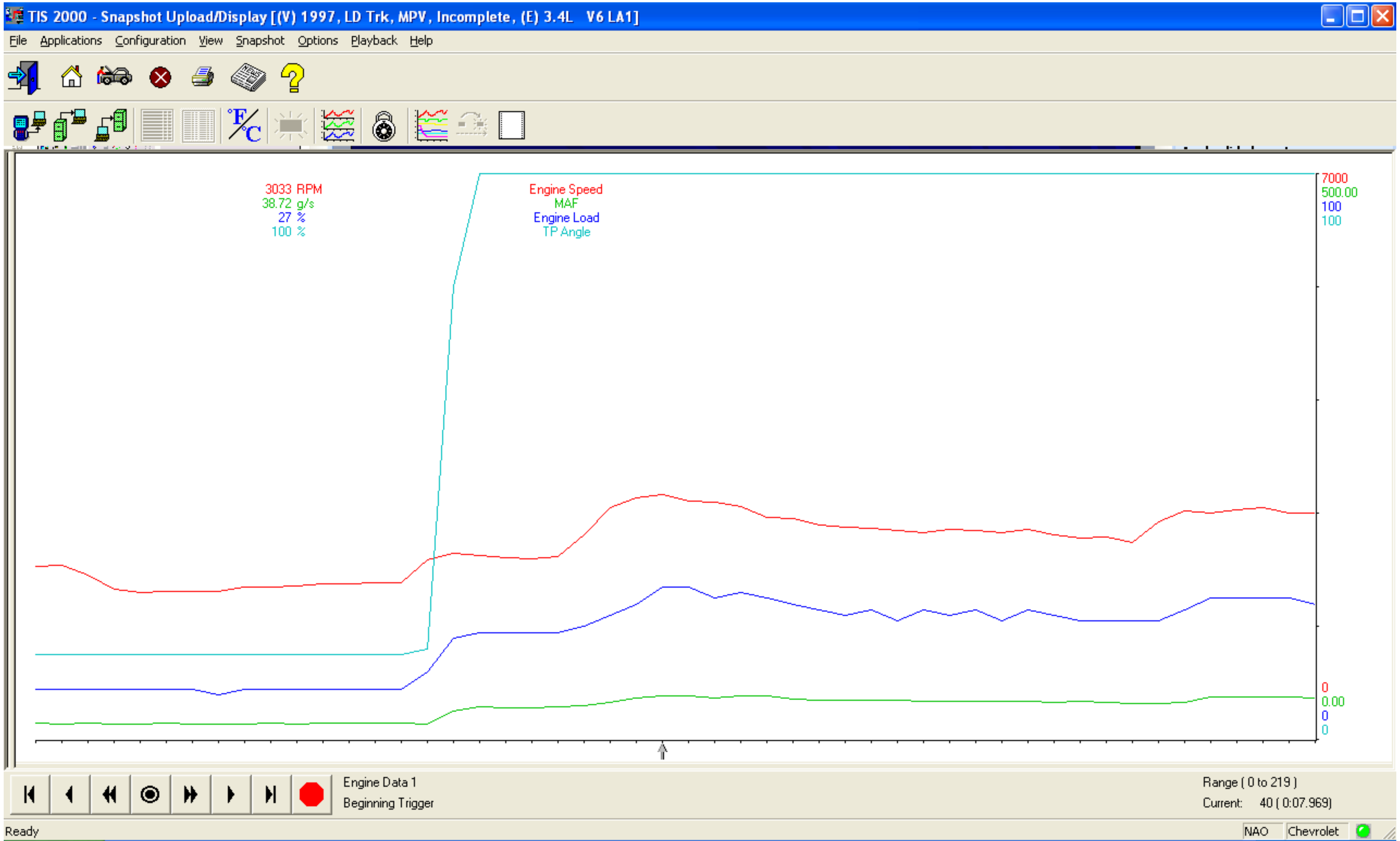

VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
2.3
Liters
RPM
5000
MAF
90
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
79%
Max. Air Flow
115 GPS
15 Lb/M
198 CFM
Fuel Vol. Req. @ Stoich
0.17 Gal/M
0.63 L/M
Fuel Vol. Req. @ Stoich + 20%
0.2 Gal/M
0.75 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%

Remember our Transport with the bad MAF?



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VE equates to Load PID

- VE was low 30%

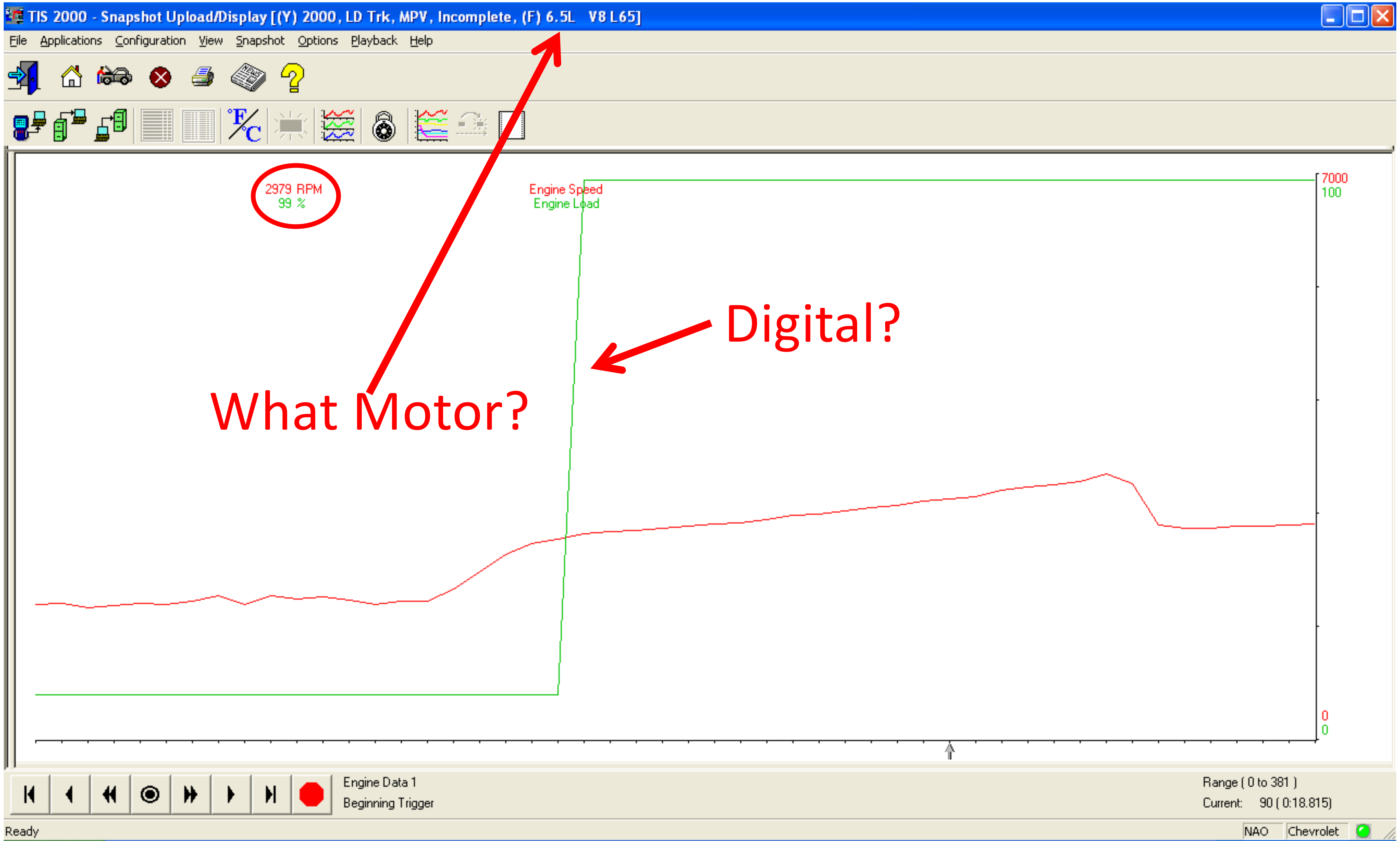
- Load PID says 27%

- Do we need to calculate?

Theory behind the Load PID

- Based on VE
  - Know VE and understand the Load PID
- Can be calculated differently by application

How about this one?



TIS 2000 - Snapshot Upload/Display [(Y) 2000, LD Trk, MPV, Incomplete, (F) 6.5L V8 L65]
File Applications Configuration View Snapshot Options Playback Help
2979 RPM
99 %
Engine Speed
Engine Load
7000
100
0
0
Digital?
What Motor?
Engine Data 1
Beginning Trigger
Range (0 to 381)
Current: 90 (0:18.815)
Ready
NAO
Chevrolet

So, if we have a Load PID, why use VE?

- Understanding of theory
- Differences in manufacturer’s choice of calculation

1999 Honda Odyssey

2HKRL1867XH517189 PGM-FI 18 99 18 01 01

Full List

Signal	Value	Units
ENGINE SPEED	1073	RPM
VEHICLE SPEED	0	MPH
ECT SENSOR 1	77.7	°F
IAT SENSOR (2)	65.3	°F
MAP SENSOR	1.05	V
CLV	33	%
BARO SENSOR	2.83	V
TP SENSOR	0.49	V
HO2S S1	0.51	V
O2 FB COND	OPEN	
FSS	OL COND	
ST FUEL TRIM	1.00	
LT FUEL TRIM	1.00	
HO2S S1 HEATER	ON	
HO2S S2	3.80	V
HO2S S2 HEATER	ON	
A/T LOCKUP B	0	%
BATTERY	14.3	V
ELD	17.94	A
ALTERNATOR	31	%
ALT CTRL	14.5V	
PNP SWITCH	N.P.	
BRAKE SWITCH	OFF	
A/C SWITCH	OFF	
A/C CLUTCH	OFF	
STARTER SWITCH	OFF	

PARSP_82_01

PARAMETER SPECIFICATION

CLV:
Calculated Load Value
(%)

Calculated load value refers to the current air flow divided by peak air flow. It indicates the percentage of engine capacity being used.

OPERATING RANGE (IDLE)
20% - 43%

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Speed Density Issues…

- Speed density vehicles may have Load PIDs

- Airflow is calculated not measured
  - If a MAF vehicle calculates load incorrectly, which input is incorrect?
  - If a MAP vehicle calculates load incorrectly, which input is incorrect?

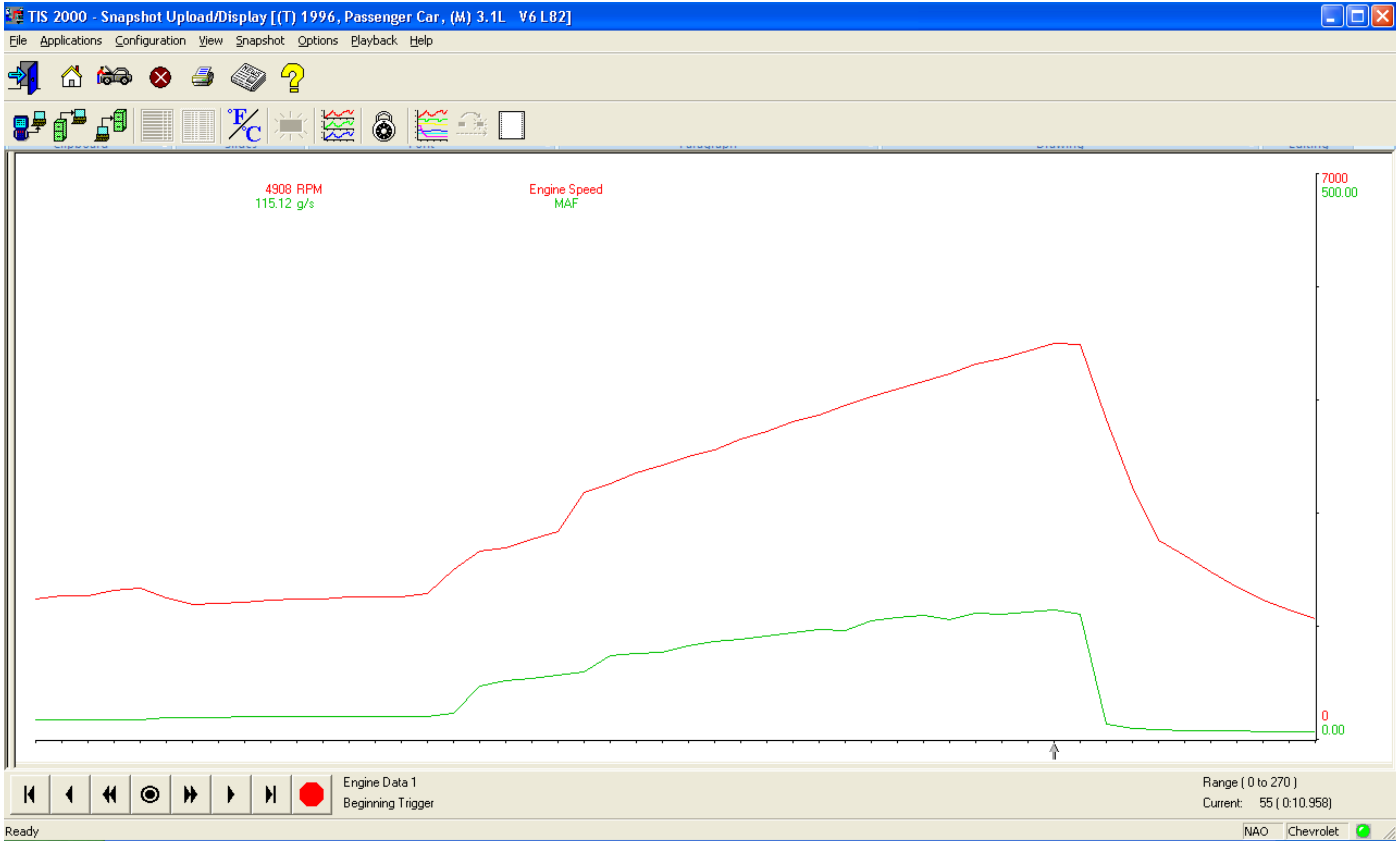
Let's apply what we've learned…

1996 Chevy Lumina 3.1 L

Low Power on acceleration

Initial Checks

- No MIL
- No trouble codes
- Is a VE test drive in order?



WTI
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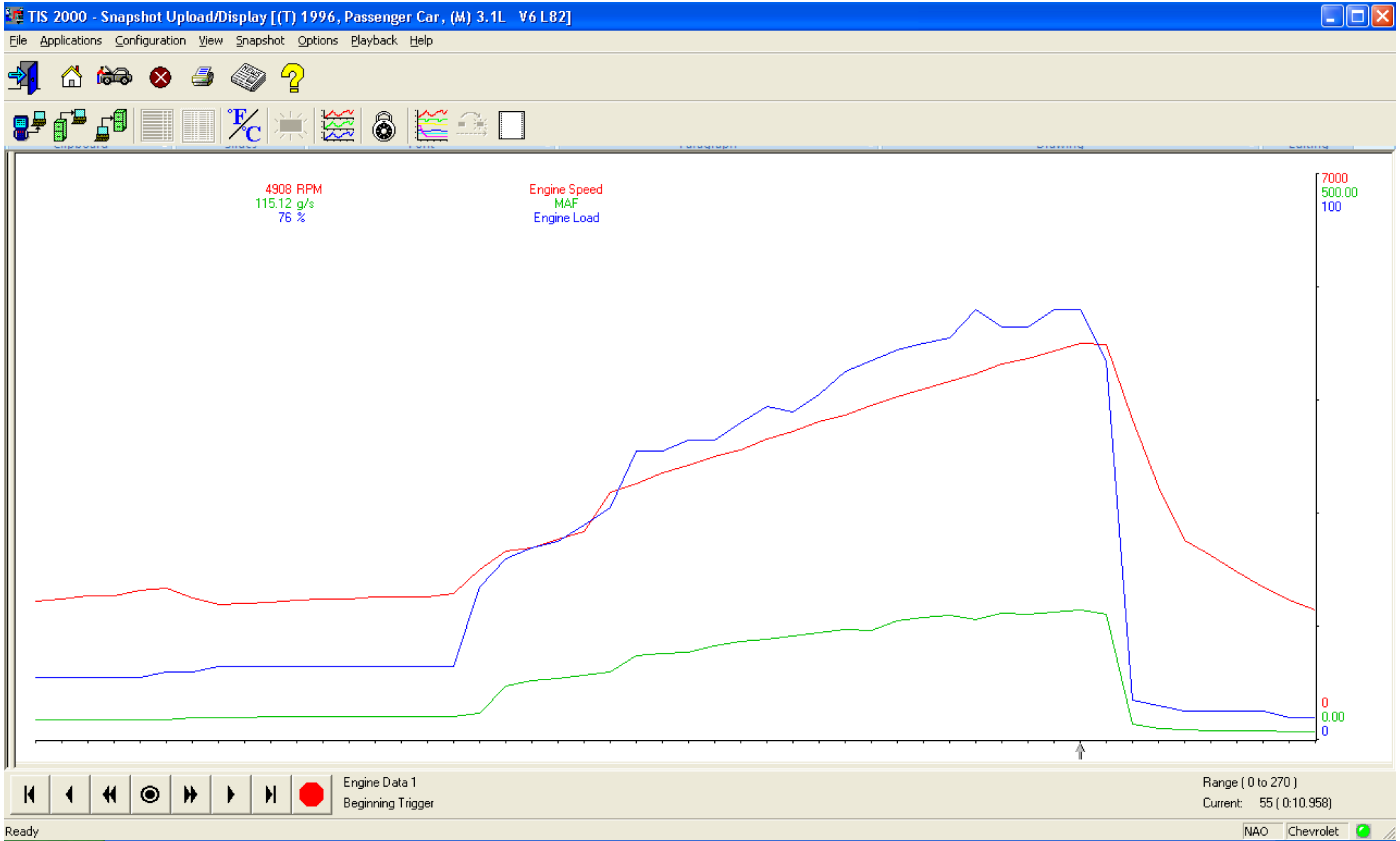
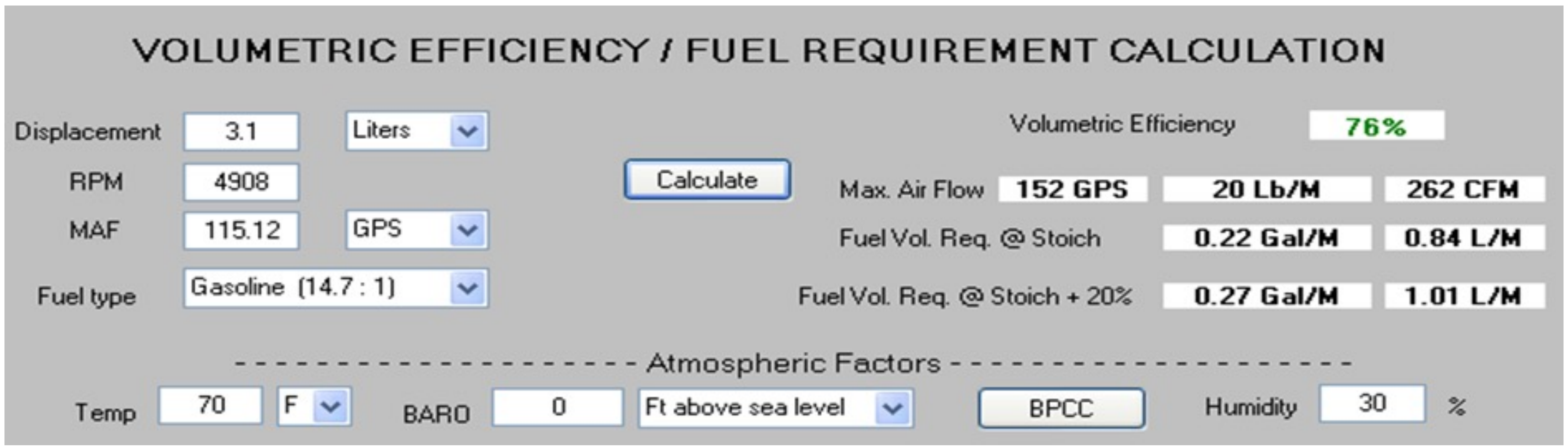
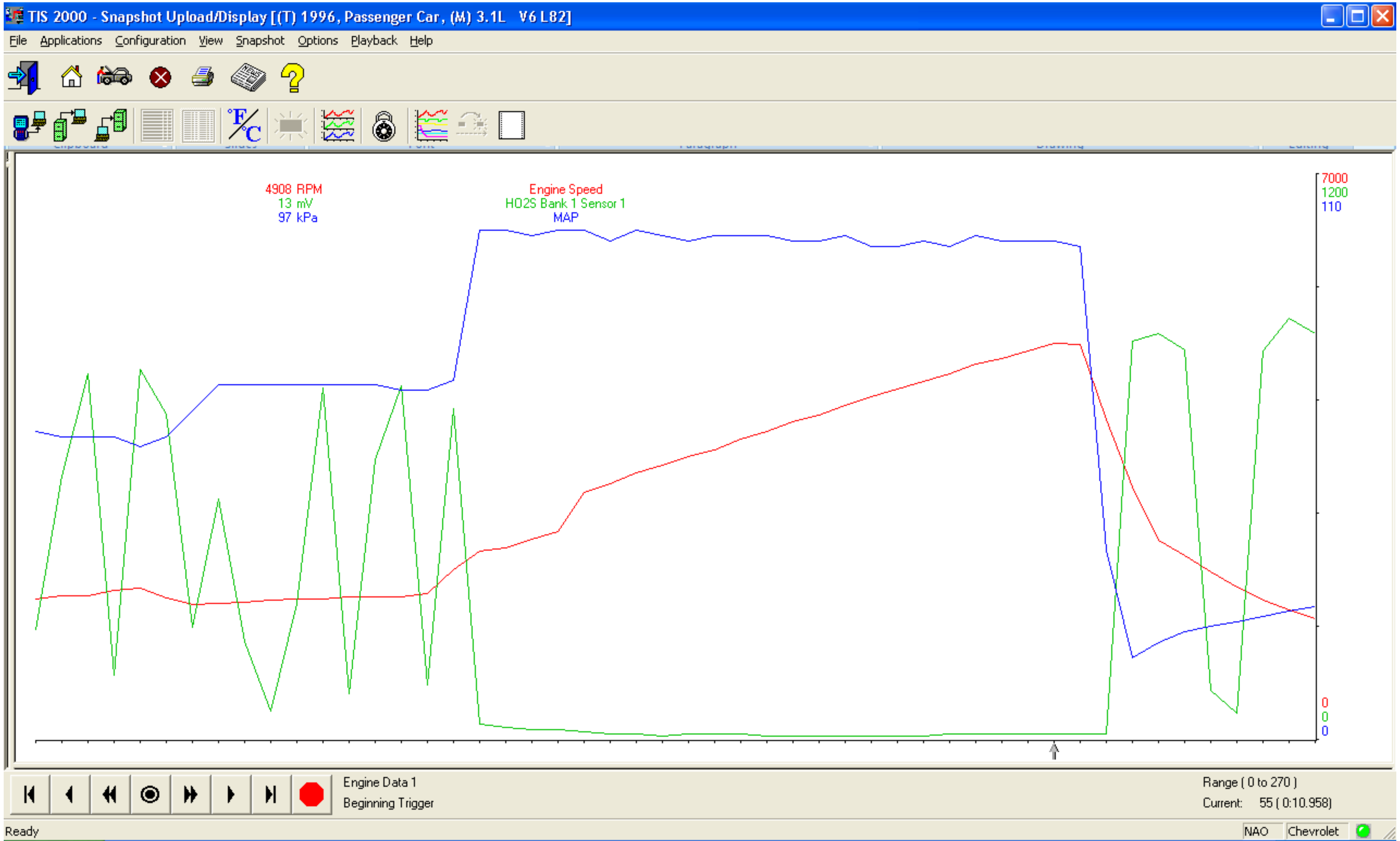
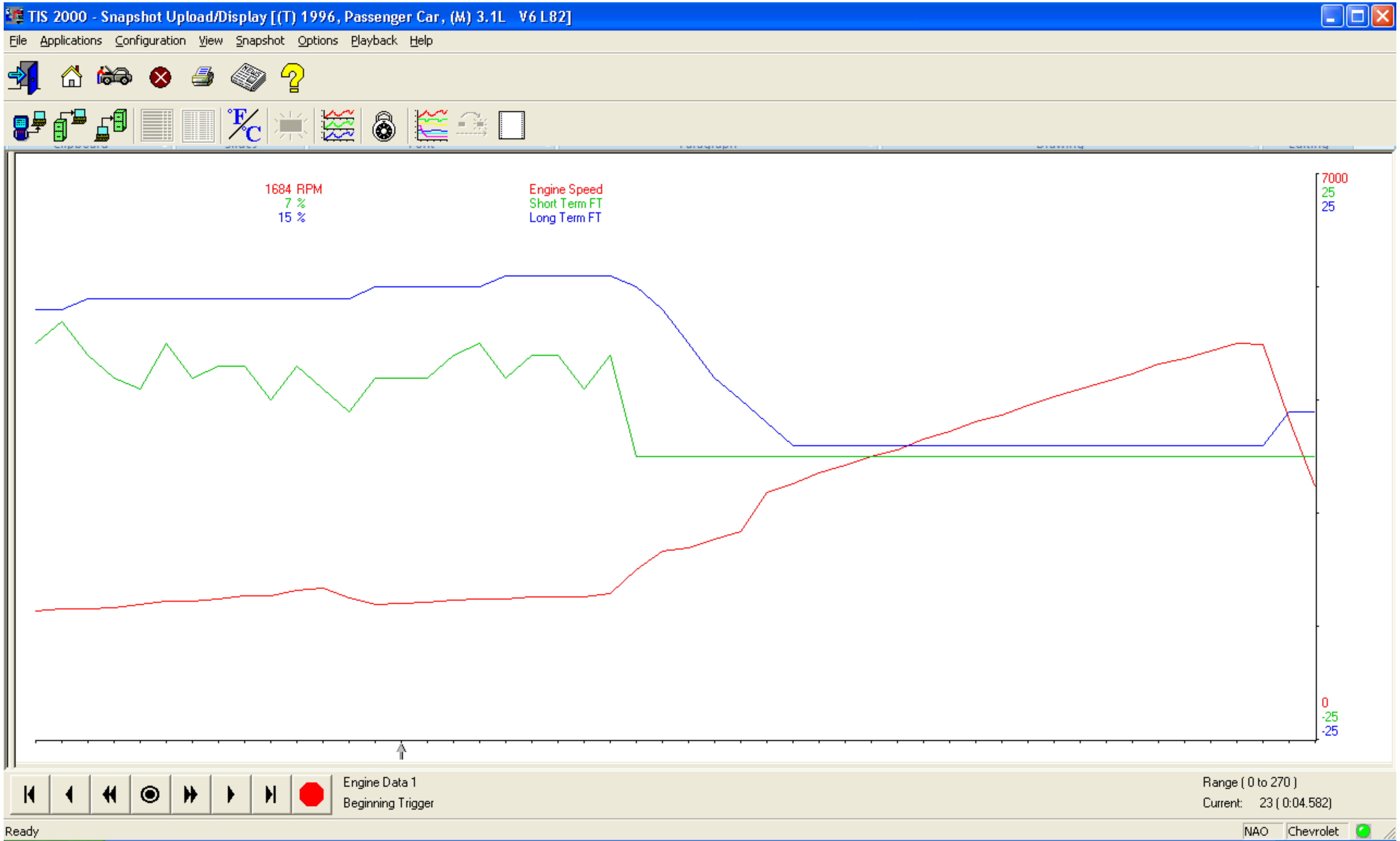

TIS 2000 - Snapshot Upload/Display [(T) 1996, Passenger Car, (M) 3.1L V6 L82]
File Applications Configuration View Snapshot Options Playback Help
4908 RPM
115.12 g/s
76 %
Engine Speed
MAF
Engine Load
7000
500.00
100
0
0.00
0
Engine Data 1
Beginning Trigger
Range (0 to 270)
Current: 55 (0:10.958)
Ready
NAO
Chevrolet


VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
3.1
Liters
RPM
4908
MAF
115.12
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
76%
Max. Air Flow
152 GPS
20 Lb/M
262 CFM
Fuel Vol. Req. @ Stoich
0.22 Gal/M
0.84 L/M
Fuel Vol. Req. @ Stoich + 20%
0.27 Gal/M
1.01 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%

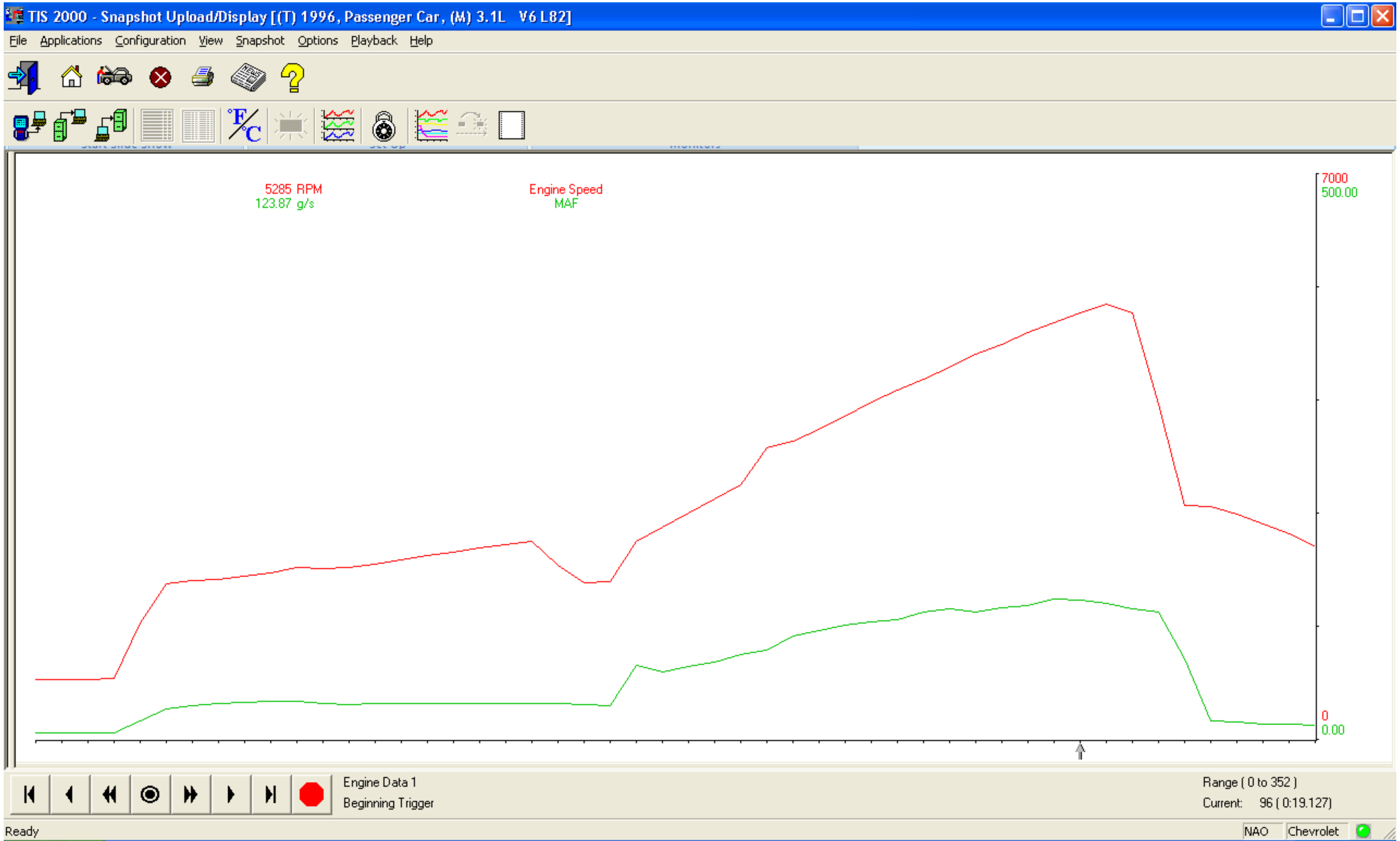


WTI WORLDPAC Training Institute.

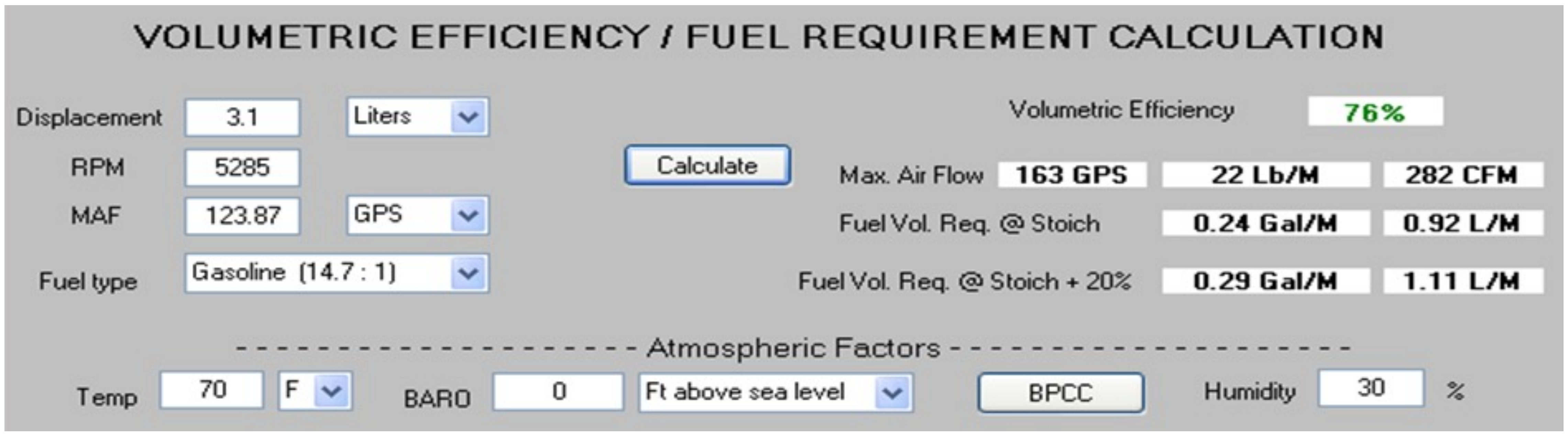

TIS 2000 - Snapshot Upload/Display [(T) 1996, Passenger Car, (M) 3.1L V6 L82]
File Applications Configuration View Snapshot Options Playback Help
1684 RPM
7 %
15 %
Engine Speed
Short Term FT
Long Term FT
7000
25
25
0
-25
-25
Engine Data 1
Beginning Trigger
Range (0 to 270)
Current: 23 (0:04.582)
Ready
NAO
Chevrolet

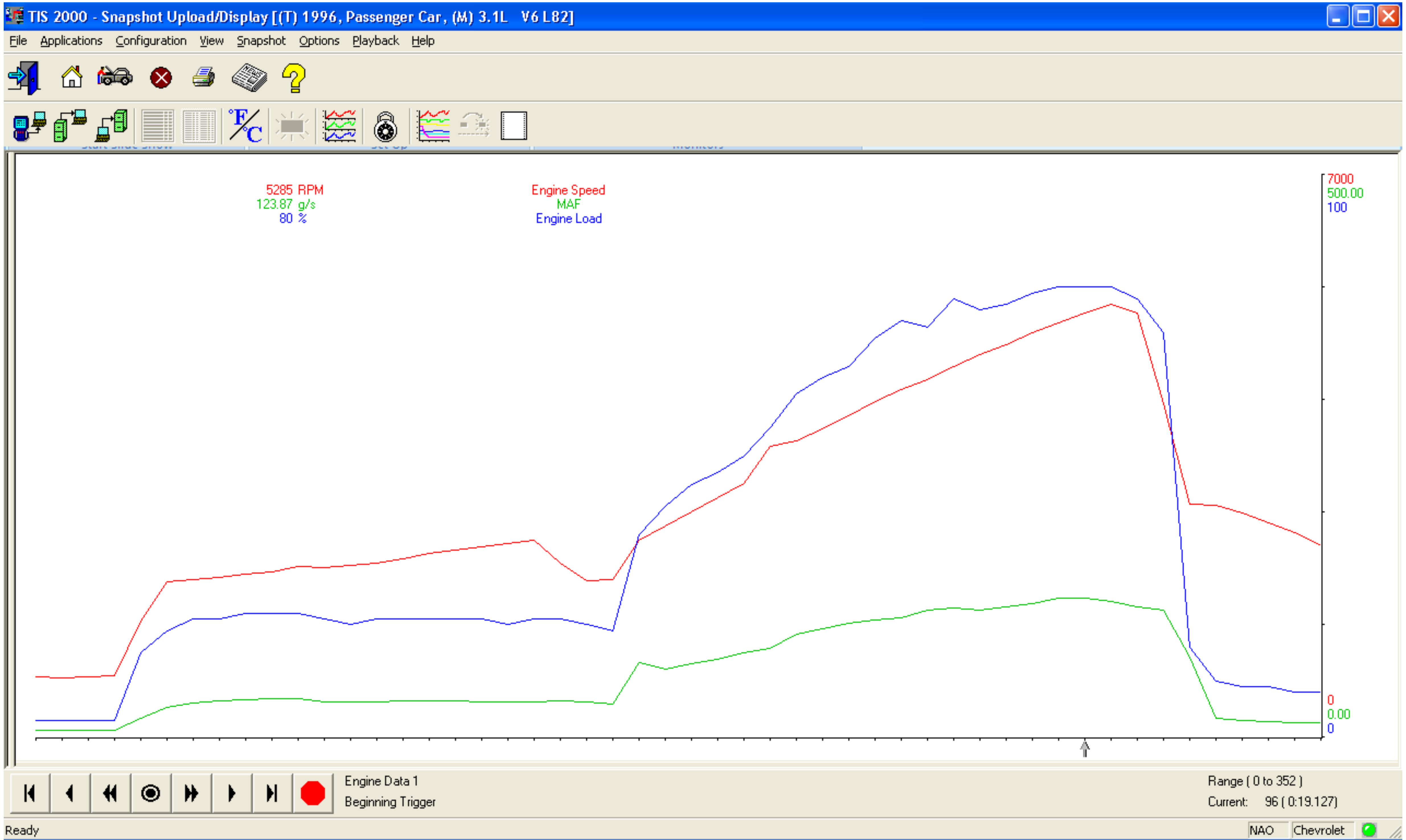
Diagnostic Decision:

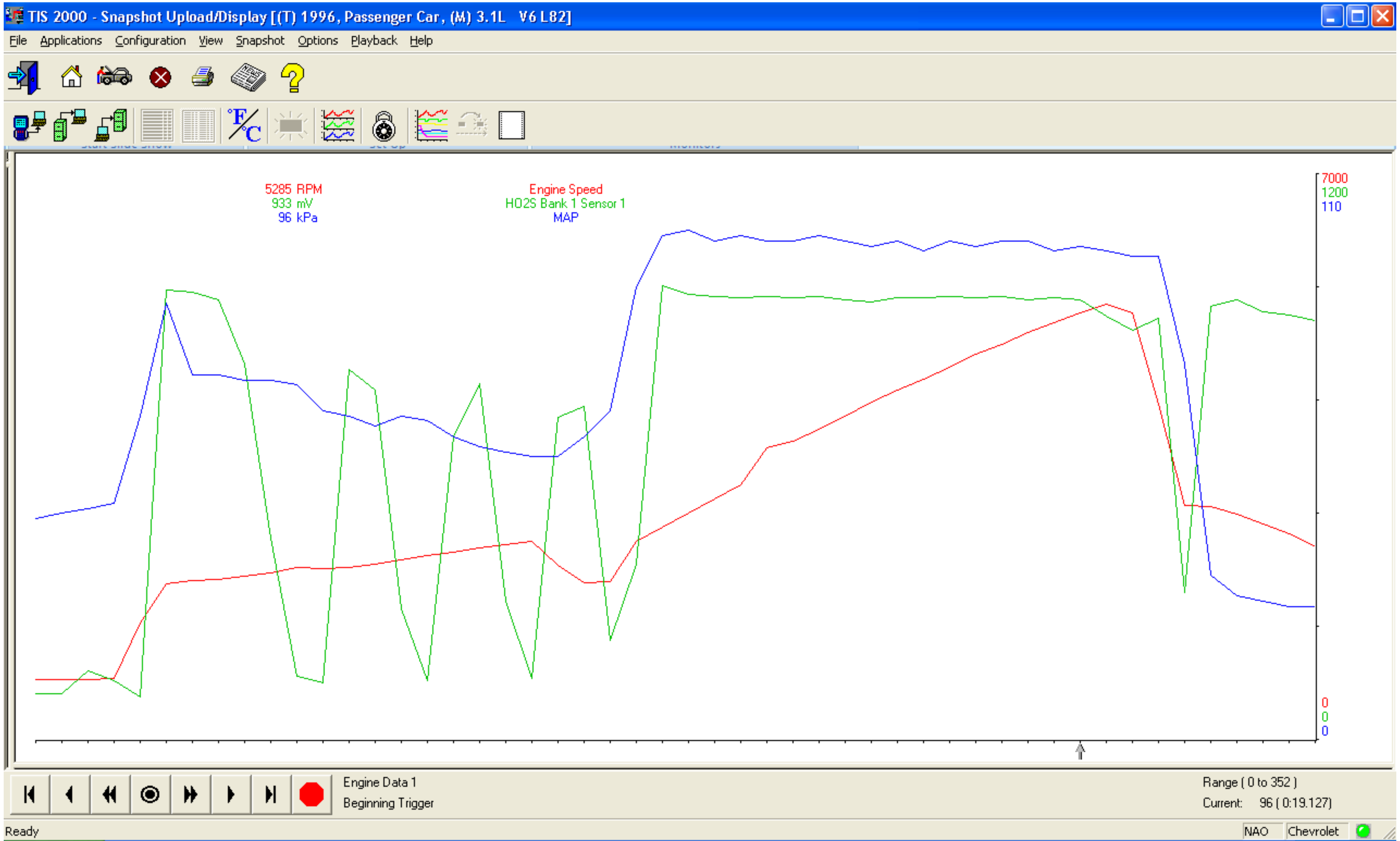
- How do the results compare to your cheat sheet?
  - VE
  - O2
  - MAP
  - Trims
- What's the problem?
- Replace the fuel pump and perform repair verification.



WTI WORLDPAC Training Institute


VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
3.1
Liters
RPM
5285
MAF
123.87
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
76%
Max. Air Flow
163 GPS
22 Lb/M
282 CFM
Fuel Vol. Req. @ Stoich
0.24 Gal/M
0.92 L/M
Fuel Vol. Req. @ Stoich + 20%
0.29 Gal/M
1.11 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%


TIS 2000 - Snapshot Upload/Display [(T) 1996, Passenger Car, (M) 3.1L V6 L82]
File Applications Configuration View Snapshot Options Playback Help
5285 RPM
123.87 g/s
80 %
Engine Speed
MAF
Engine Load
7000
500.00
100
0
0.00
0
Engine Data 1
Beginning Trigger
Range (0 to 352)
Current: 96 (0:19.127)
Ready
NAO
Chevrolet



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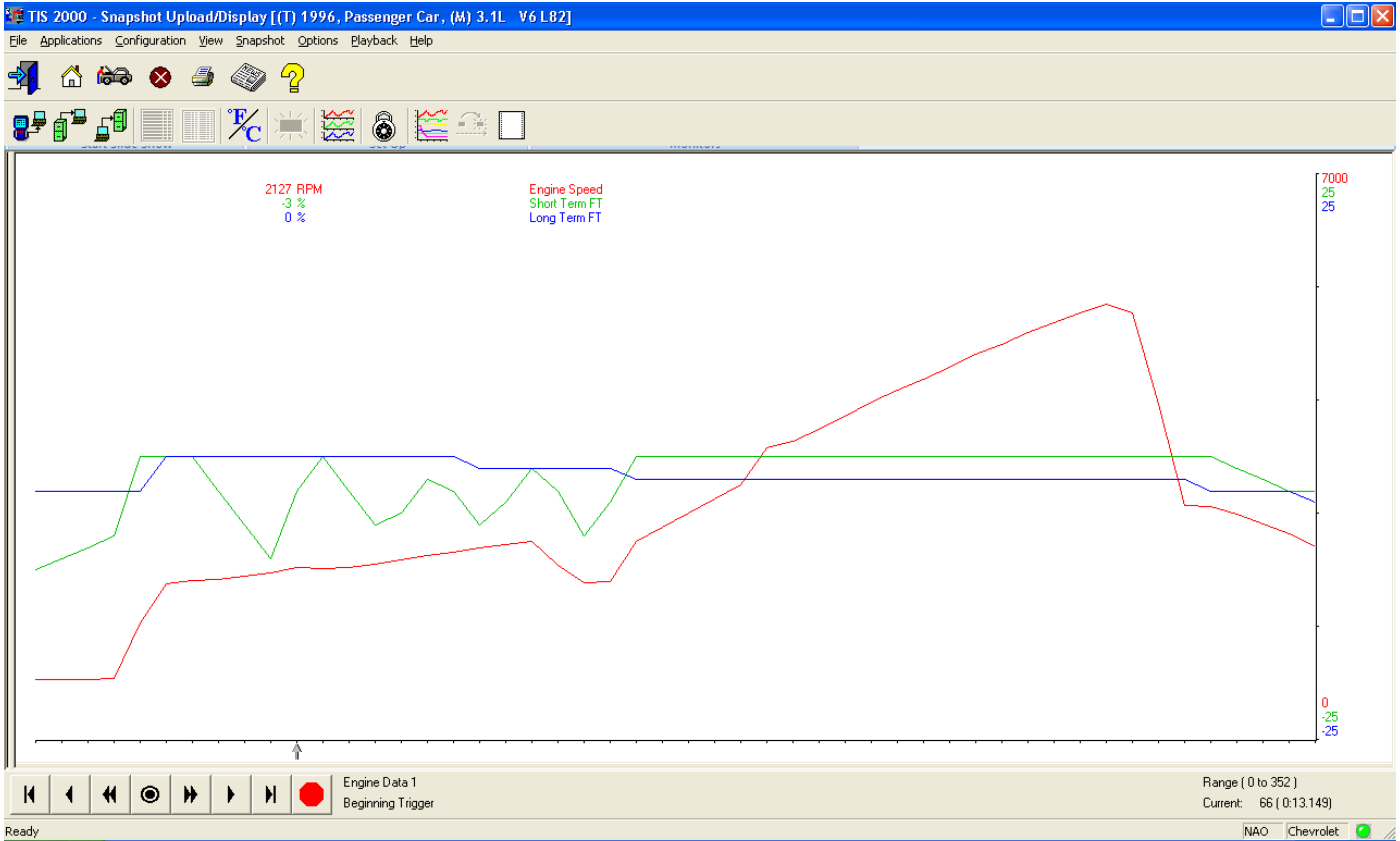

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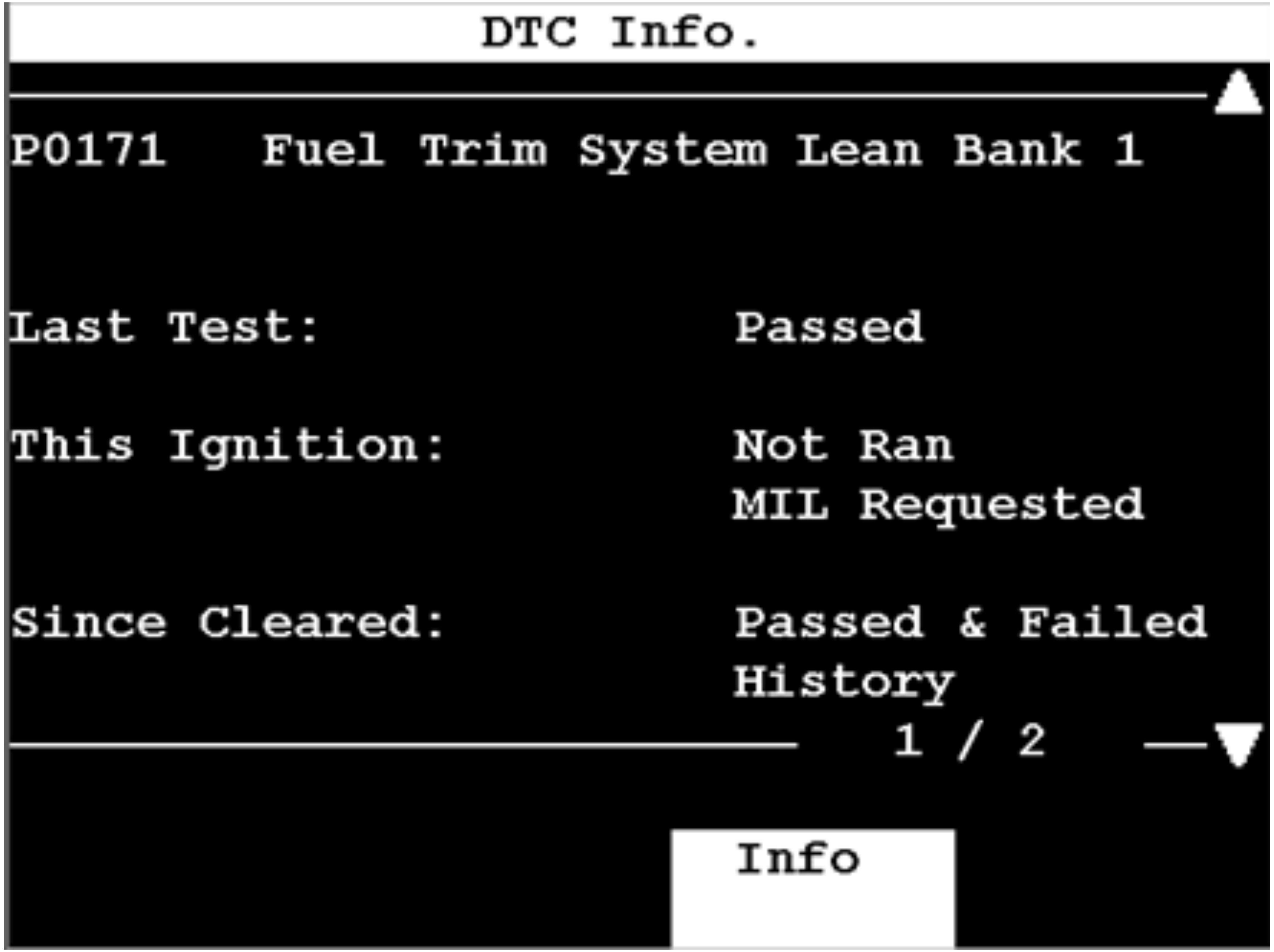
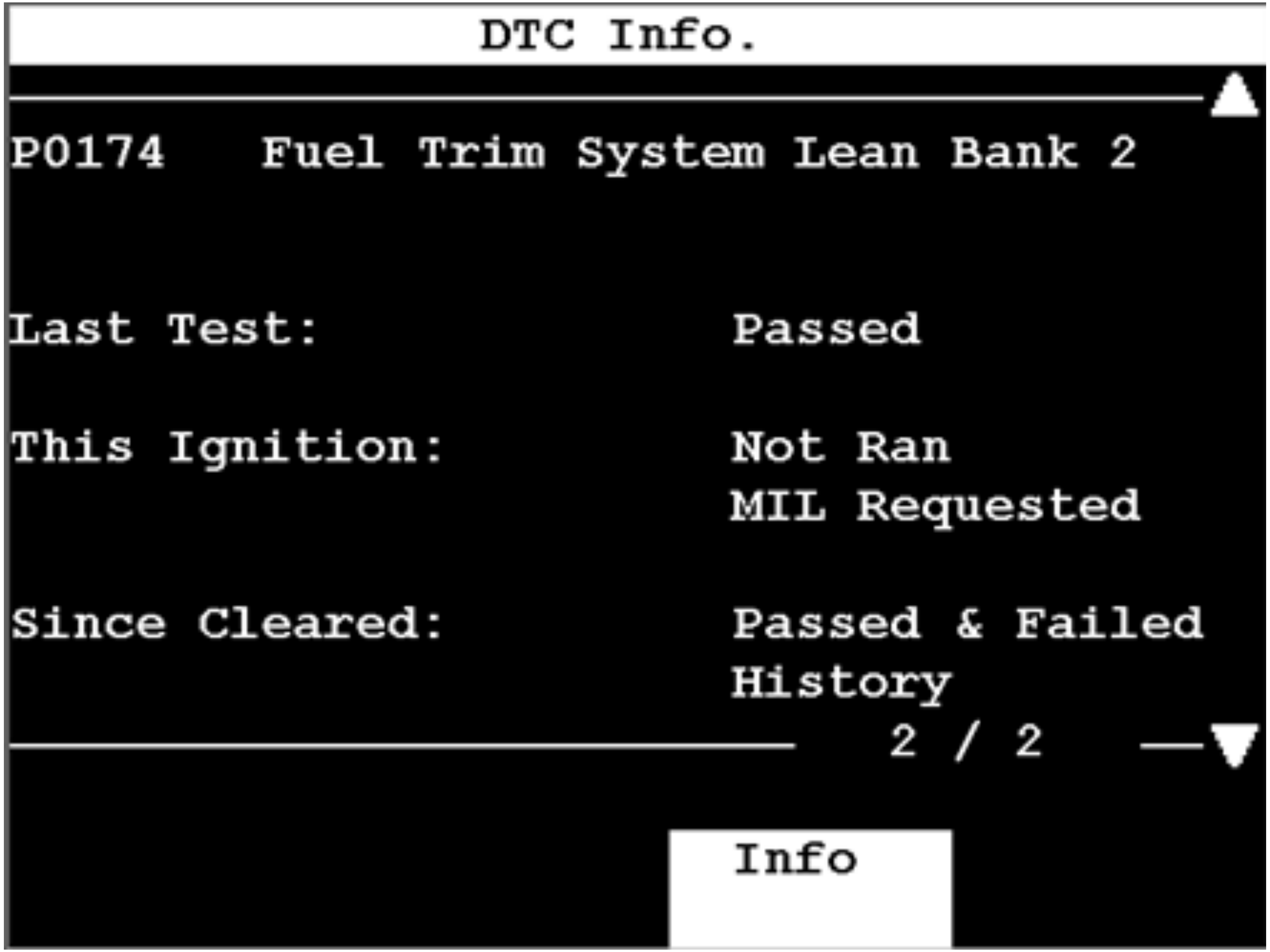
1998 Chevy T10 Blazer 4.3 L

MIL on

Back to the vehicle we skipped earlier in class.


DTC Info.
P0171 Fuel Trim System Lean Bank 1
Last Test: Passed
This Ignition: Not Ran
MIL Requested
Since Cleared: Passed & Failed
History
1 / 2
Info


DTC Info.
P0174 Fuel Trim System Lean Bank 2
Last Test: Passed
This Ignition: Not Ran
MIL Requested
Since Cleared: Passed & Failed
History
2 / 2
Info

Freeze Frame/Failure Records

Select Freeze Frame or Failure Record:

F0: Freeze Frame Data: P0174

F1: P0171

F2: P0174

0000

0000

0000

All three are similar, let's look at the freeze frame

P0174 Freeze Frame Data

Engine Speed	2042 RPM
ECT	199 °F
MAP	61 kPa
Short Term FT Bank 1	1 %
Long Term FT Bank 1	25 %
Loop Status	Clo
TP Angle	16 %
Engine Load	23 %
MAF	40.14 g/s

1 / 12

Engine Speed

Select Items | DTC Desc. | More

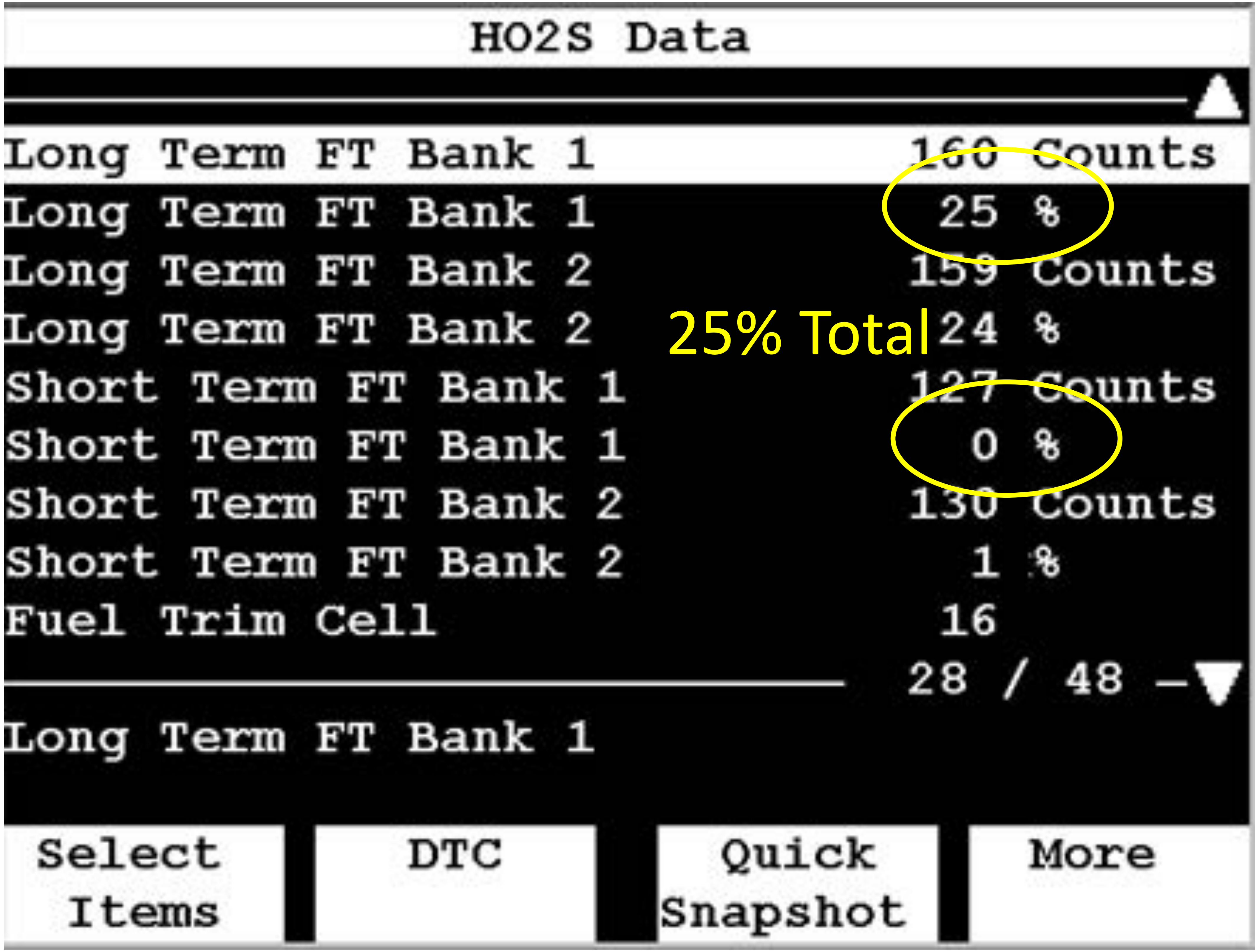
P0174 Freeze Frame Data

Short Term FT Bank 1	1 %
Long Term FT Bank 1	25 %
Loop Status	Clo
TP Angle	16 %
Engine Load	23 %
MAF	40.14 g/s
Vehicle Speed	69 mph
Mileage Since First Fai	71 miles
Mileage Since Last Fail	49 miles

10 / 12

Vehicle Speed

Select Items | DTC Desc. | More



HO2S Data
Long Term FT Bank 1 160 Counts
Long Term FT Bank 1 25 %
Long Term FT Bank 2 159 Counts
Long Term FT Bank 2 24 %
25% Total
Short Term FT Bank 1 127 Counts
Short Term FT Bank 1 0 %
Short Term FT Bank 2 130 Counts
Short Term FT Bank 2 1 %
Fuel Trim Cell 16
28 / 48
Long Term FT Bank 1
Select Items
DTC
Quick Snapshot
More

HO2S Data

Long Term FT Bank 1	139 Counts
Long Term FT Bank 1	8 %
Long Term FT Bank 2	141 Counts
Long Term FT Bank 2	10 %
Short Term FT Bank 1	149 Counts
Short Term FT Bank 1	16 %
Short Term FT Bank 2	148 Counts
Short Term FT Bank 2	15 %
Fuel Trim Cell	7

24% Total

2500 RPM

28 / 48

Long Term FT Bank 1

Select Items | DTC | Quick Snapshot | More

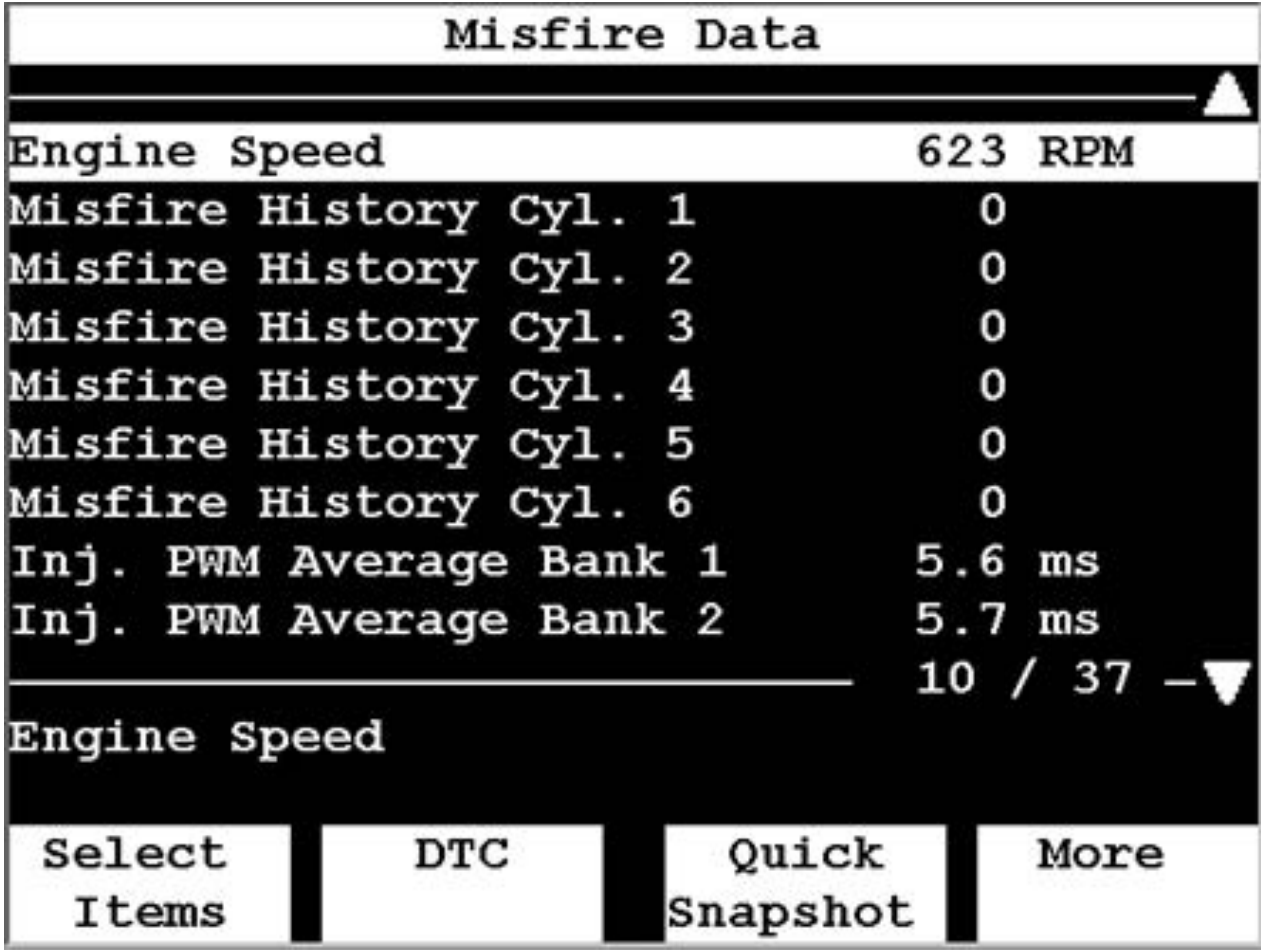
Misfire Data

Engine Speed	641 RPM
Misfire Current Cyl. 1	0
Misfire Current Cyl. 2	0
Misfire Current Cyl. 3	0
Misfire Current Cyl. 4	0
Misfire Current Cyl. 5	0
Misfire Current Cyl. 6	0
Cycles of Misfire Data	52
Total Misfire Current C	0

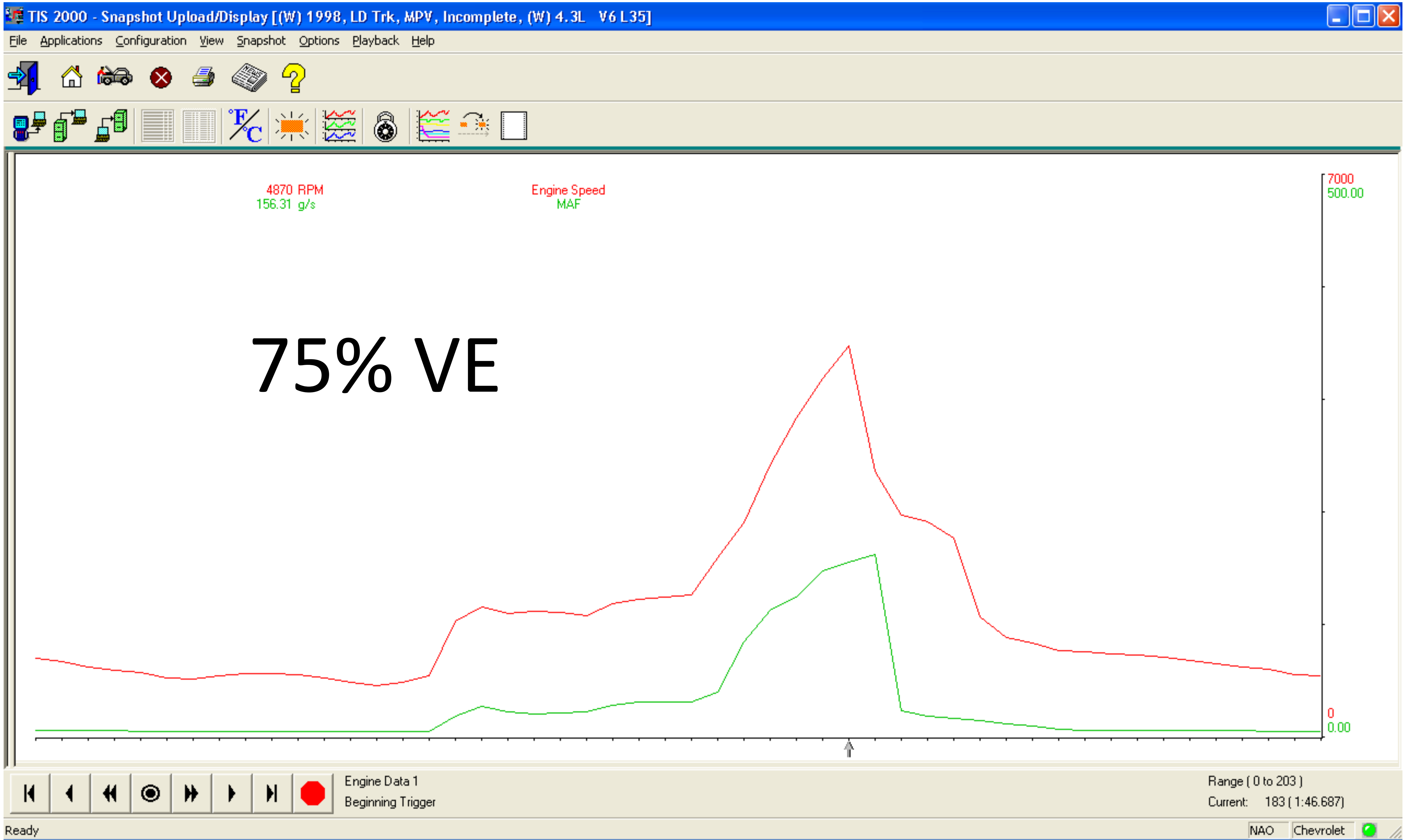
1 / 37

Engine Speed

Select Items | DTC | Quick Snapshot | More



Misfire Data
Engine Speed 623 RPM
Misfire History Cyl. 1 0
Misfire History Cyl. 2 0
Misfire History Cyl. 3 0
Misfire History Cyl. 4 0
Misfire History Cyl. 5 0
Misfire History Cyl. 6 0
Inj. PWM Average Bank 1 5.6 ms
Inj. PWM Average Bank 2 5.7 ms
10 / 37
Engine Speed
Select Items
DTC
Quick Snapshot
More



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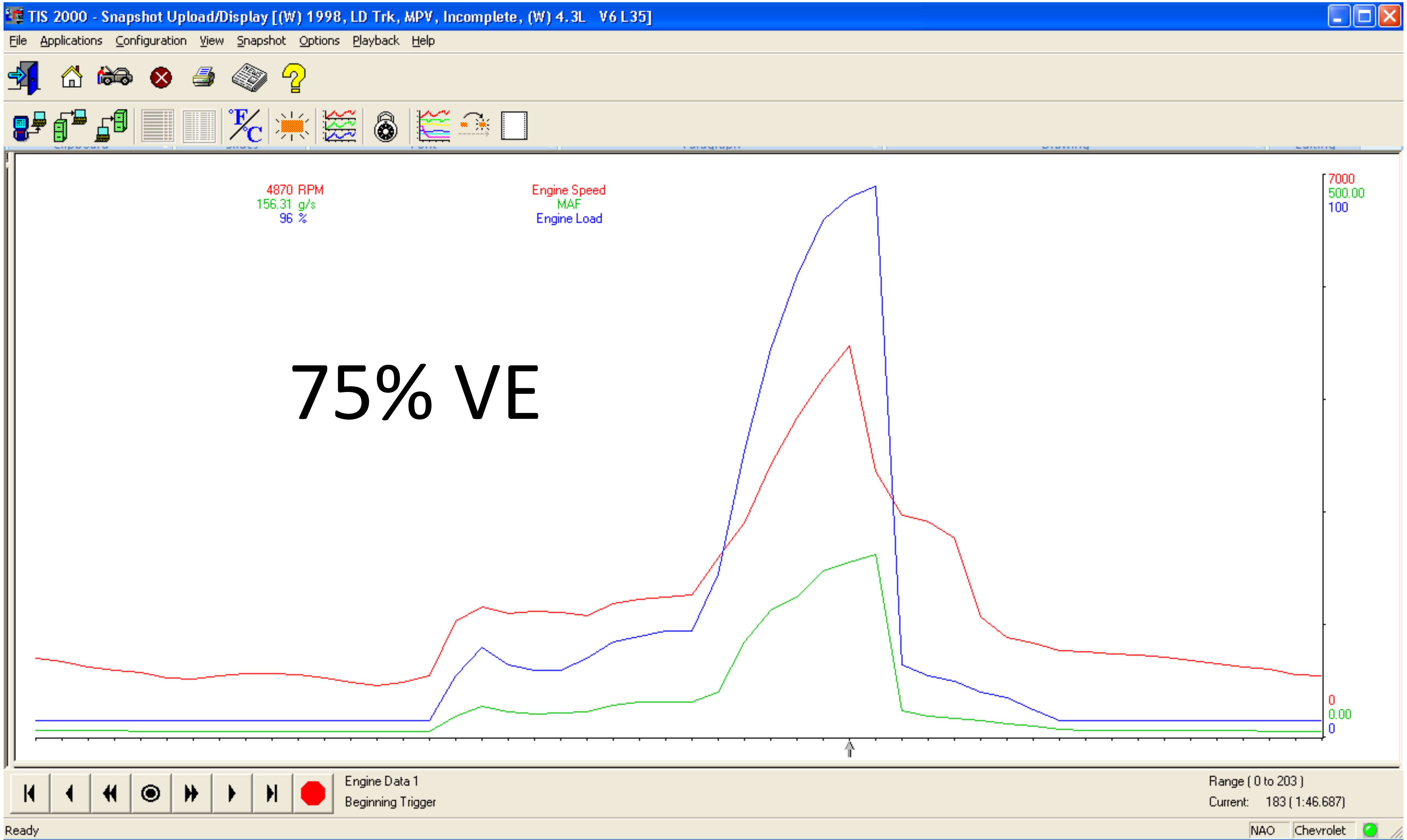
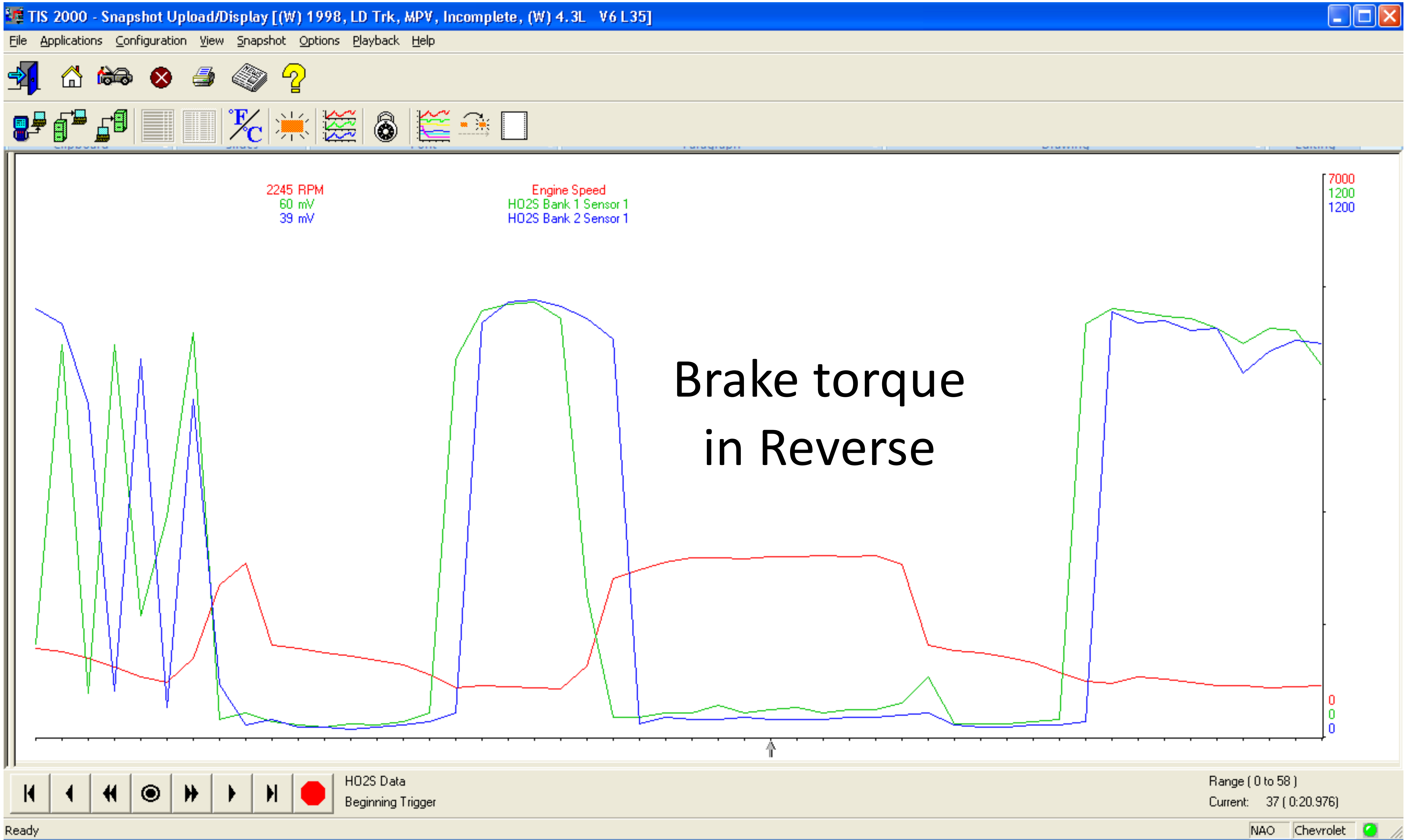
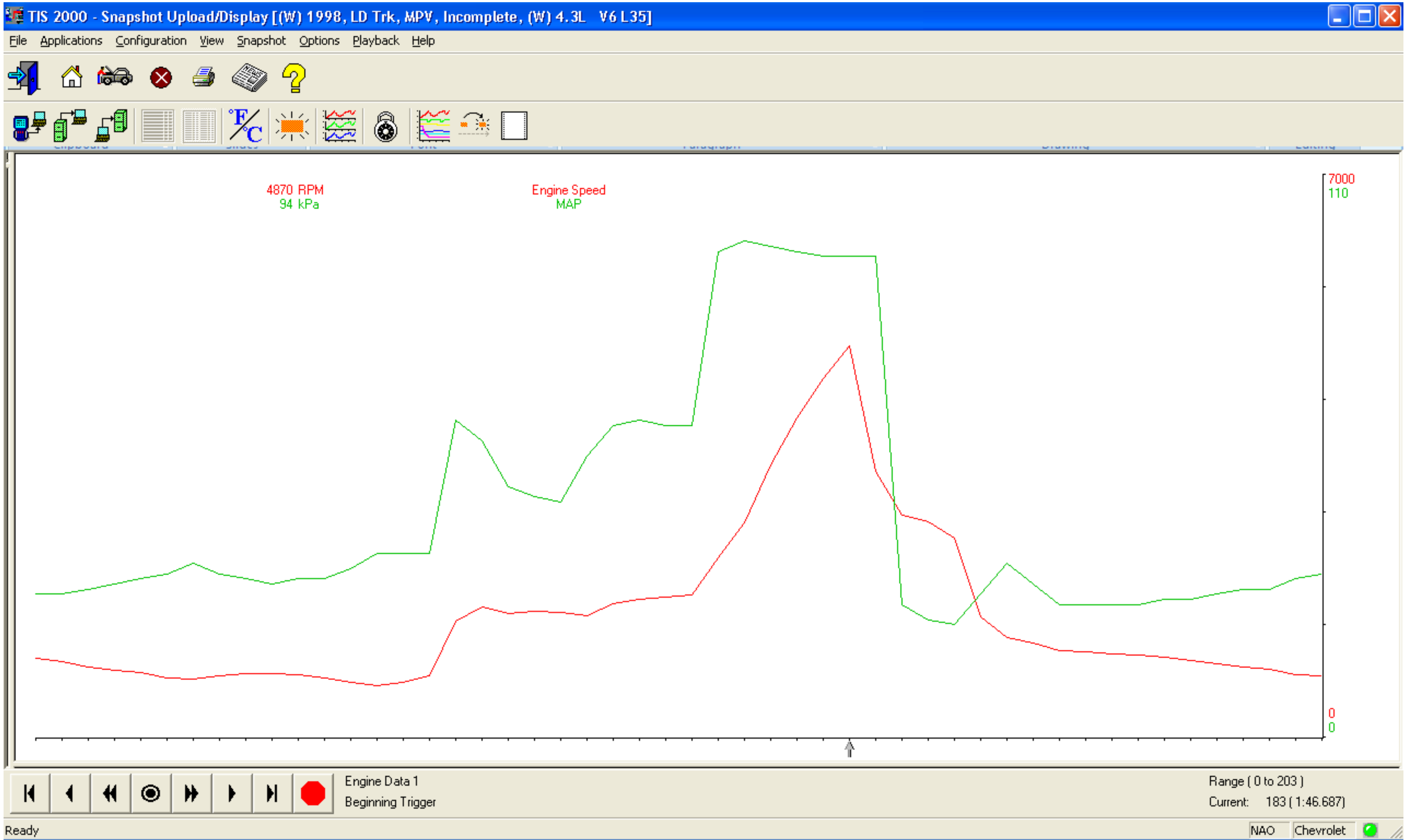
75% VE


TIS 2000 - Snapshot Upload/Display [(W) 1998, LD Trk, MPV, Incomplete, (W) 4.3L V6 L35]
File Applications Configuration View Snapshot Options Playback Help
4870 RPM
156.31 g/s
96 %
Engine Speed
MAF
Engine Load
7000
500.00
100
0
0.00
0
Engine Data 1
Beginning Trigger
Range (0 to 203)
Current: 183 (1:46.687)
Ready
NAO
Chevrolet


TIS 2000 - Snapshot Upload/Display [(W) 1998, LD Trk, MPV, Incomplete, (W) 4.3L V6 L35]
File Applications Configuration View Snapshot Options Playback Help
2245 RPM
60 mV
39 mV
Engine Speed
HO2S Bank 1 Sensor 1
HO2S Bank 2 Sensor 1
7000
1200
1200
0
0
0
Brake torque
in Reverse
HO2S Data
Beginning Trigger
Range (0 to 58)
Current: 37 (0:20.976)
Ready
NAO
Chevrolet



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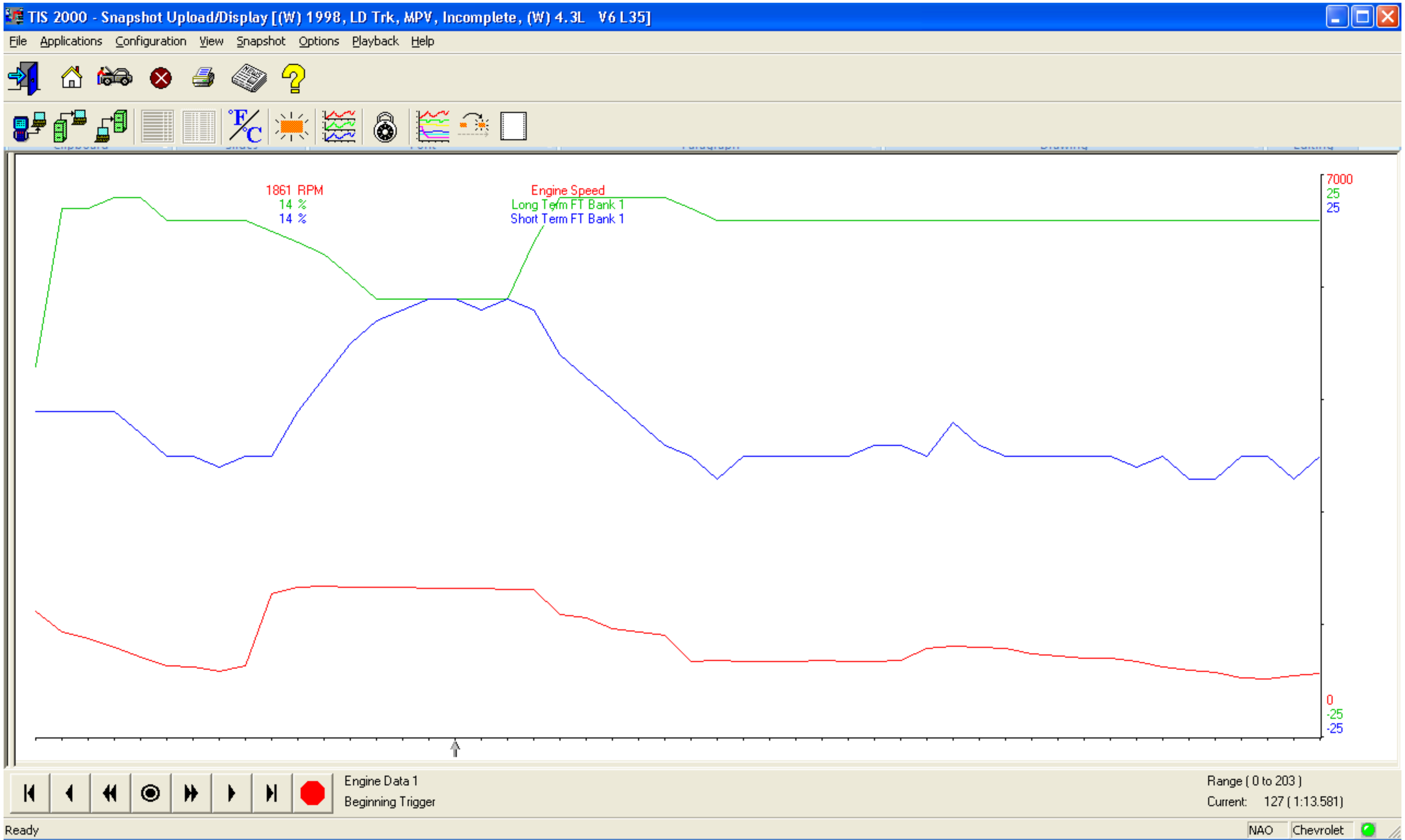
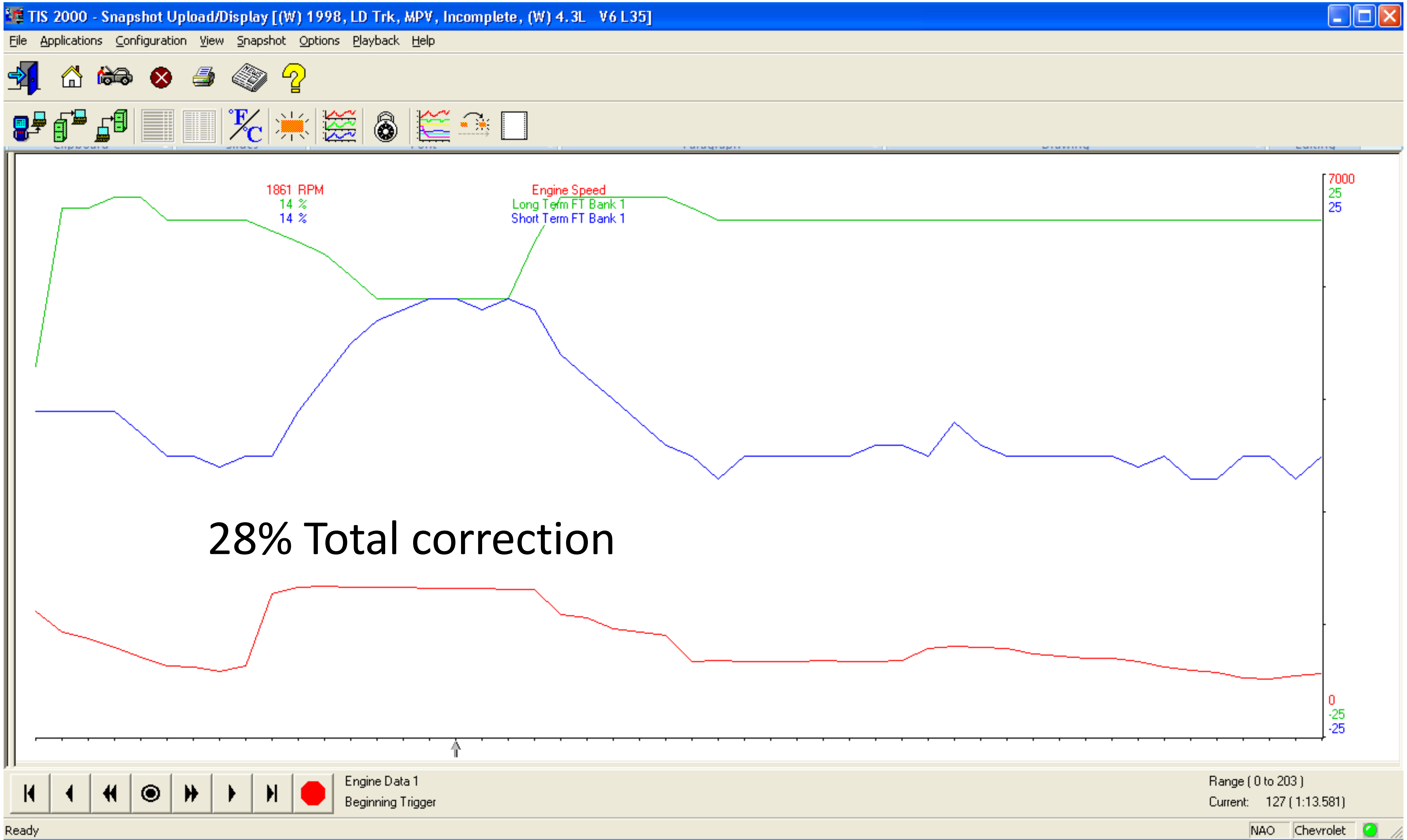

TIS 2000 - Snapshot Upload/Display [(W) 1998, LD Trk, MPV, Incomplete, (W) 4.3L V6 L35]
File Applications Configuration View Snapshot Options Playback Help
1861 RPM
14 %
14 %
Engine Speed
Long Term FT Bank 1
Short Term FT Bank 1
7000
25
25
0
-25
-25
Engine Data 1
Beginning Trigger
Range (0 to 203)
Current: 127 (1:13.581)
Ready
NAO
Chevrolet

Analysis so far:

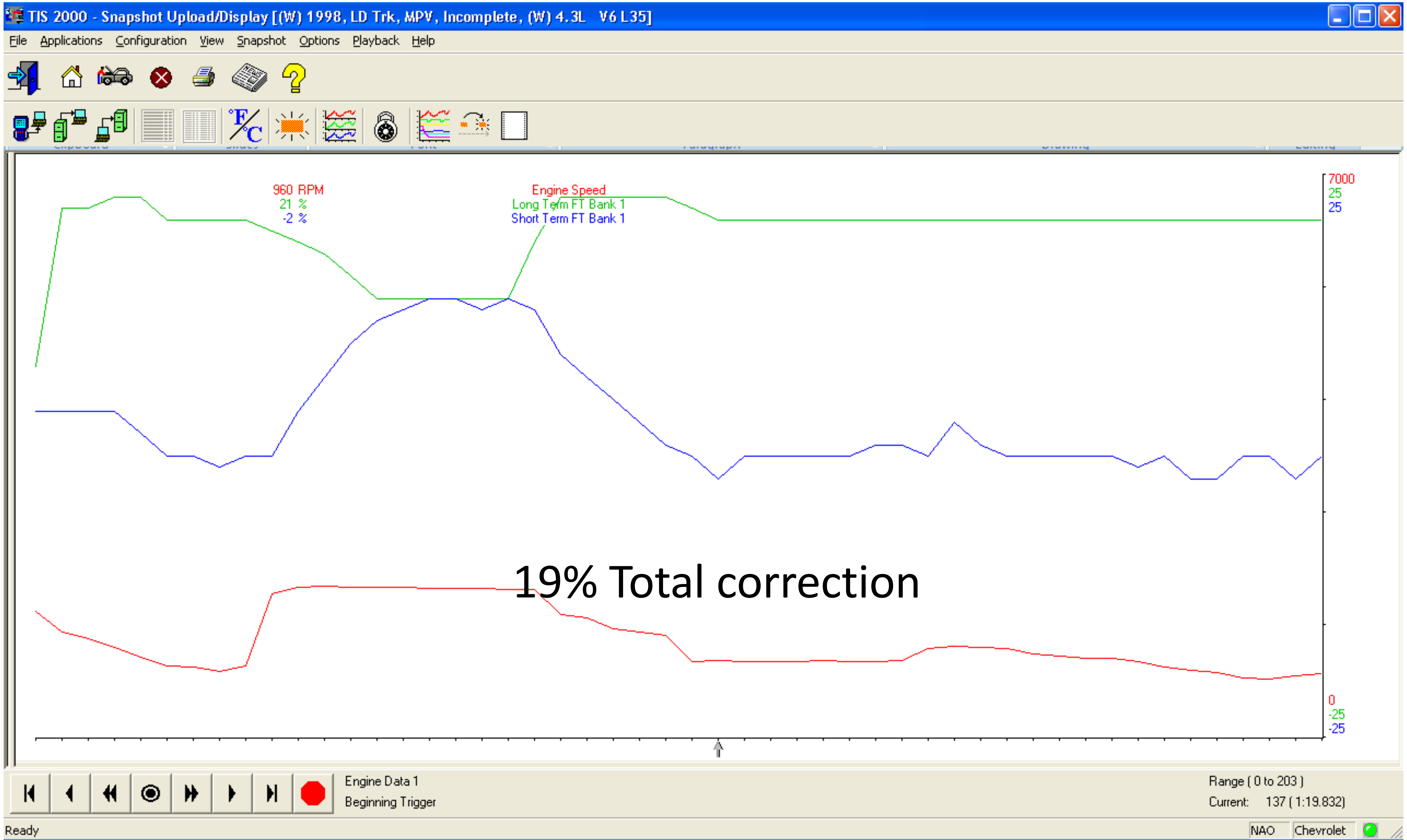
- Not a vacuum leak
- Positive trims in FF, at Idle, and at 2500 rpm
- VE good / Load PID good
- O2 goes lean with WOT
- MAP near BARO
- Fuel trims high under all conditions in closed loop
- Thoughts?

Fuel Pump:

- Fuel pressure tests good
- Fuel volume tests good
- Scope pattern of pump looks good
- What did we miss?



28% Total correction



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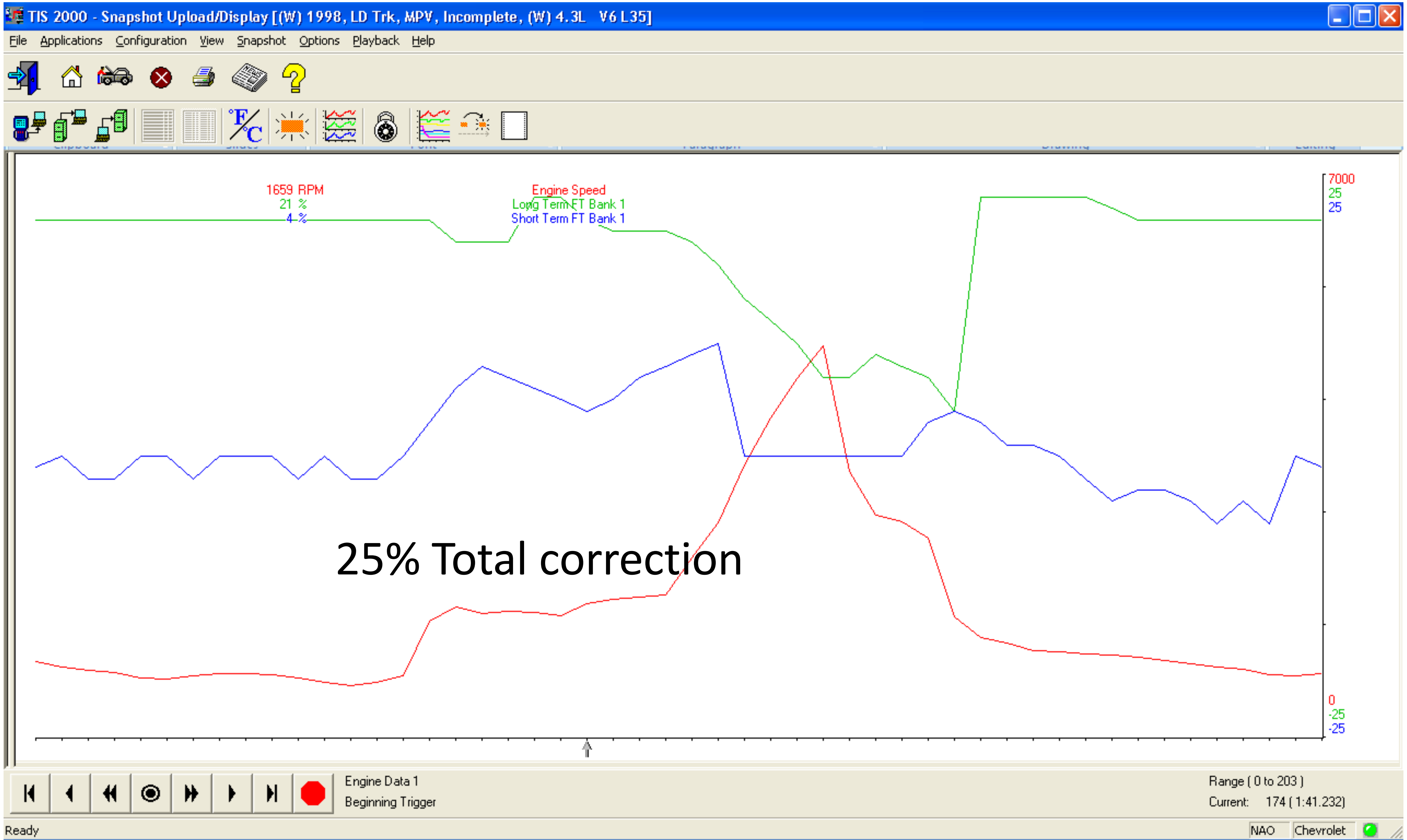
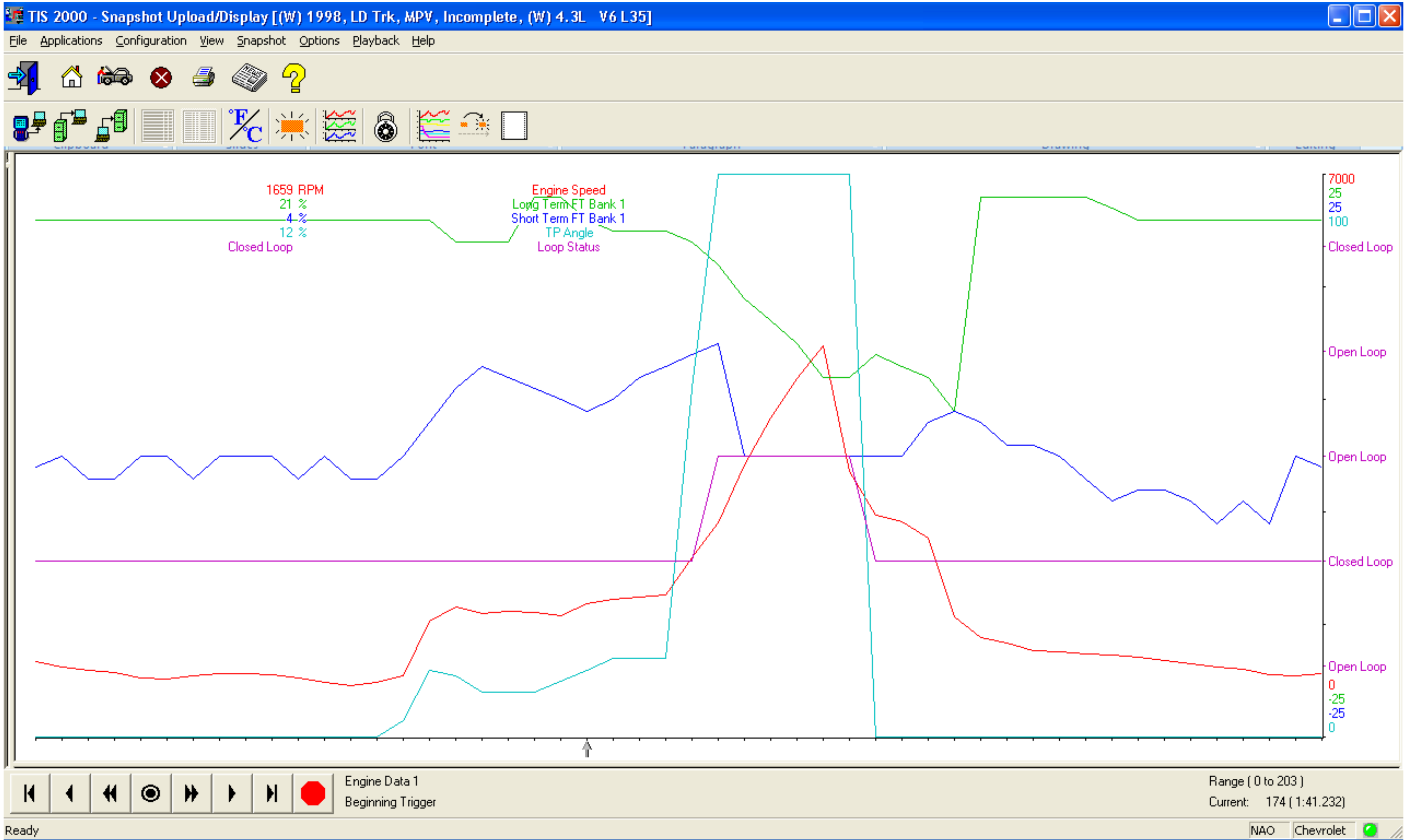


WTI WORLDPAC Training Institute.



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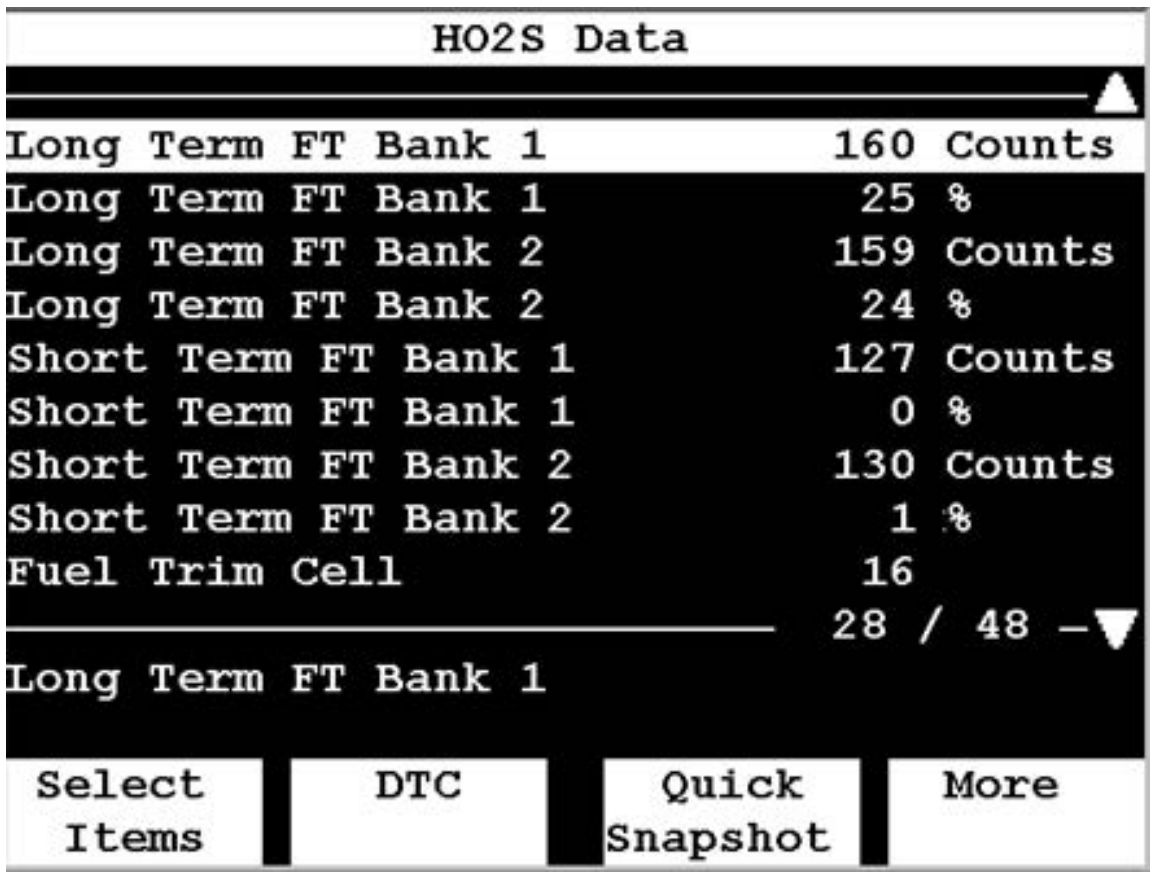
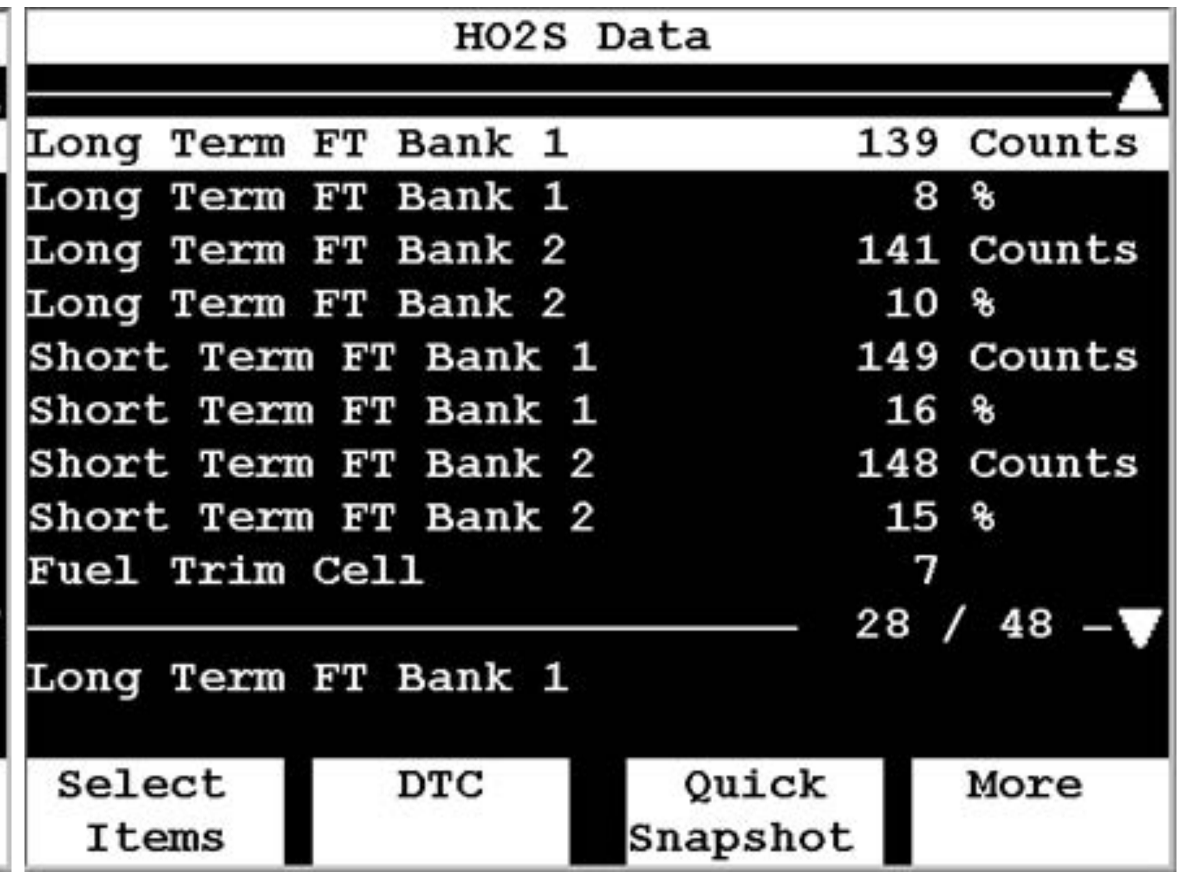
Remember these slides?

Idle



25% total trim correction

2500 rpm



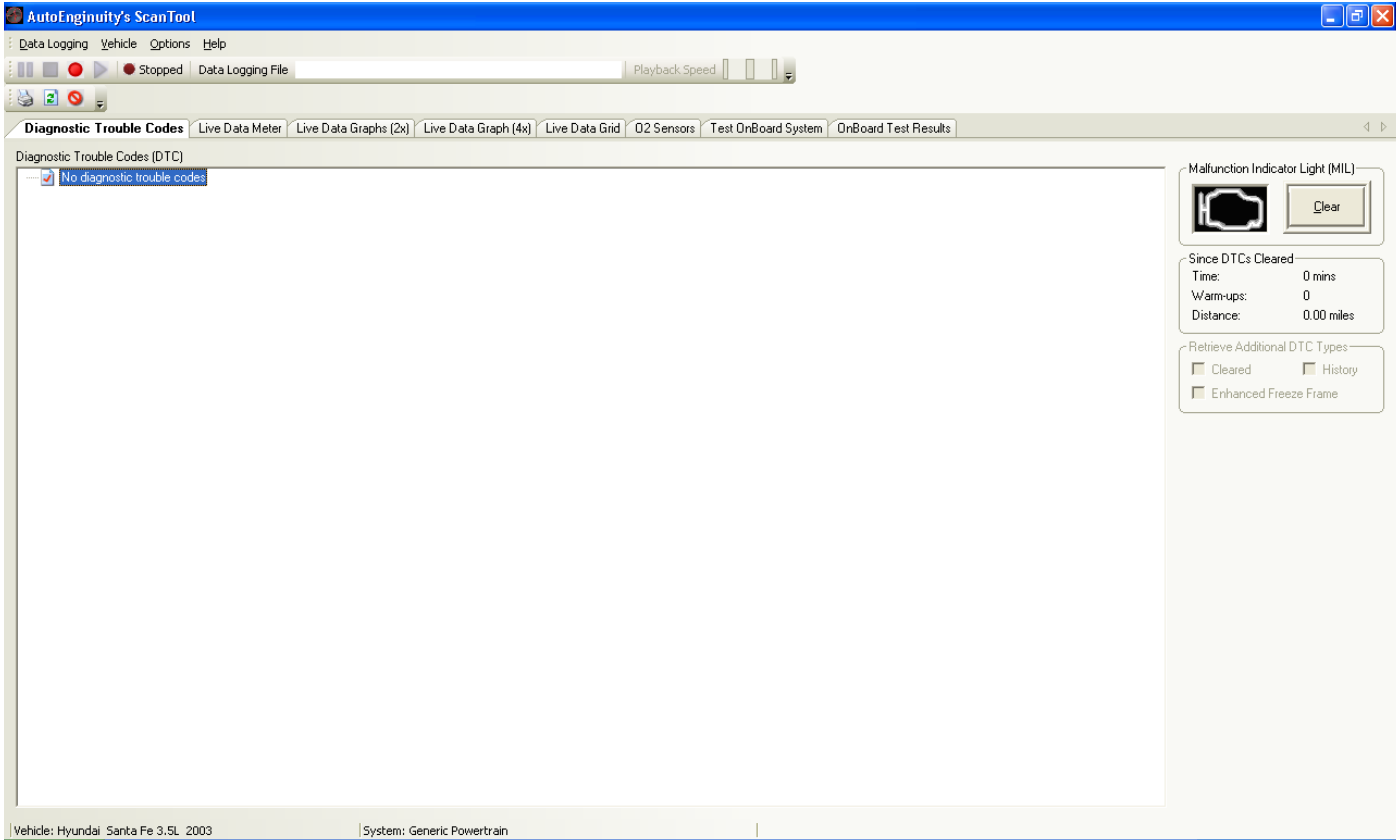
24% total trim correction

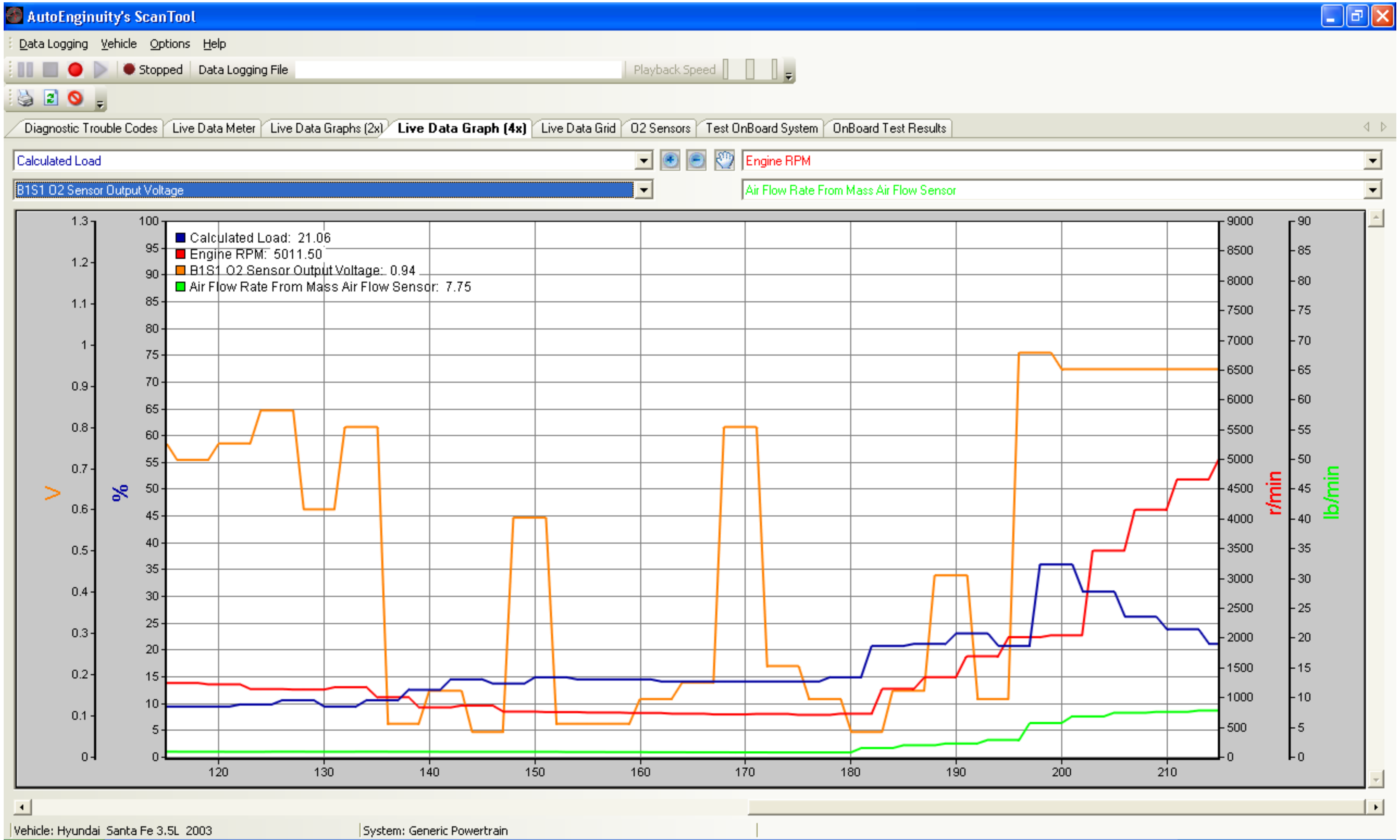
Trim Deviation?

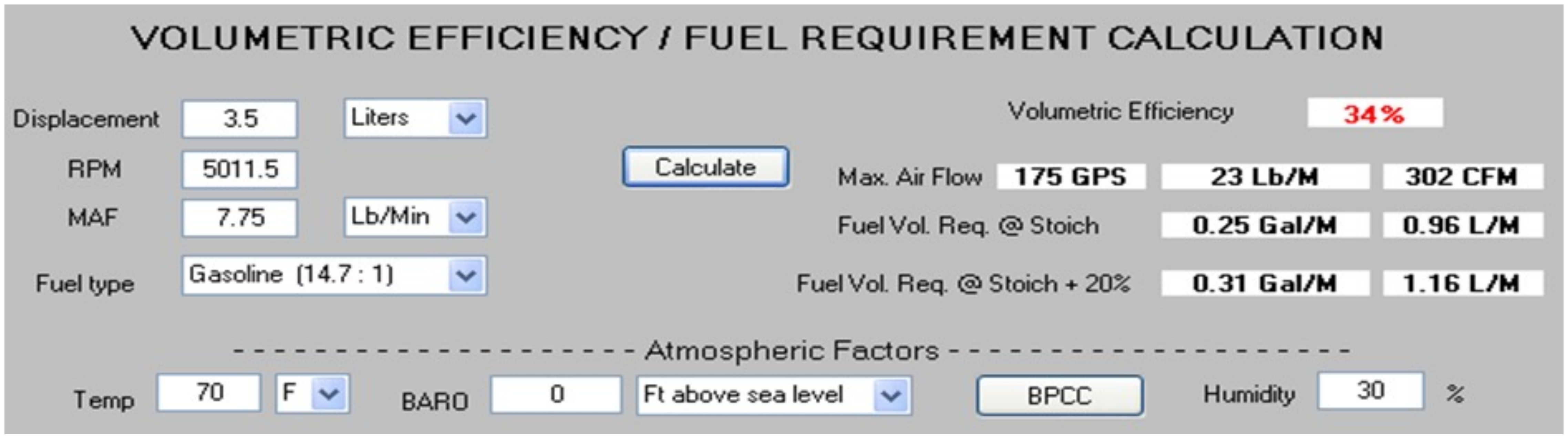
- Total corrections range from 19% to 28%
- Deviation is 9%
- Acceptable variance
- Relatively flat but high
- Does this still look like a Fuel Pump?

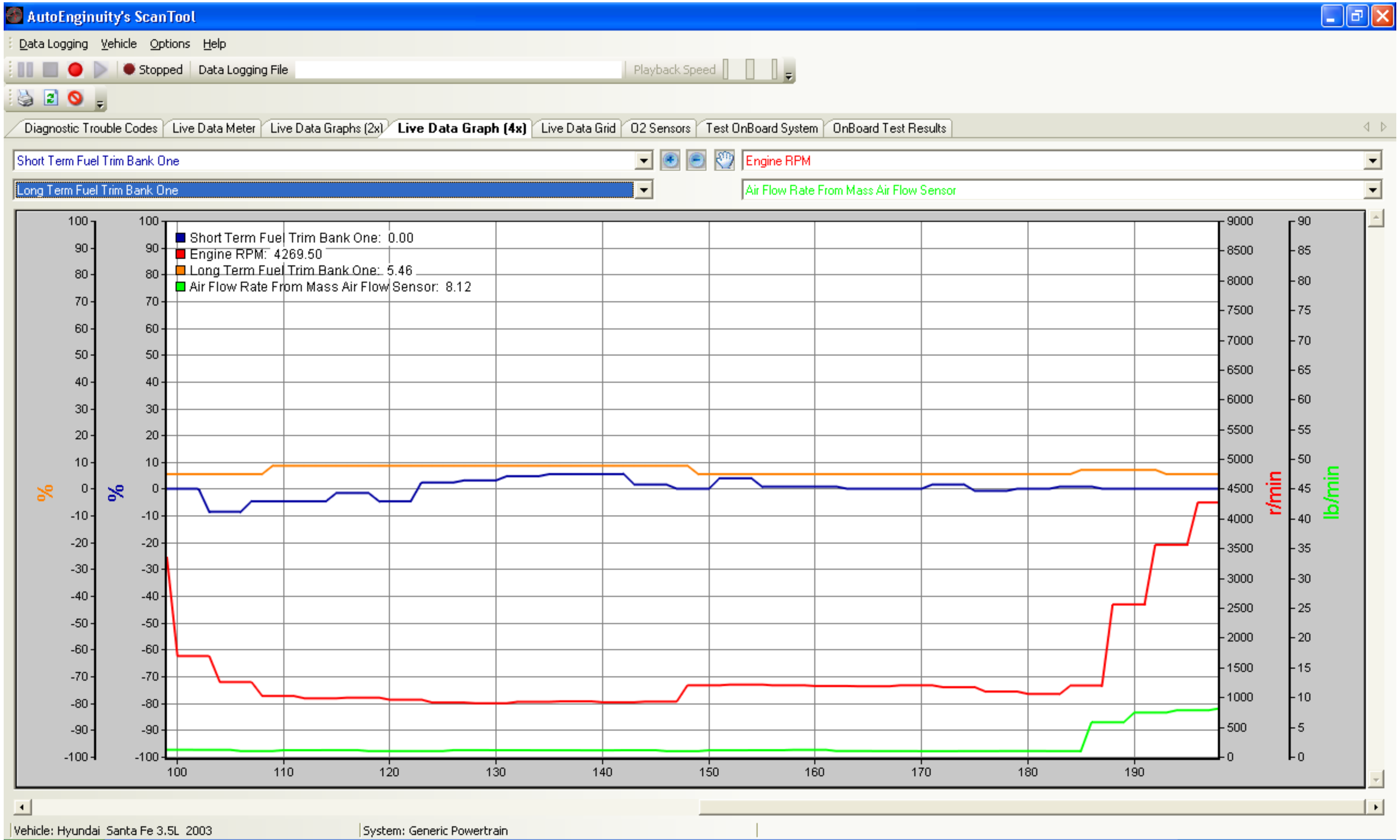
2003 Hyundai Santa Fe 3.5 L

No Power


AutoEnginuity's ScanTool
Data Logging Vehicle Options Help
Stopped Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
Diagnostic Trouble Codes (DTC)
No diagnostic trouble codes
Malfunction Indicator Light (MIL)
Clear
Since DTCs Cleared
Time: 0 mins
Warm-ups: 0
Distance: 0.00 miles
Retrieve Additional DTC Types
Cleared
History
Enhanced Freeze Frame
Vehicle: Hyundai Santa Fe 3.5L 2003
System: Generic Powertrain

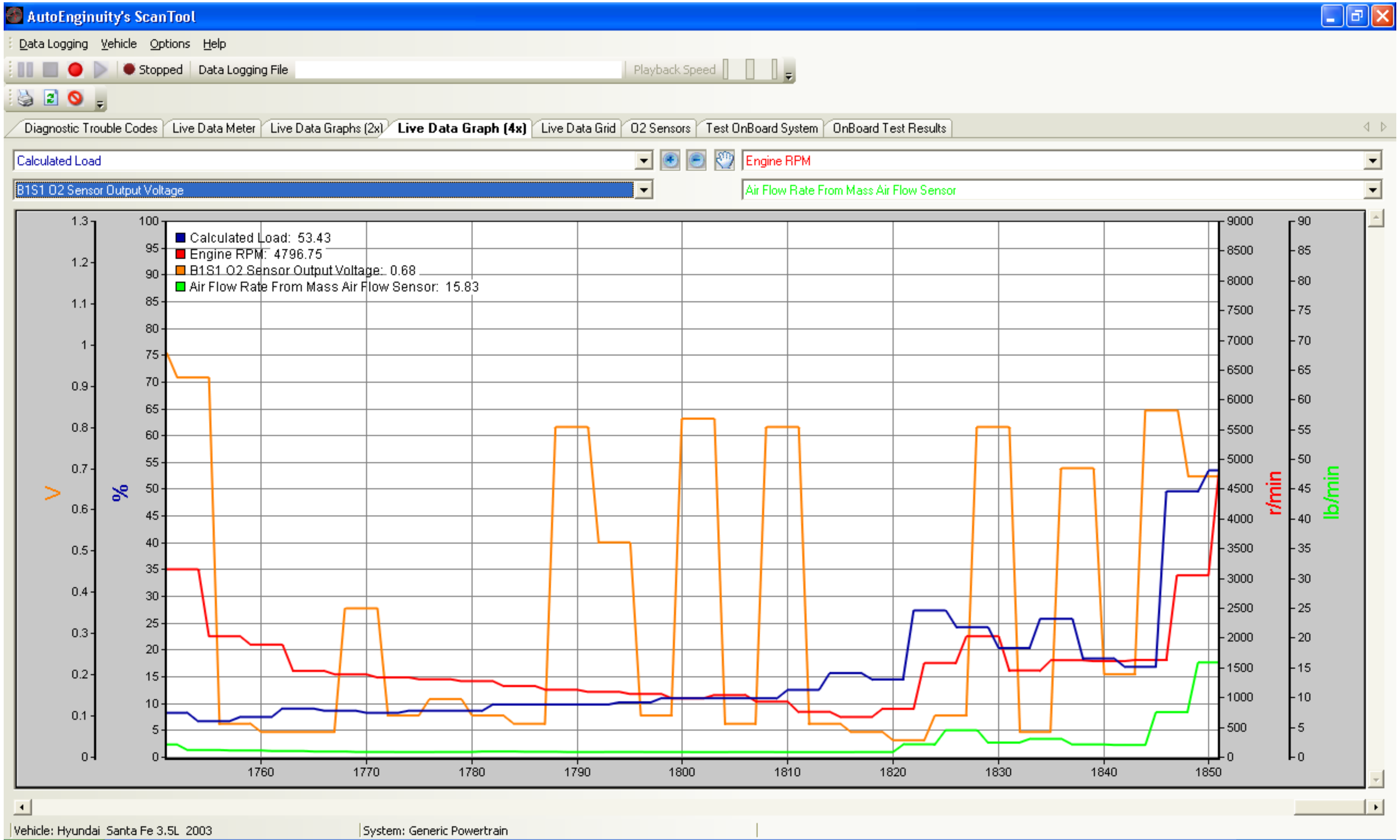

AutoEnginuity's ScanTool
Data Logging
Vehicle
Options
Help
Stopped
Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
Calculated Load
Engine RPM
B1S1 O2 Sensor Output Voltage
Air Flow Rate From Mass Air Flow Sensor
Calculated Load: 21.06
Engine RPM: 5011.50
B1S1 O2 Sensor Output Voltage: 0.94
Air Flow Rate From Mass Air Flow Sensor: 7.75
V
%
r/min
lb/min
Vehicle: Hyundai Santa Fe 3.5L 2003
System: Generic Powertrain


VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
3.5
Liters
RPM
5011.5
MAF
7.75
Lb/Min
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
34%
Max. Air Flow
175 GPS
23 Lb/M
302 CFM
Fuel Vol. Req. @ Stoich
0.25 Gal/M
0.96 L/M
Fuel Vol. Req. @ Stoich + 20%
0.31 Gal/M
1.16 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%


AutoEnginuity's ScanTool
Data Logging
Vehicle
Options
Help
Stopped
Data Logging File
Playback Speed
Diagnostic Trouble Codes
Live Data Meter
Live Data Graphs (2x)
Live Data Graph (4x)
Live Data Grid
O2 Sensors
Test OnBoard System
OnBoard Test Results
Short Term Fuel Trim Bank One
Long Term Fuel Trim Bank One
Engine RPM
Air Flow Rate From Mass Air Flow Sensor
Short Term Fuel Trim Bank One: 0.00
Engine RPM: 4269.50
Long Term Fuel Trim Bank One: 5.46
Air Flow Rate From Mass Air Flow Sensor: 8.12
%
%
r/min
lb/min
Vehicle: Hyundai Santa Fe 3.5L 2003
System: Generic Powertrain

Diagnosis

- VE and Load PID poor
- O2 reads high / Rich
- No MAP
- Fuel Trims normal – acceptable positive level
- Any thoughts?



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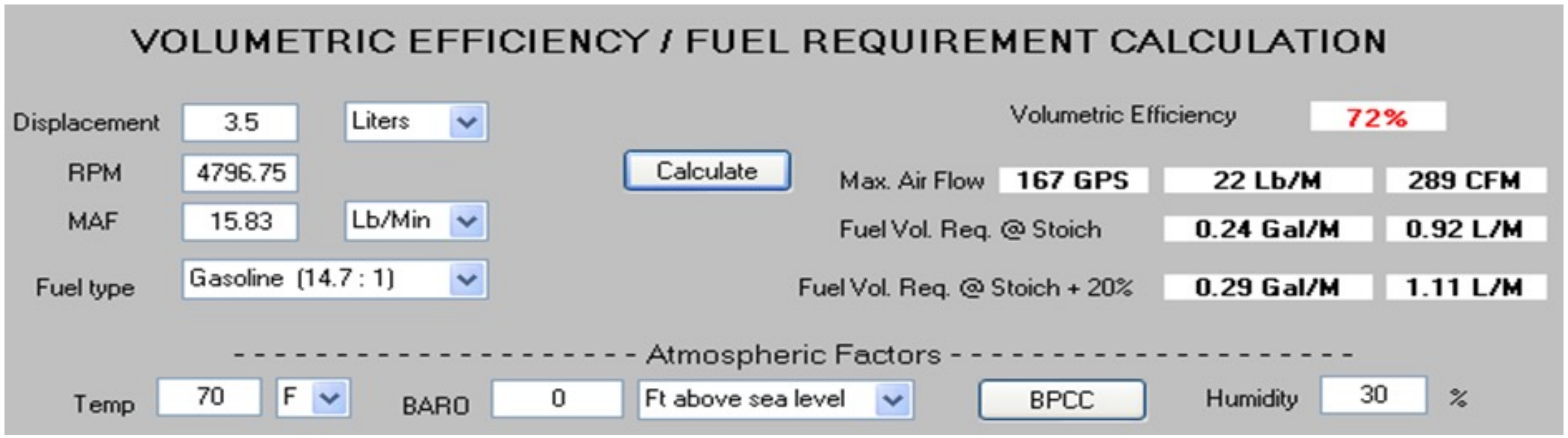
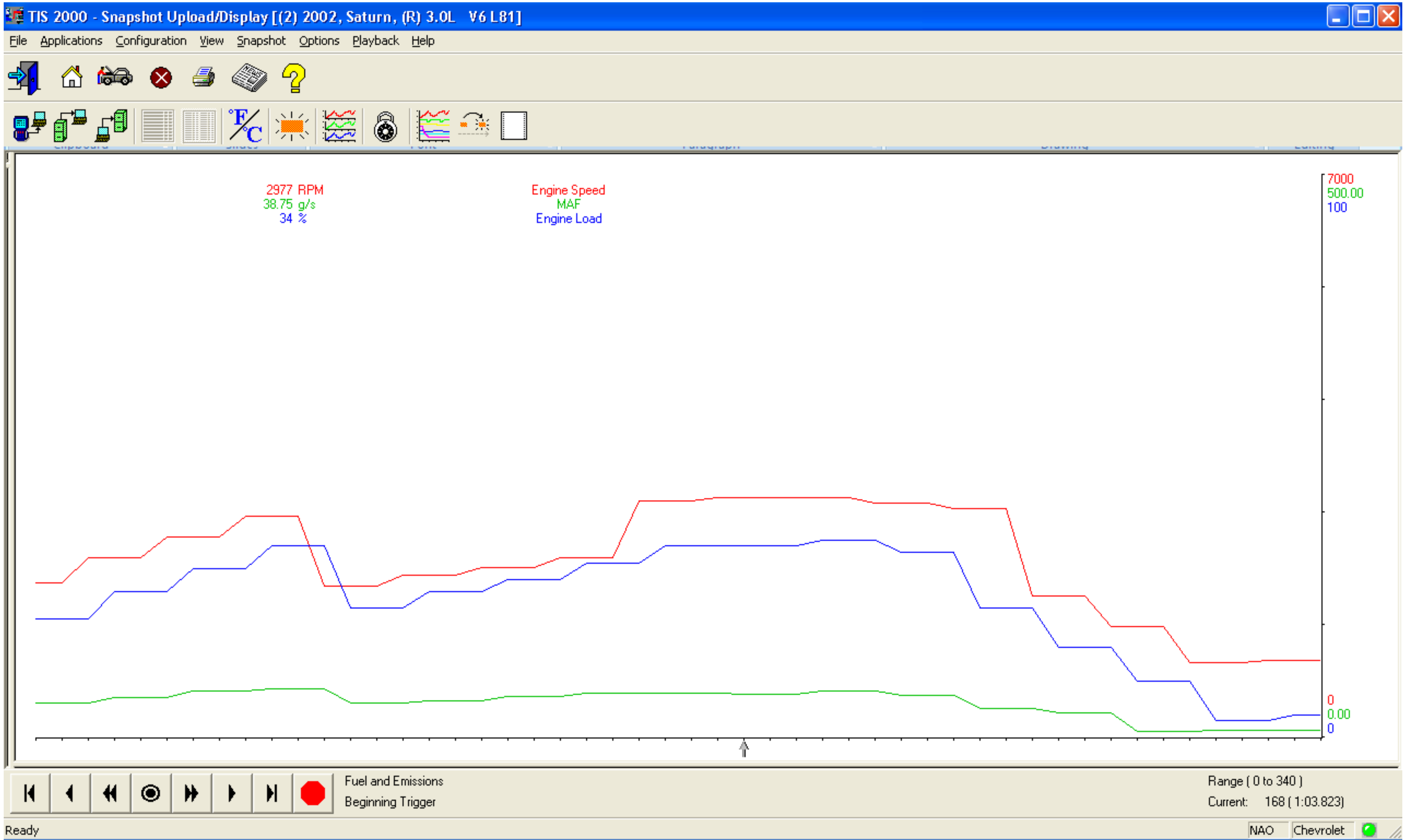

VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
3.5
Liters
RPM
4796.75
MAF
15.83
Lb/Min
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
72%
Max. Air Flow
167 GPS
22 Lb/M
289 CFM
Fuel Vol. Req. @ Stoich
0.24 Gal/M
0.92 L/M
Fuel Vol. Req. @ Stoich + 20%
0.29 Gal/M
1.11 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%

2002 Saturn L200 3.0 L

No Power



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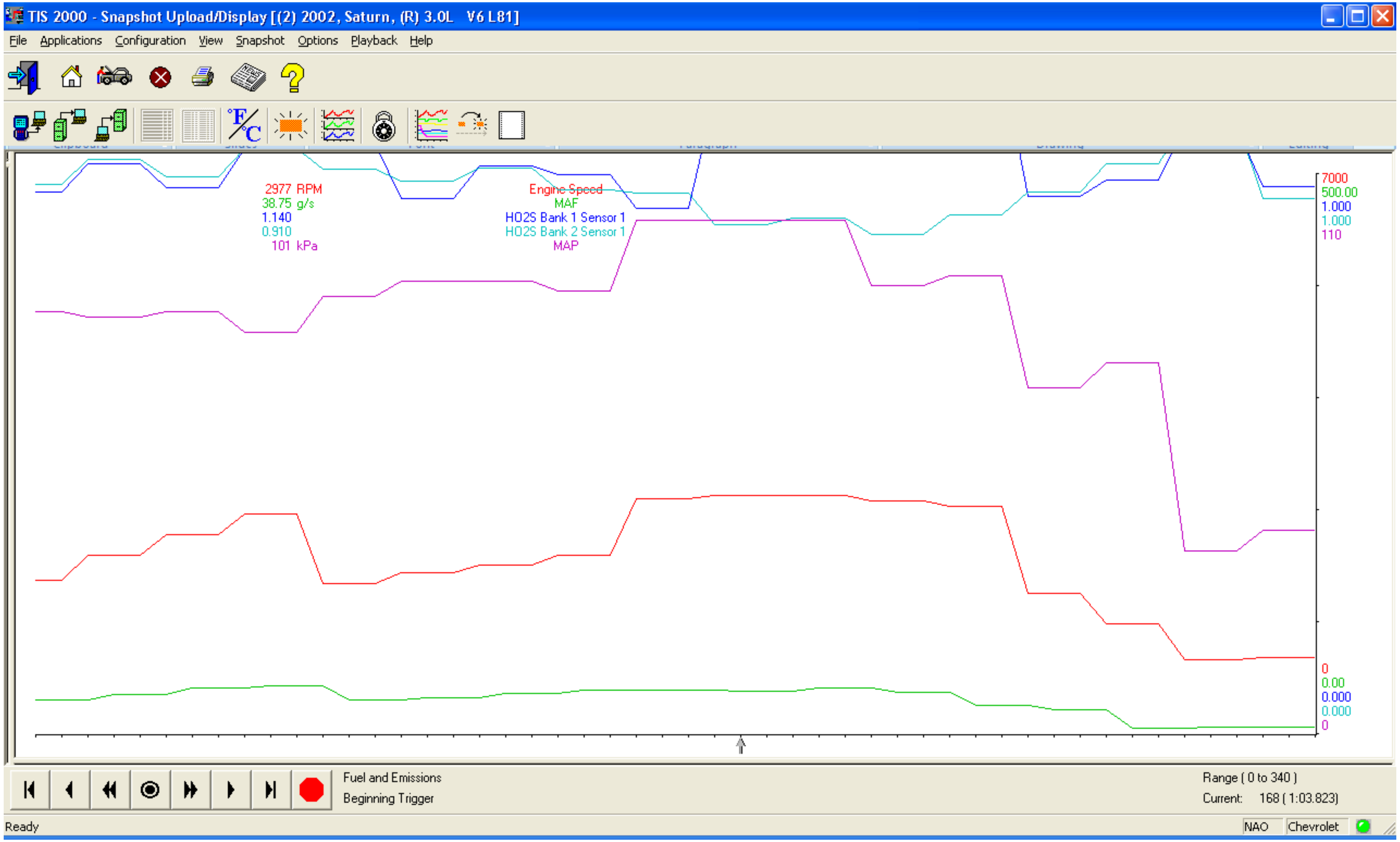

WTI
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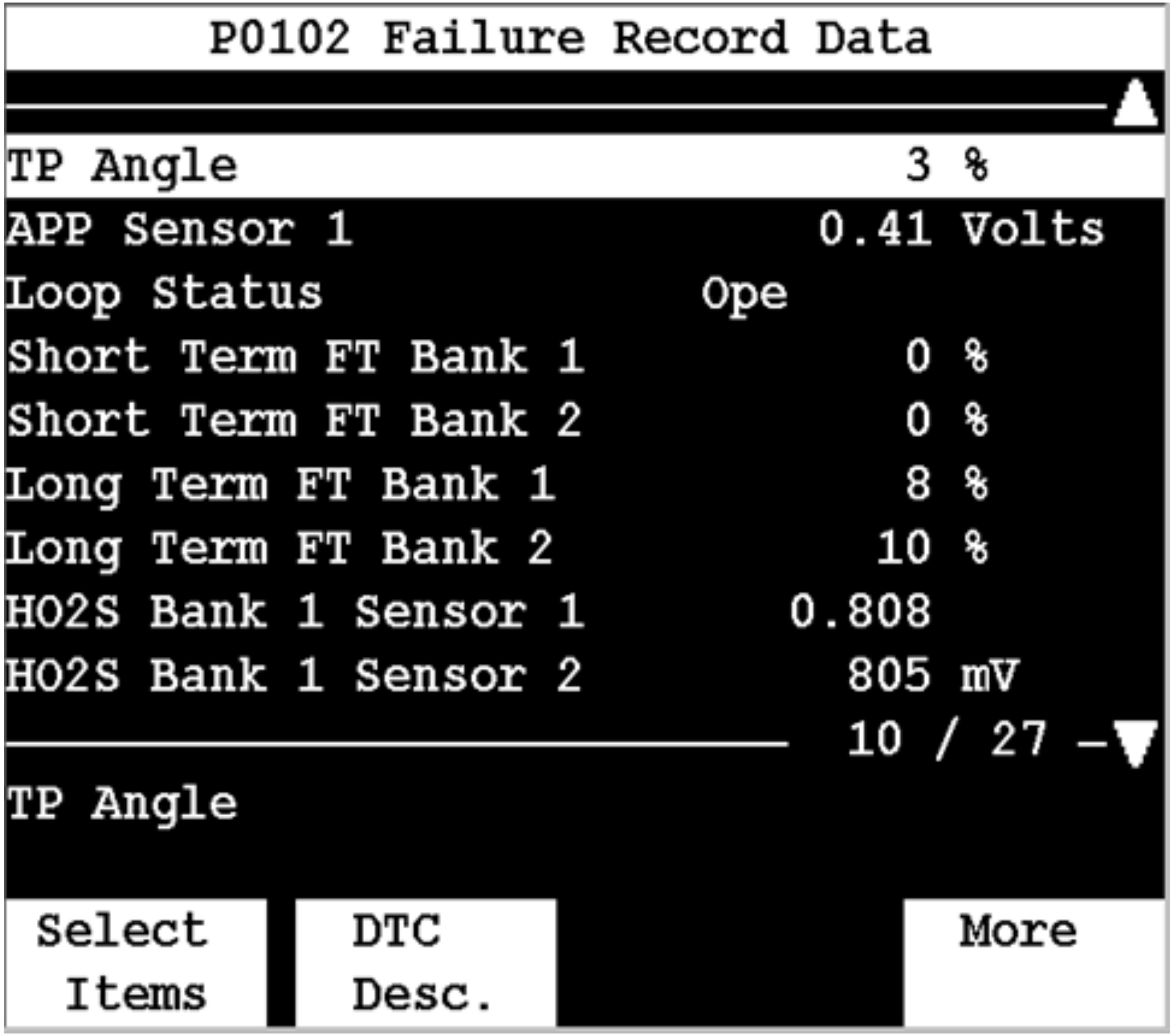
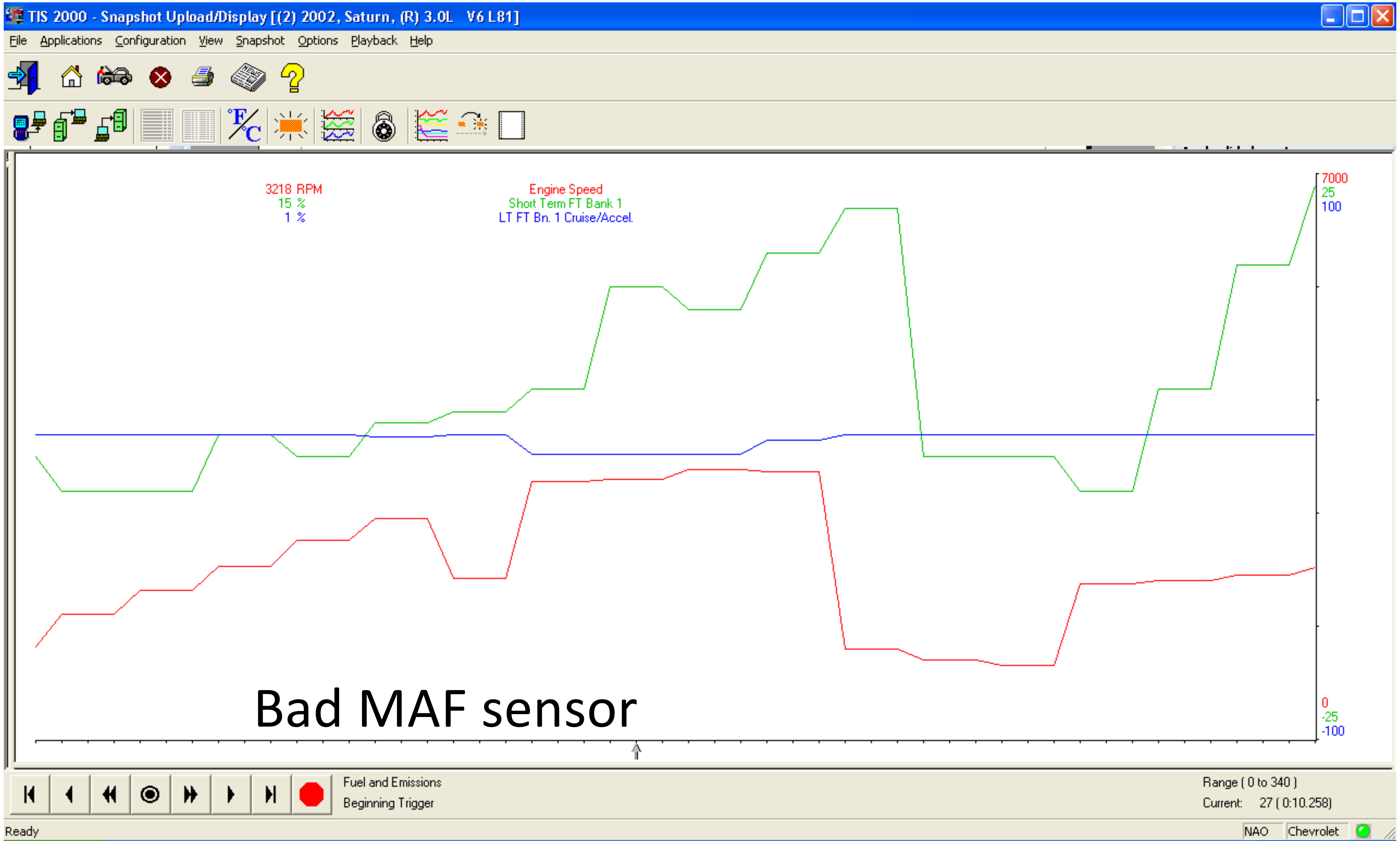
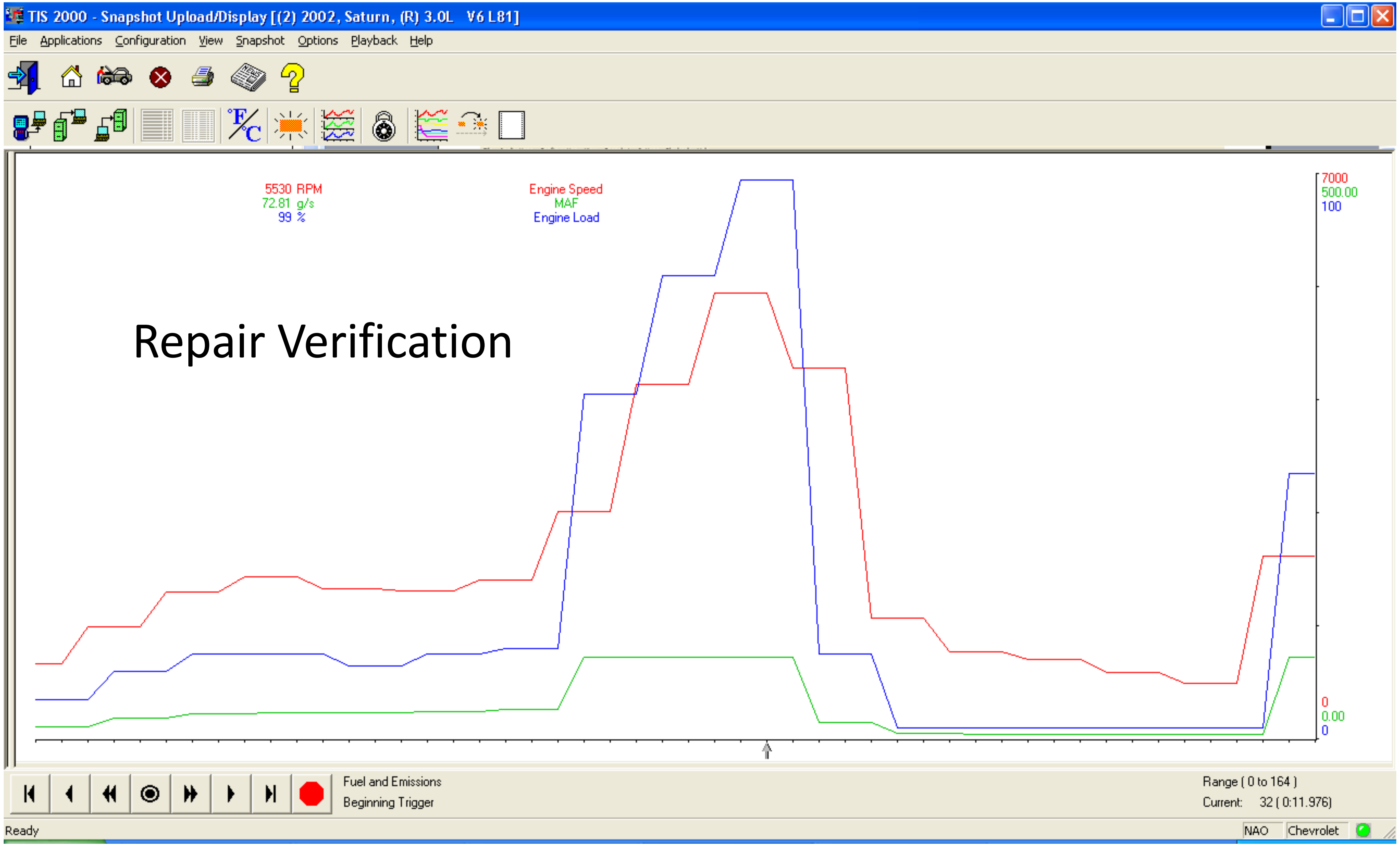
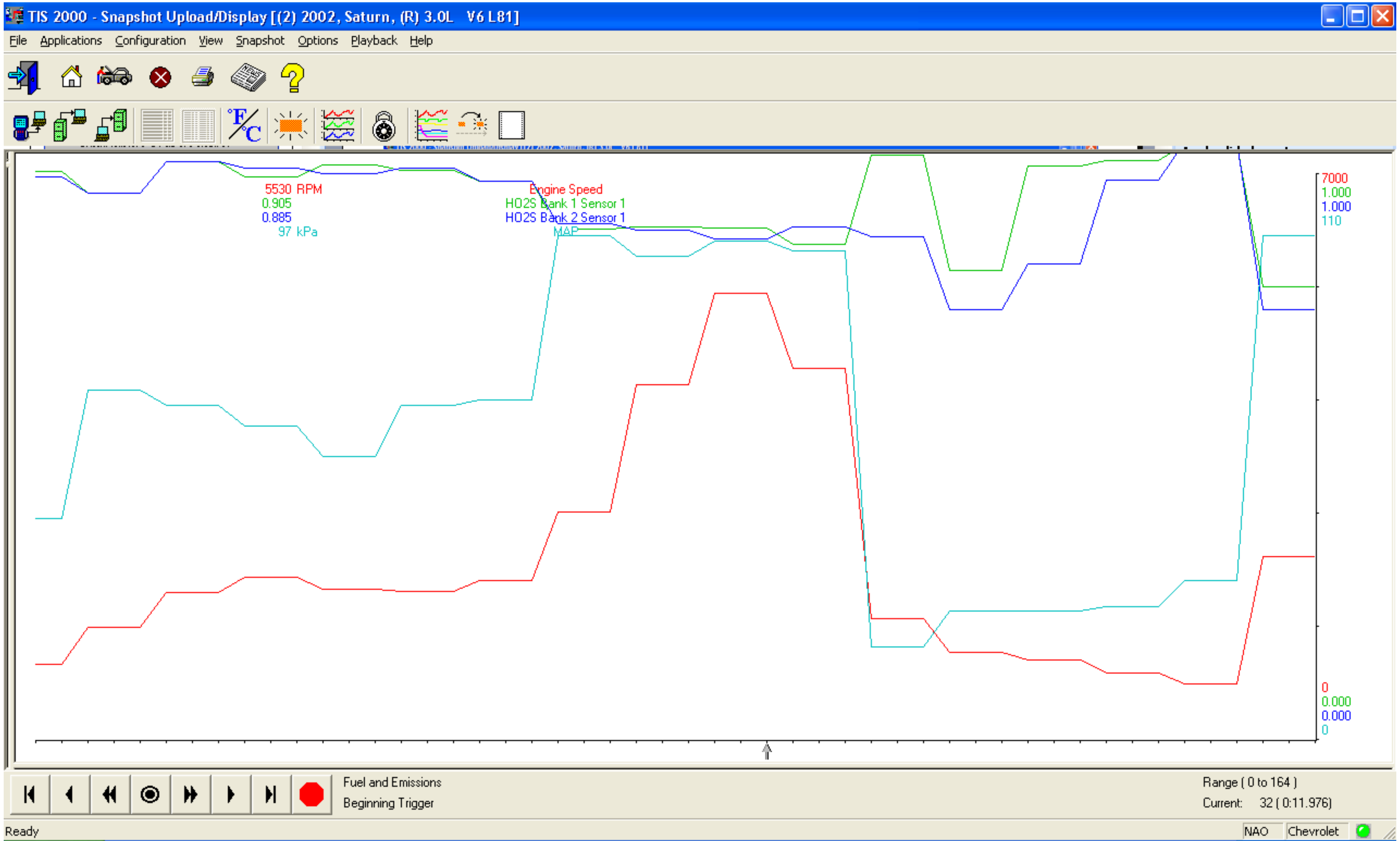

P0102 Failure Record Data
TP Angle 3 %
APP Sensor 1 0.41 Volts
Loop Status Ope
Short Term FT Bank 1 0 %
Short Term FT Bank 2 0 %
Long Term FT Bank 1 8 %
Long Term FT Bank 2 10 %
HO2S Bank 1 Sensor 1 0.808
HO2S Bank 1 Sensor 2 805 mV
10 / 27
TP Angle
Select Items
DTC Desc.
More



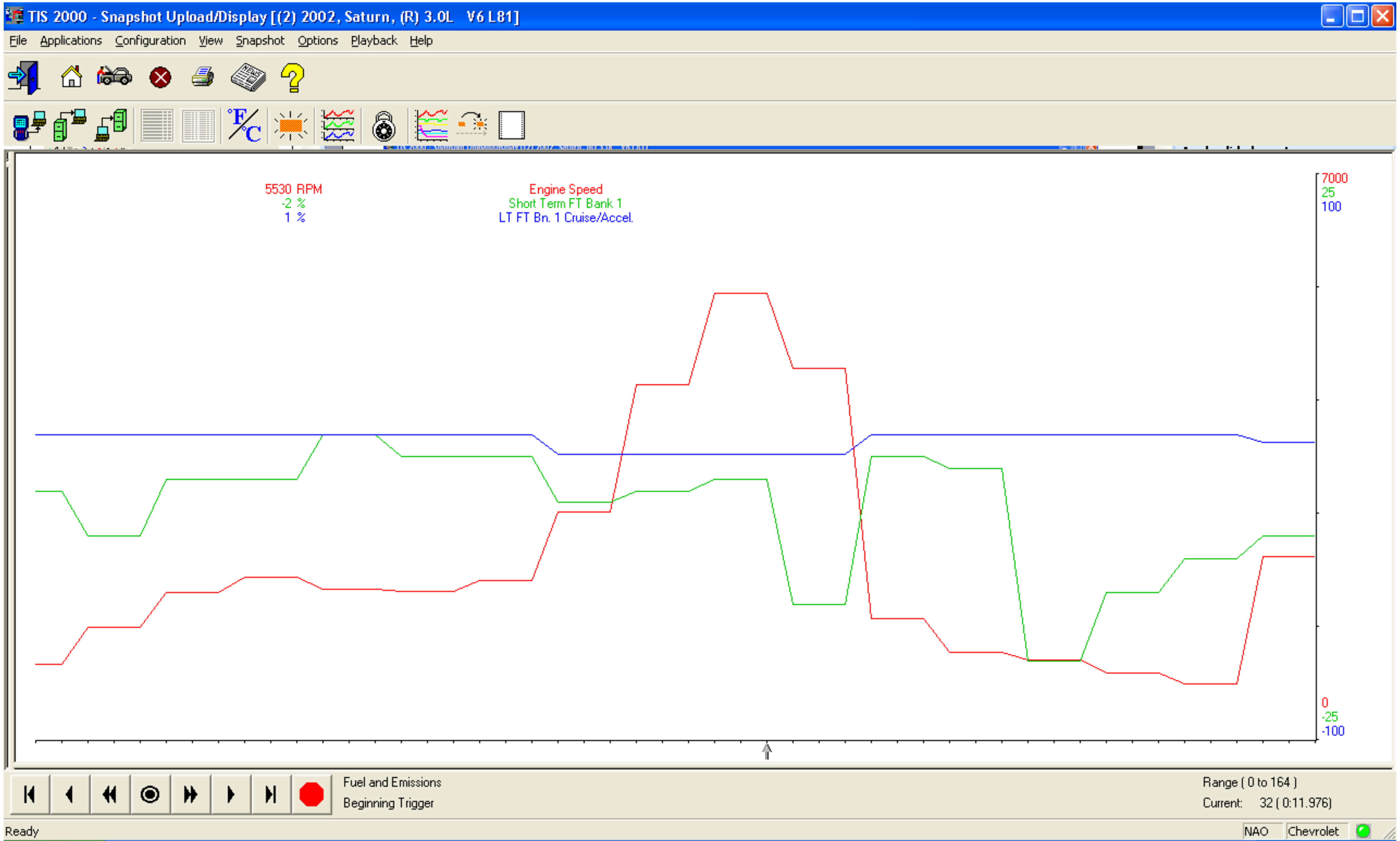
WTI
WORLDPAC Training Institute.

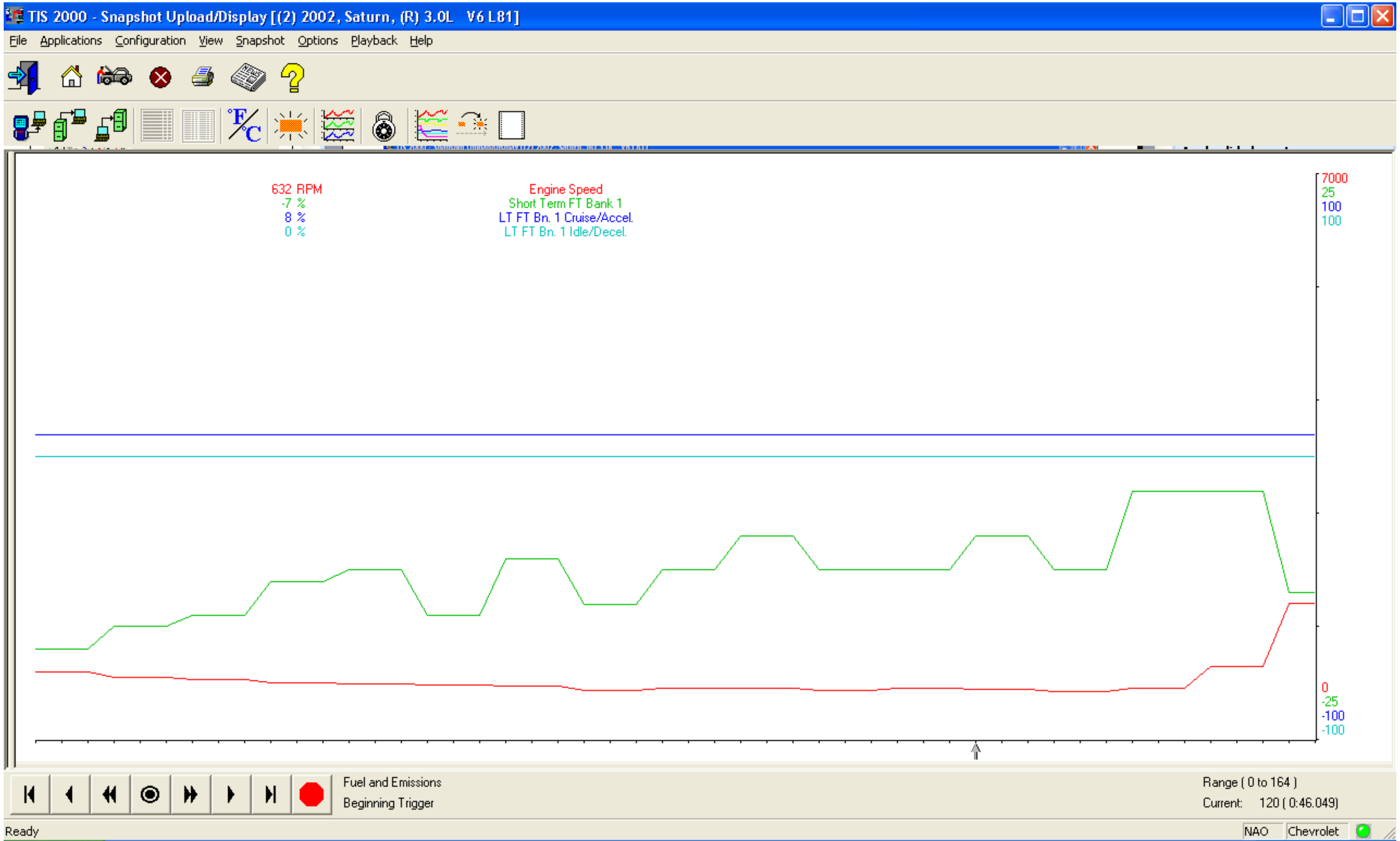


WTI WORLDPAC Training Institute.



WORLDPAC Training Institute


TIS 2000 - Snapshot Upload/Display [(2) 2002, Saturn, (R) 3.0L V6 L81]
File Applications Configuration View Snapshot Options Playback Help
5530 RPM
-2 %
1 %
Engine Speed
Short Term FT Bank 1
LT FT Bn. 1 Cruise/Accel.
7000
25
100
0
-25
-100
Fuel and Emissions
Beginning Trigger
Range (0 to 164)
Current: 32 (0:11.976)
Ready
NAO
Chevrolet



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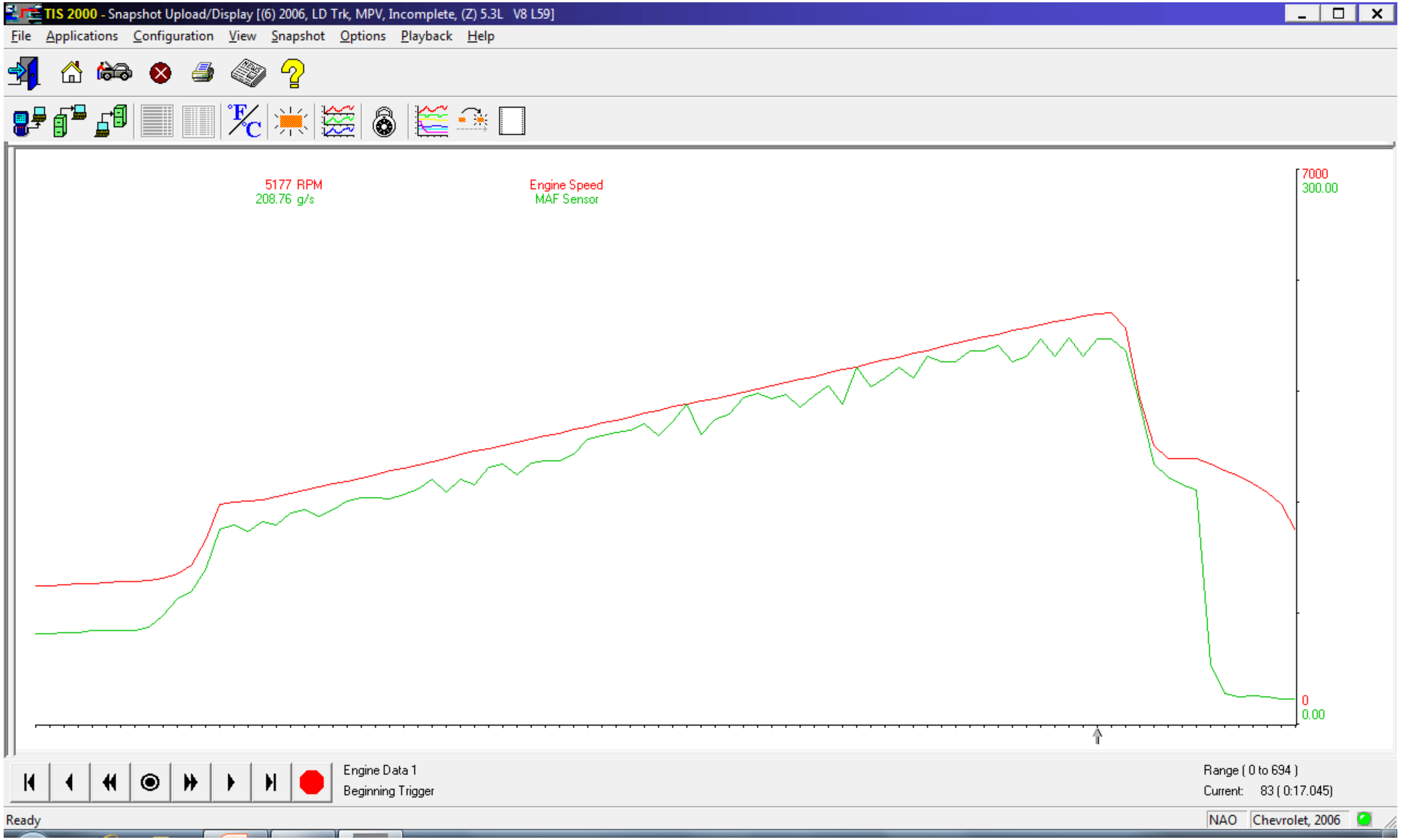
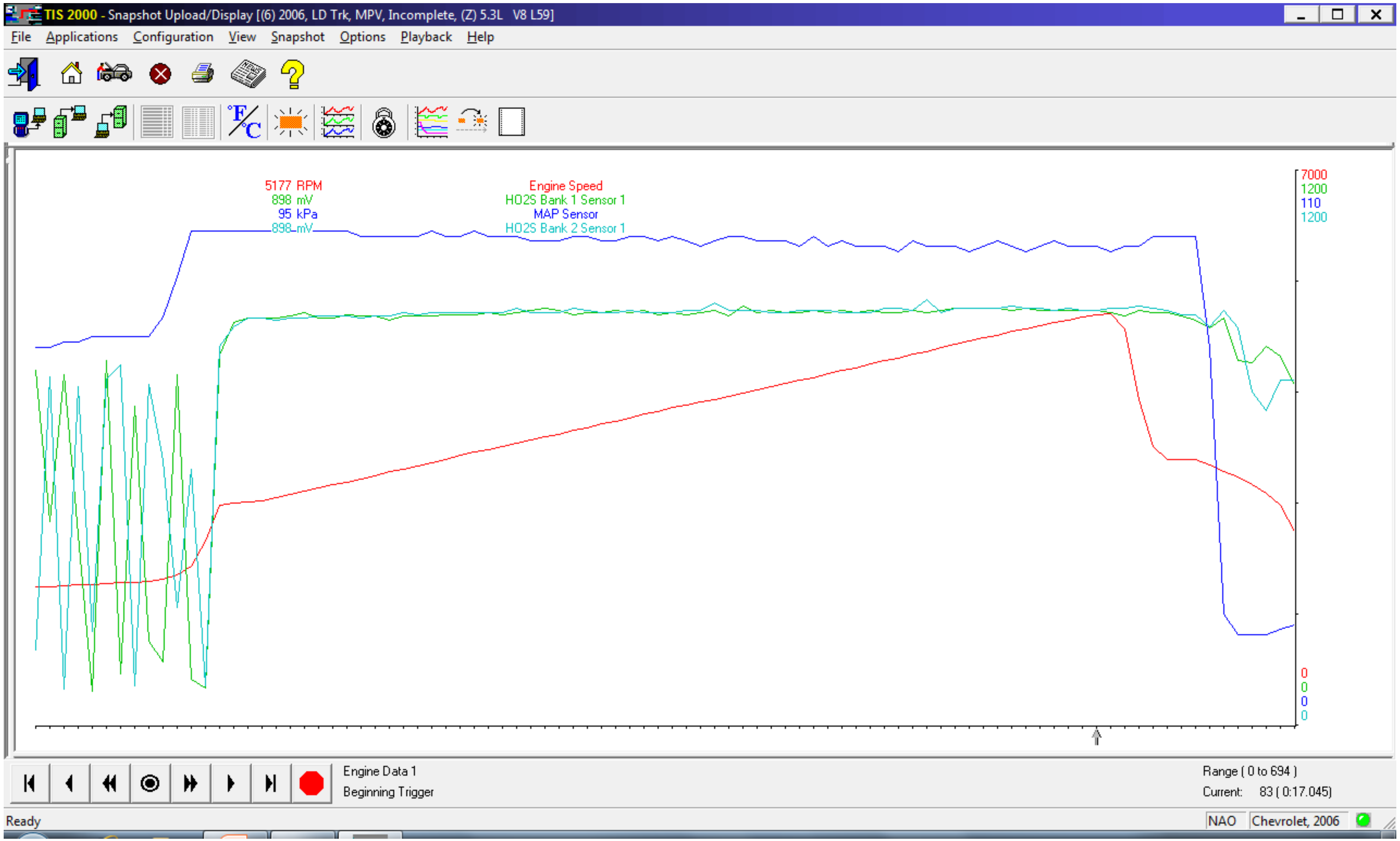
2006 Yukon 5.3

Known good with downstream comparison

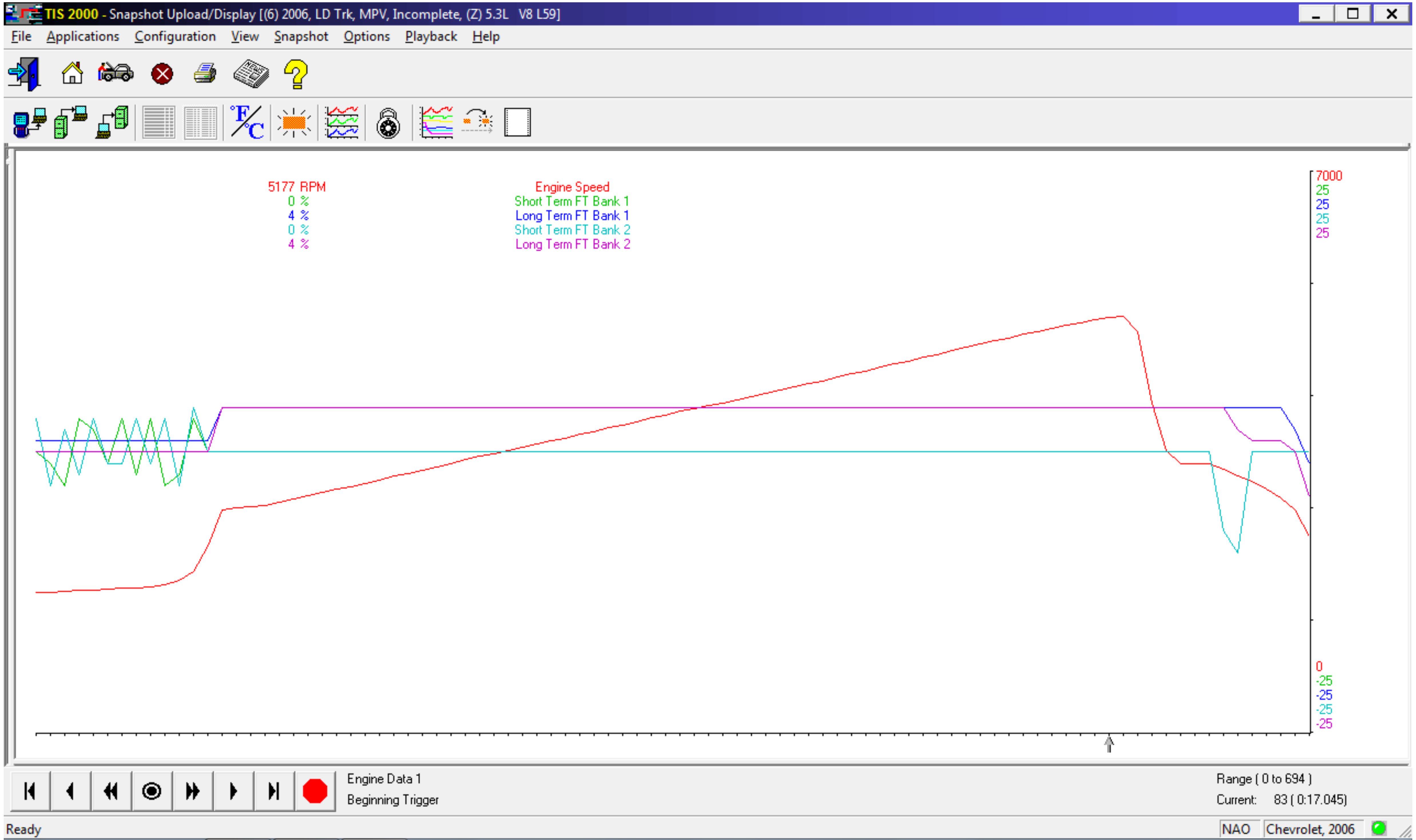


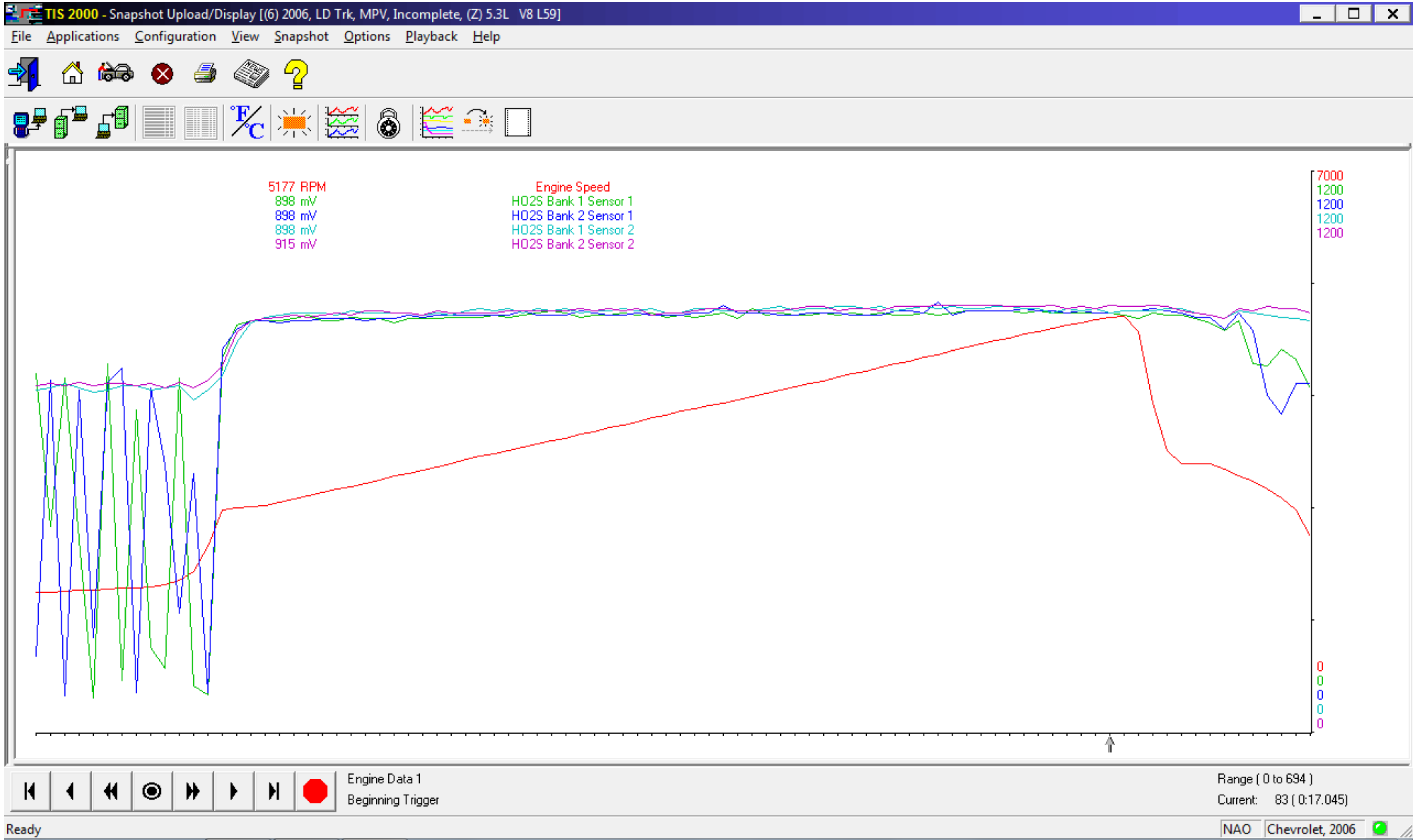
WTI WORLDPAC Training Institute.

WTI WORLDPAC Training Institute.



WTI
WORLDPAC Training Institute.


TIS 2000 - Snapshot Upload/Display [(6) 2006, LD Trk, MPV, Incomplete, (Z) 5.3L V8 L59]
File Applications Configuration View Snapshot Options Playback Help
5177 RPM
0 %
4 %
0 %
4 %
Engine Speed
Short Term FT Bank 1
Long Term FT Bank 1
Short Term FT Bank 2
Long Term FT Bank 2
7000
25
25
25
25
0
-25
-25
-25
-25
Engine Data 1
Beginning Trigger
Range (0 to 694)
Current: 83 (0:17.045)
Ready
NAO
Chevrolet, 2006



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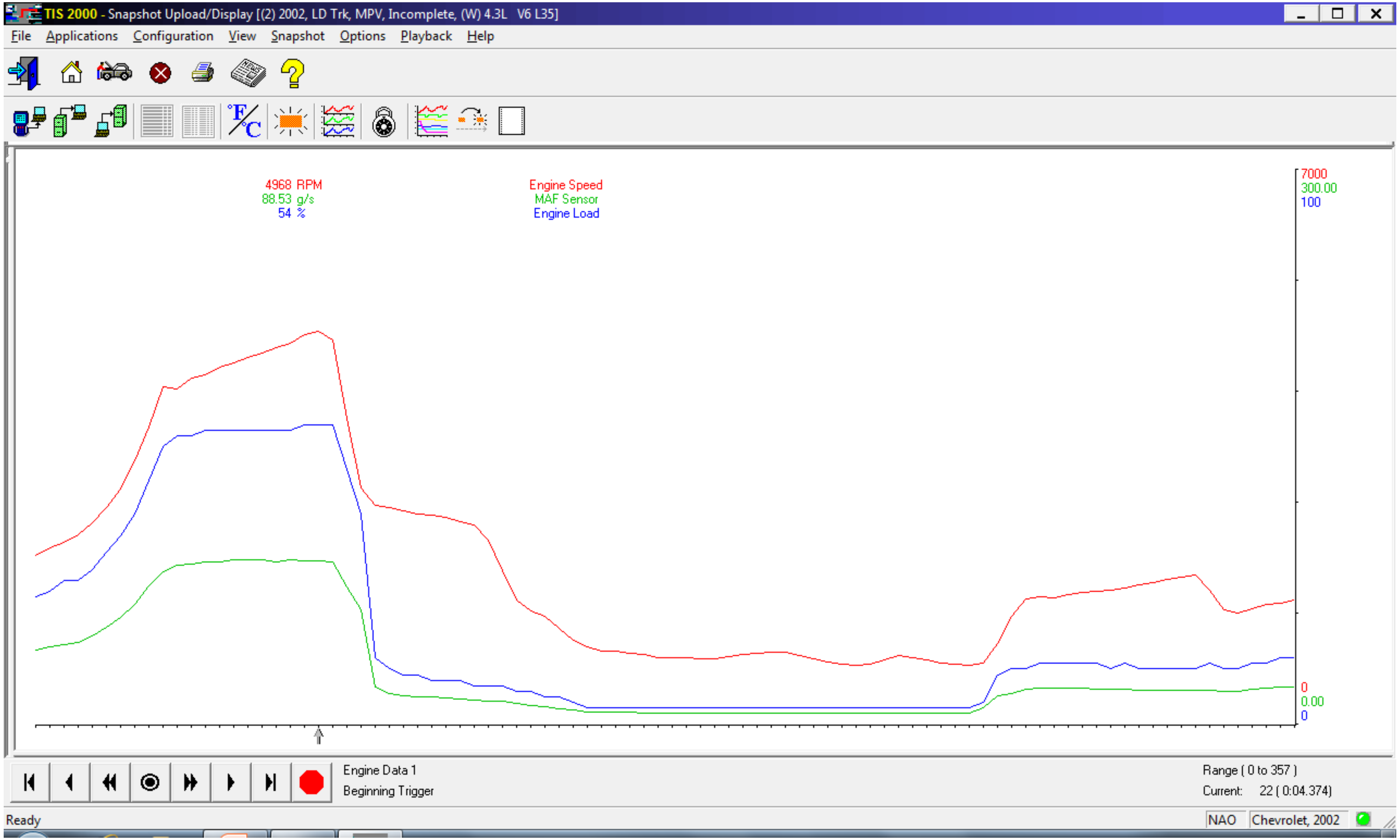
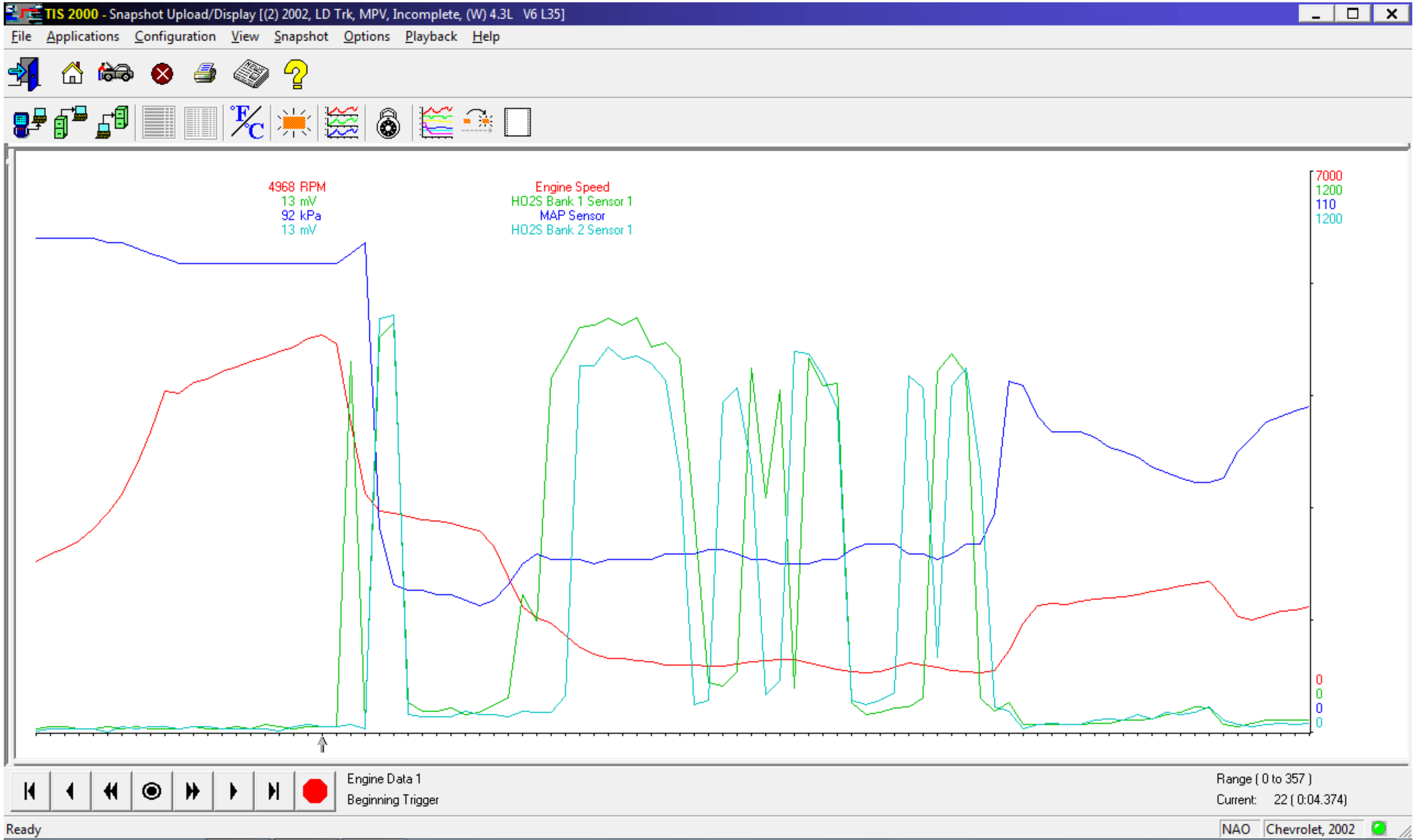
2002 Blazer 4.3

Low Power


TIS 2000 - Snapshot Upload/Display [(2) 2002, LD Trk, MPV, Incomplete, (W) 4.3L V6 L35]
File Applications Configuration View Snapshot Options Playback Help
4968 RPM
88.53 g/s
54 %
Engine Speed
MAF Sensor
Engine Load
7000
300.00
100
0
0.00
0
Engine Data 1
Beginning Trigger
Range (0 to 357)
Current: 22 (0:04.374)
Ready
NAO
Chevrolet, 2002



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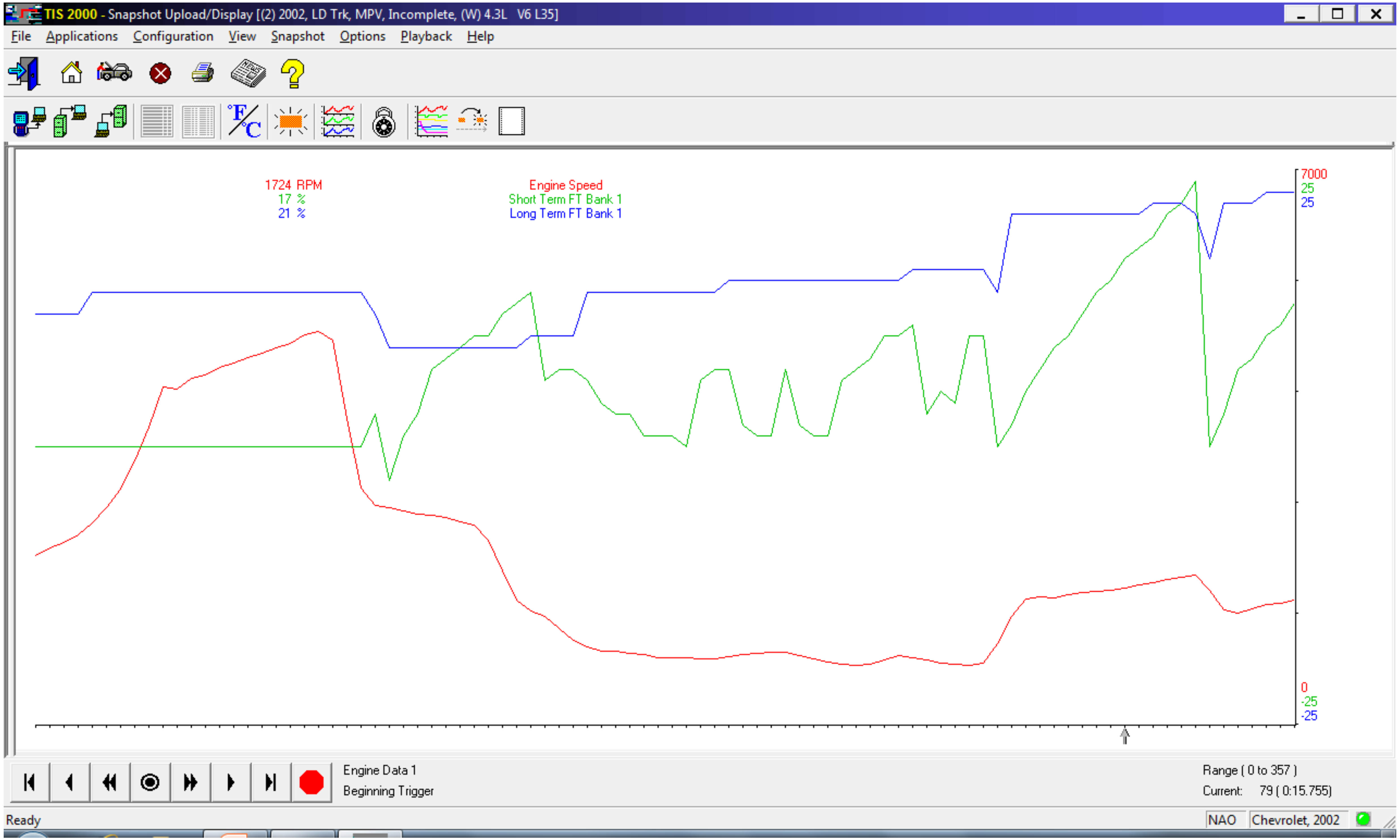
WORLDPAC Training Institute.



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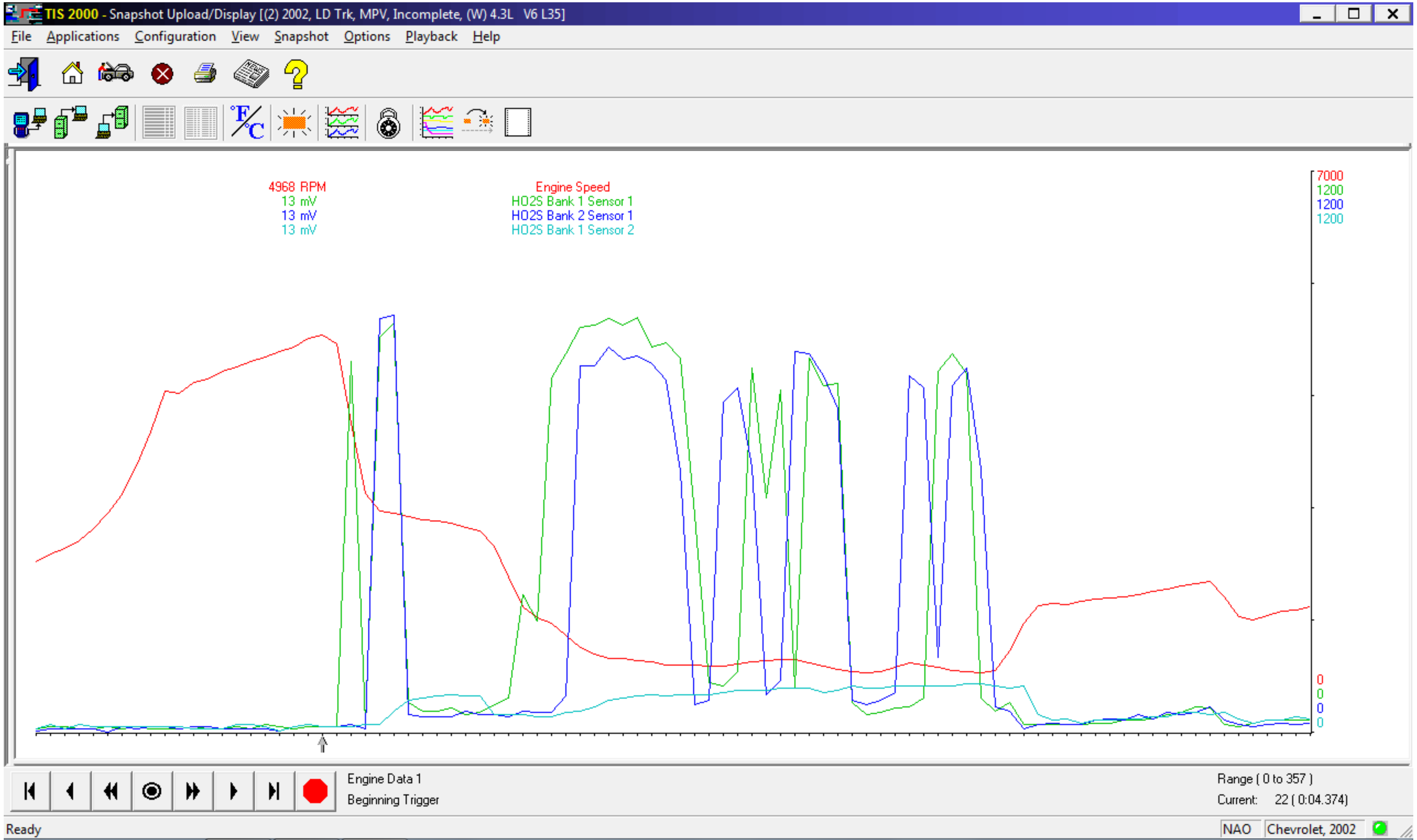

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1998 E150 Low power

4.2 Liter Engine

Scan tool: Ease and Mastertech

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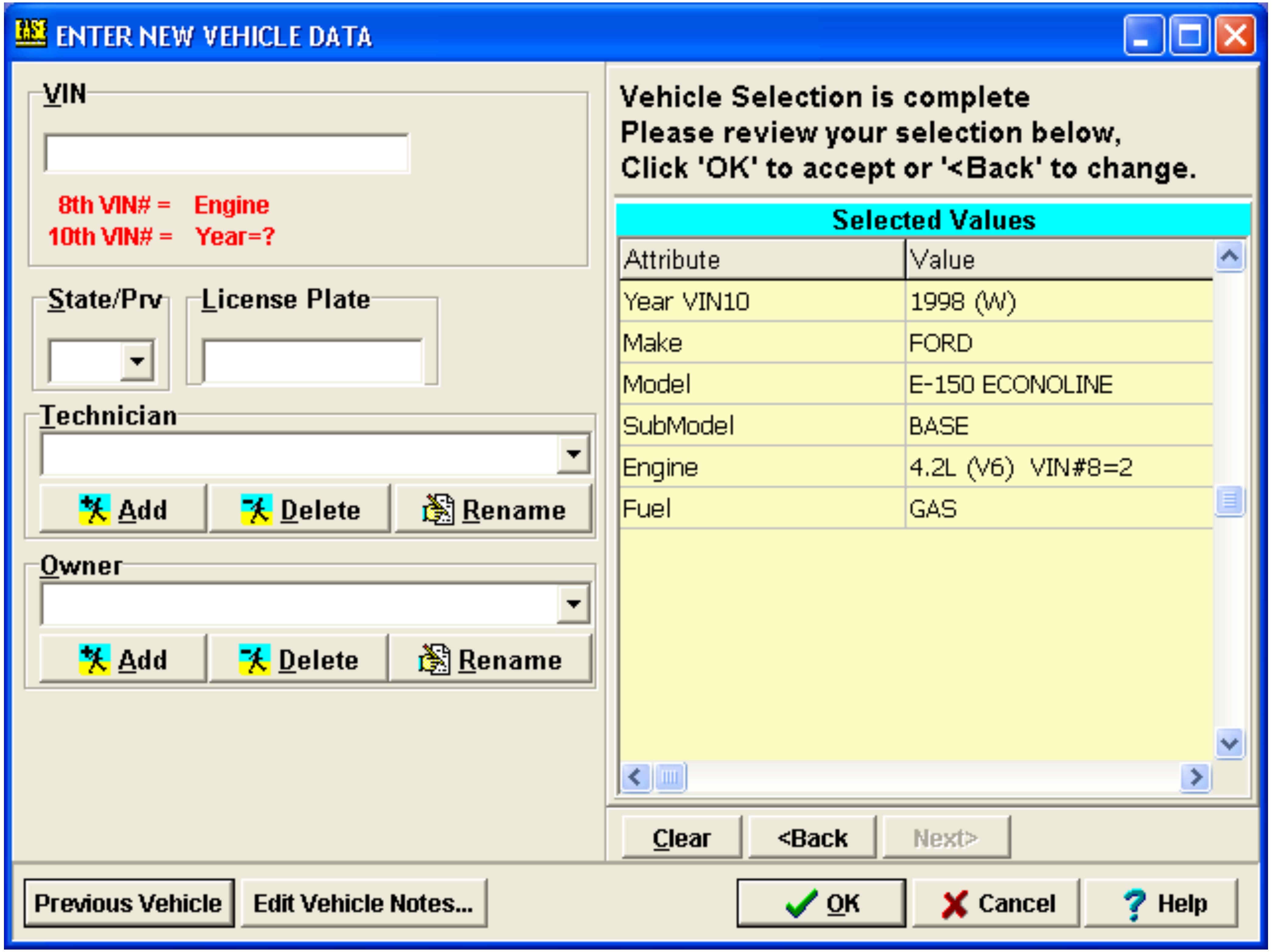
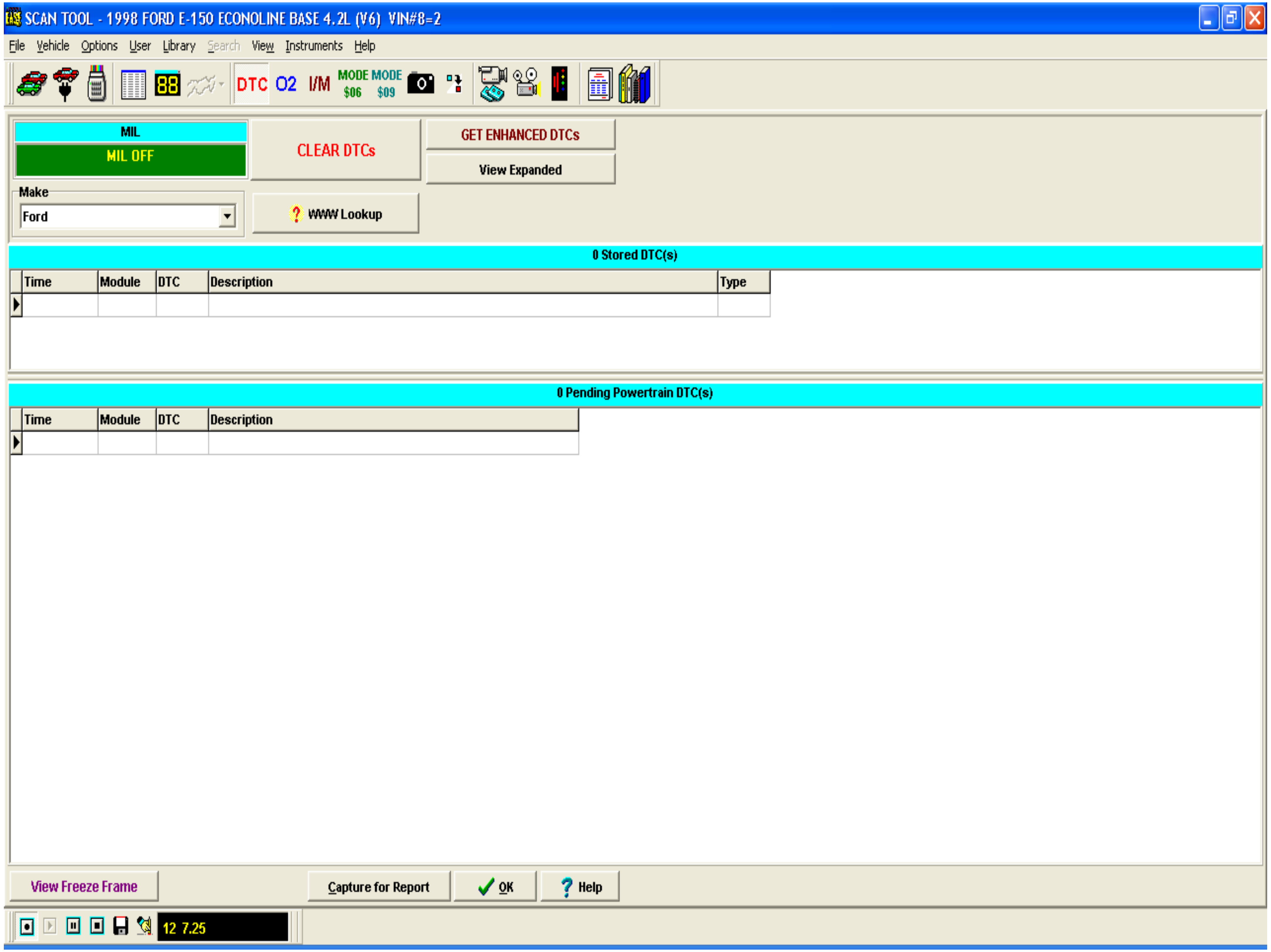
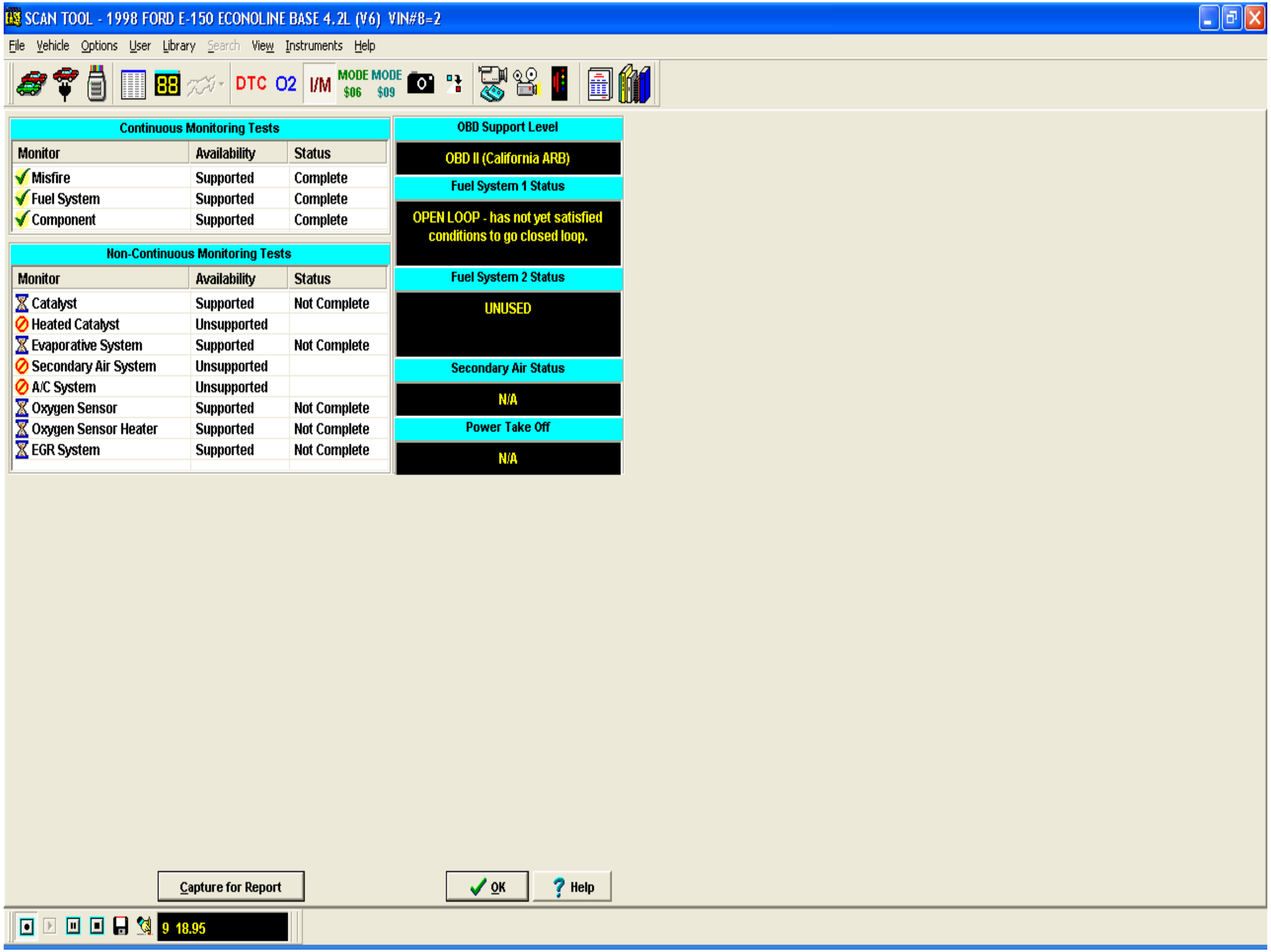
Shop replaced the following:

- Fuel Pump
- Entire exhaust minus the exhaust manifolds
- Plugs, wires and coil pack
- Swapped a MAF from another known good E150 with no change
- Had an engine ready to go!

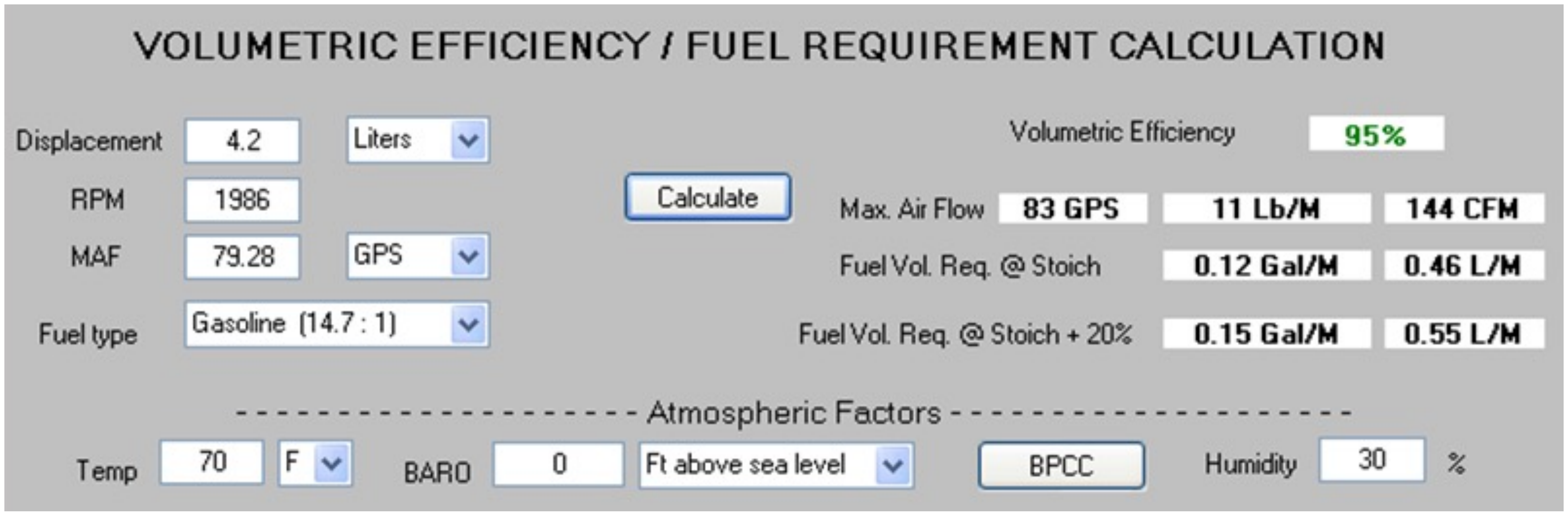


ENTER NEW VEHICLE DATA
VIN
8th VIN# = Engine
10th VIN# = Year=?
State/Prv
License Plate
Technician
Add
Delete
Rename
Owner
Add
Delete
Rename
Vehicle Selection is complete
Please review your selection below,
Click 'OK' to accept or '<Back' to change.
Selected Values
Attribute | Value
Year VIN10 | 1998 (W)
Make | FORD
Model | E-150 ECONOLINE
SubModel | BASE
Engine | 4.2L (V6) VIN#8=2
Fuel | GAS
Clear
<Back
Next>
Previous Vehicle
Edit Vehicle Notes...
OK
Cancel
Help


SCAN TOOL - 1998 FORD E-150 ECONOLINE BASE 4.2L (V6) VIN#8=2
File Vehicle Options User Library Search View Instruments Help
DTC O2 I/M MODE $06 MODE $09
MIL
MIL OFF
CLEAR DTCs
GET ENHANCED DTCs
View Expanded
Make
Ford
WWW Lookup
0 Stored DTC(s)
Time Module DTC Description Type
0 Pending Powertrain DTC(s)
Time Module DTC Description
View Freeze Frame
Capture for Report
OK
Help
12 7.25


SCAN TOOL - 1998 FORD E-150 ECONOLINE BASE 4.2L (V6) VIN#8=2
File Vehicle Options User Library Search View Instruments Help
DTC O2 I/M MODE $06 MODE $09
Continuous Monitoring Tests
Monitor Availability Status
Misfire Supported Complete
Fuel System Supported Complete
Component Supported Complete
Non-Continuous Monitoring Tests
Monitor Availability Status
Catalyst Supported Not Complete
Heated Catalyst Unsupported
Evaporative System Supported Not Complete
Secondary Air System Unsupported
A/C System Unsupported
Oxygen Sensor Supported Not Complete
Oxygen Sensor Heater Supported Not Complete
EGR System Supported Not Complete
OBD Support Level
OBD II (California ARB)
Fuel System 1 Status
OPEN LOOP - has not yet satisfied conditions to go closed loop.
Fuel System 2 Status
UNUSED
Secondary Air Status
N/A
Power Take Off
N/A
Capture for Report
OK
Help
9 18.95

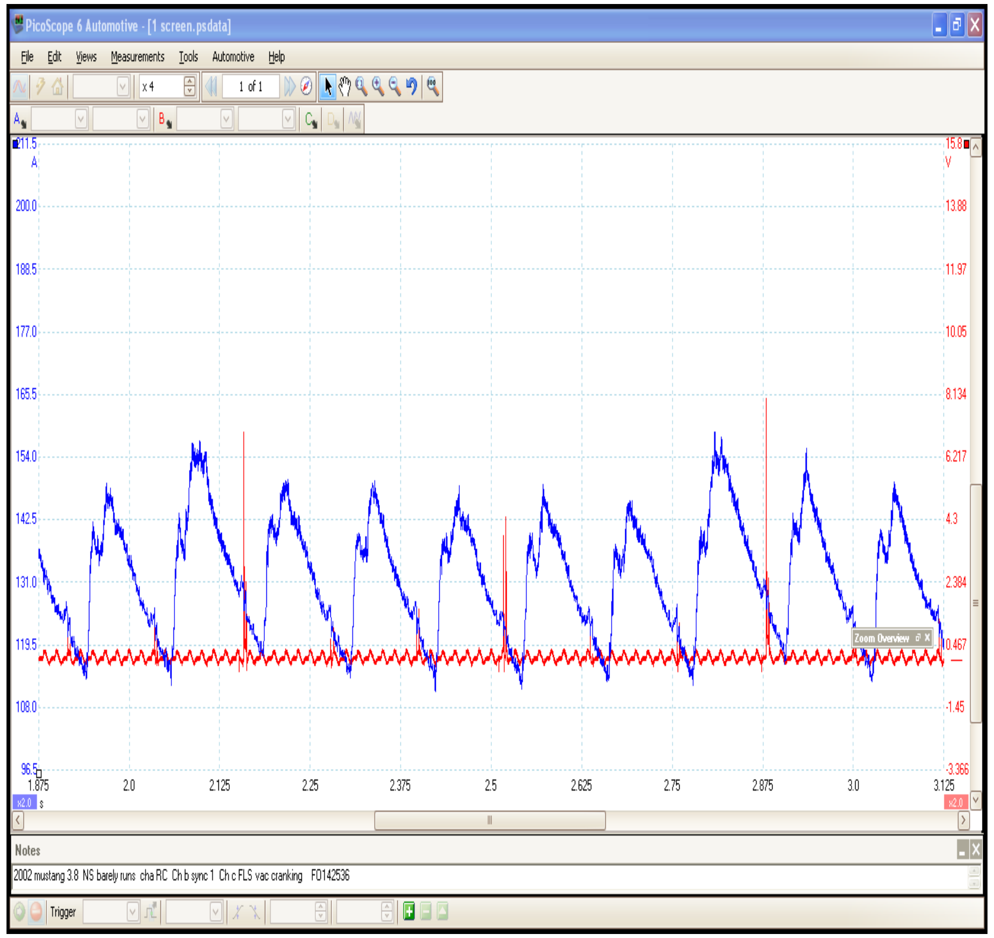

CHARTS - 1998 FORD E-150 ECONOLINE BASE 4.2L (V6) VIN#8=2
Frame Number
15,400
15,450
15,500
15,550
15,600
gm/s_
RPM
Air Flow Rate MAF Sensor
79.28
gm/s_
Engine RPM
1986
RPM
%
Long Term Fuel Trim B1
-1.6
%
Short Term Fuel Trim B1
14.06
%
Short Term Fuel Trim B1
14.06
%
Long Term Fuel Trim B2
-2.3
%
V
O2 Sensor Out Volts B1/S1
0.87
V
O2 Sensor Out Volts B2/S1
0.83
V
15474 974.13

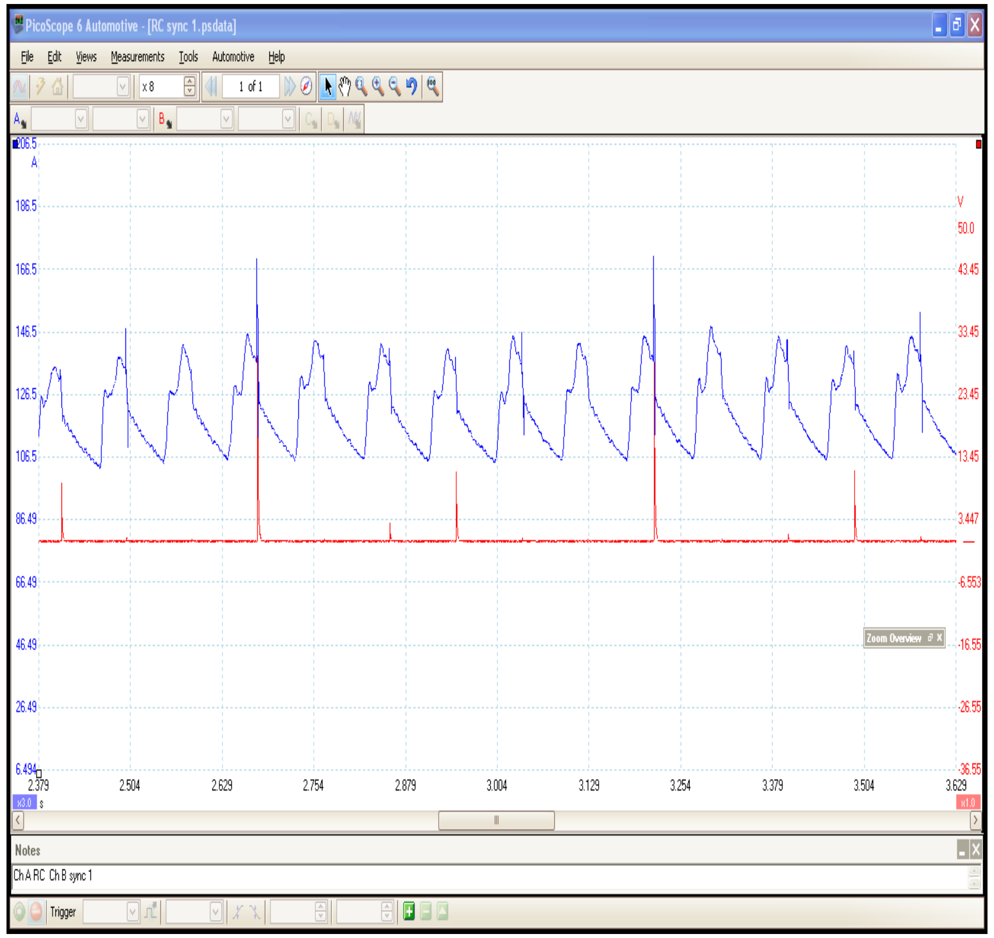

VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement
4.2
Liters
RPM
1986
MAF
79.28
GPS
Fuel type
Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency
95%
Max. Air Flow
83 GPS
11 Lb/M
144 CFM
Fuel Vol. Req. @ Stoich
0.12 Gal/M
0.46 L/M
Fuel Vol. Req. @ Stoich + 20%
0.15 Gal/M
0.55 L/M
Atmospheric Factors
Temp
70
F
BARO
0
Ft above sea level
BPCC
Humidity
30
%

Diagnosis

- VE is good
- O2’s go rich
- Fuel trims normal
- BARO hz good
- Many components replaced
- What else could cause low power?

Can you think of a test that would have quickly found this??





Answer- Relative Compression with Ignition Sync

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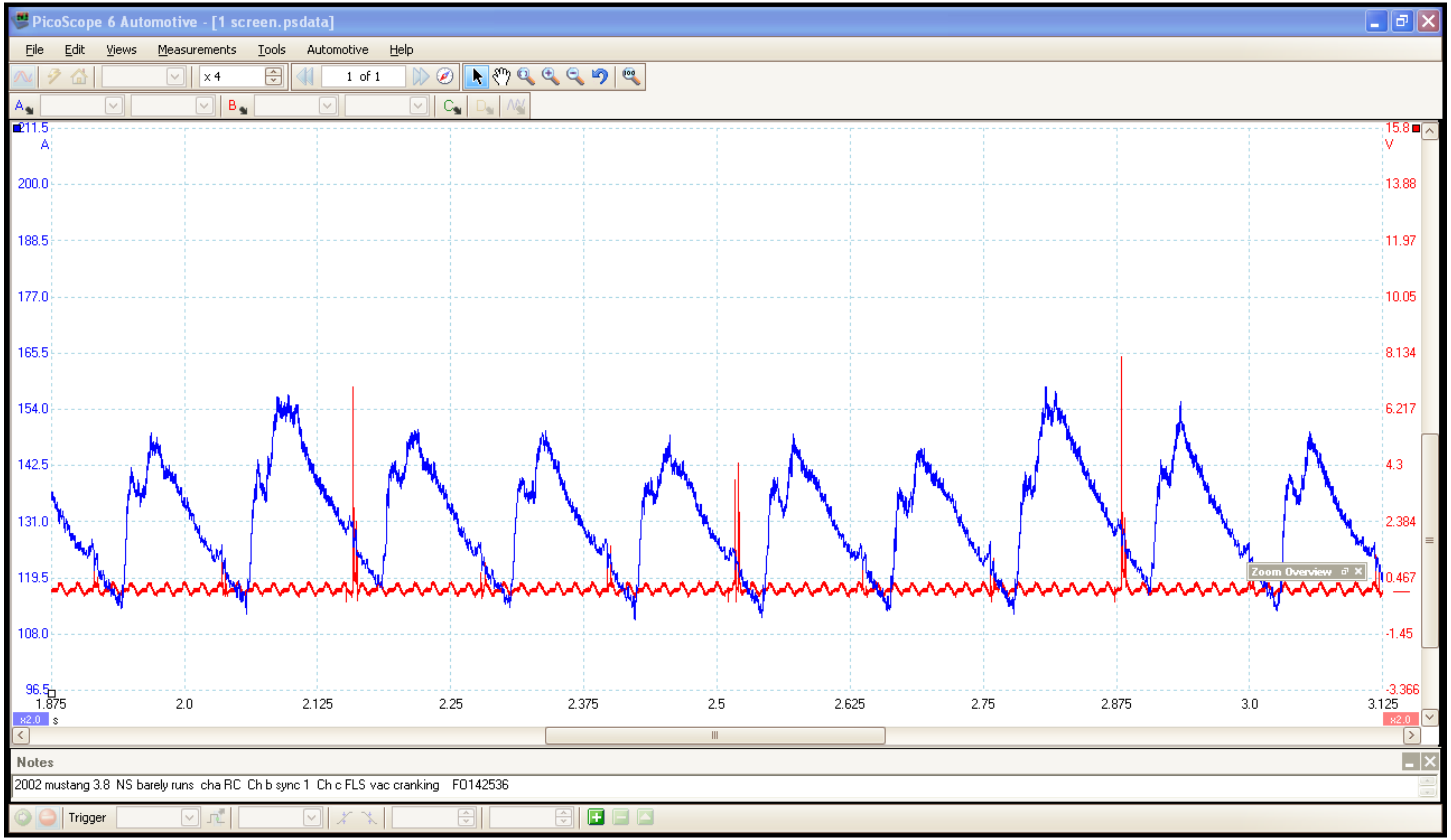
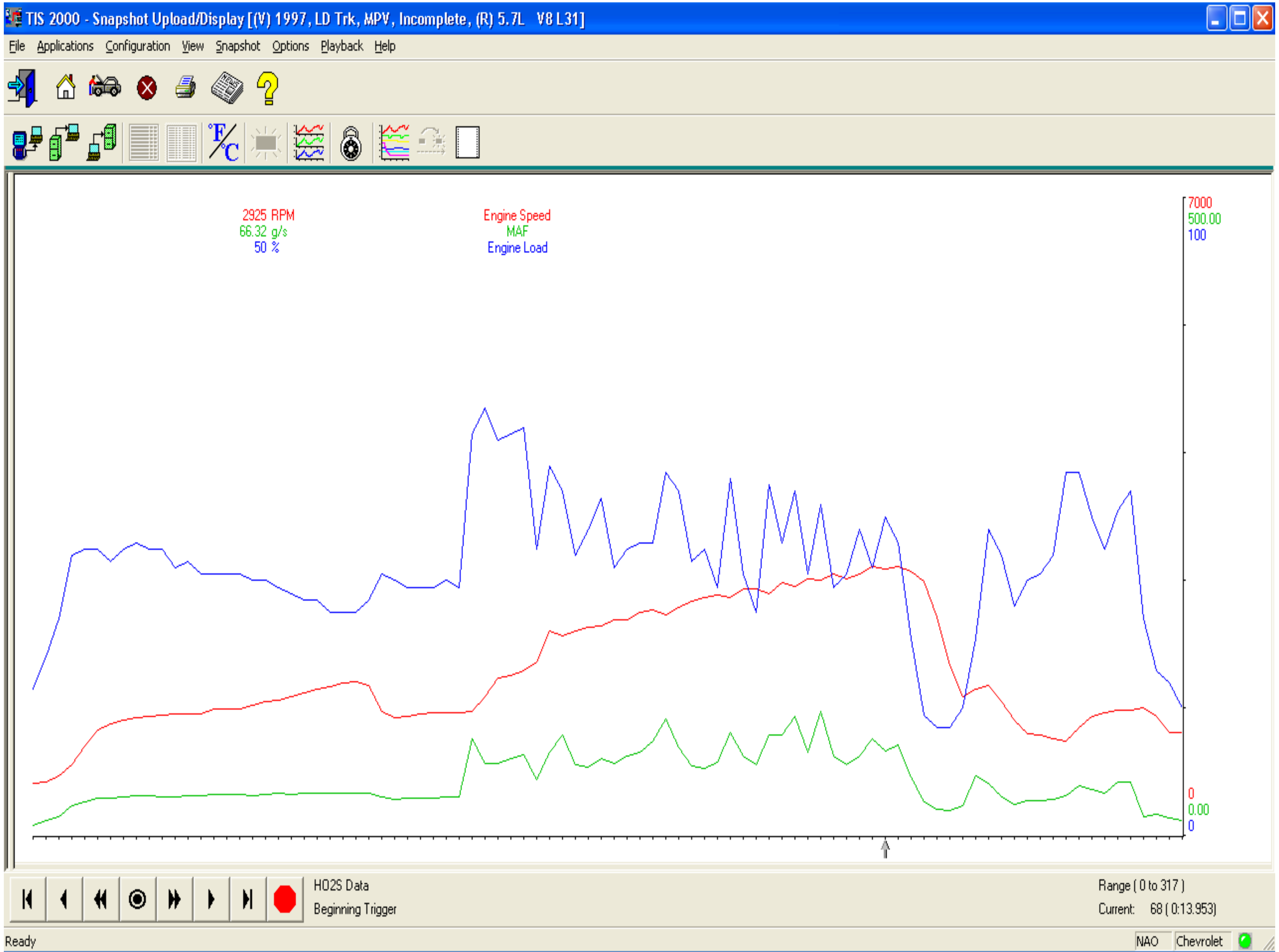
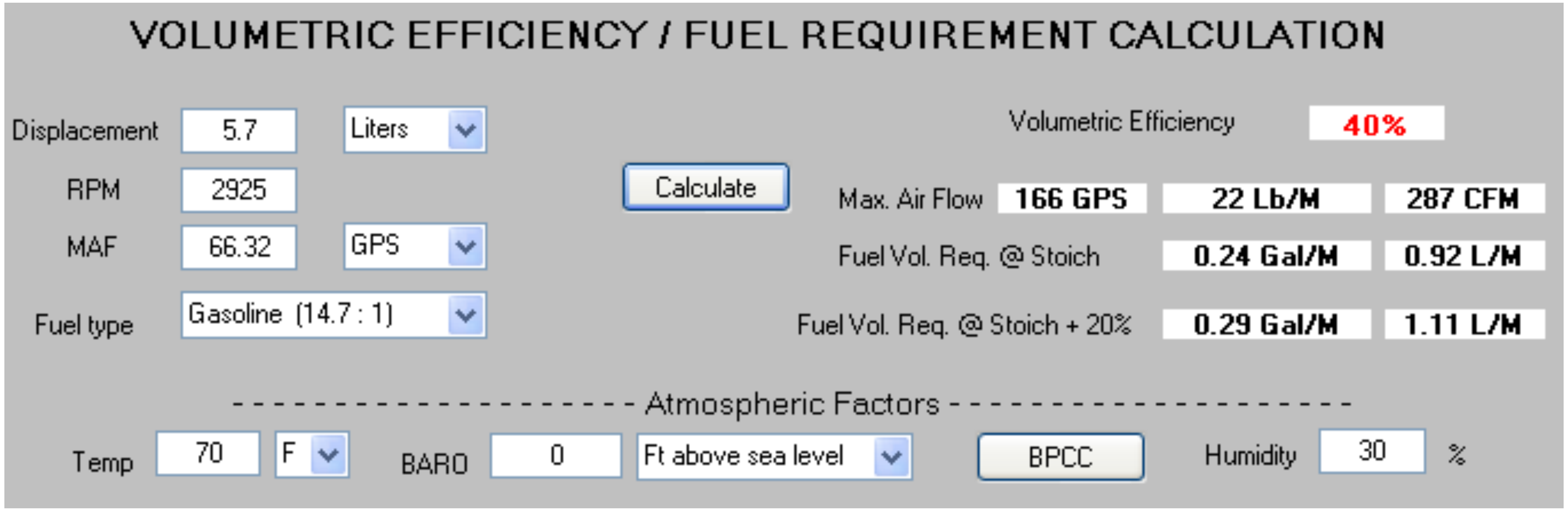


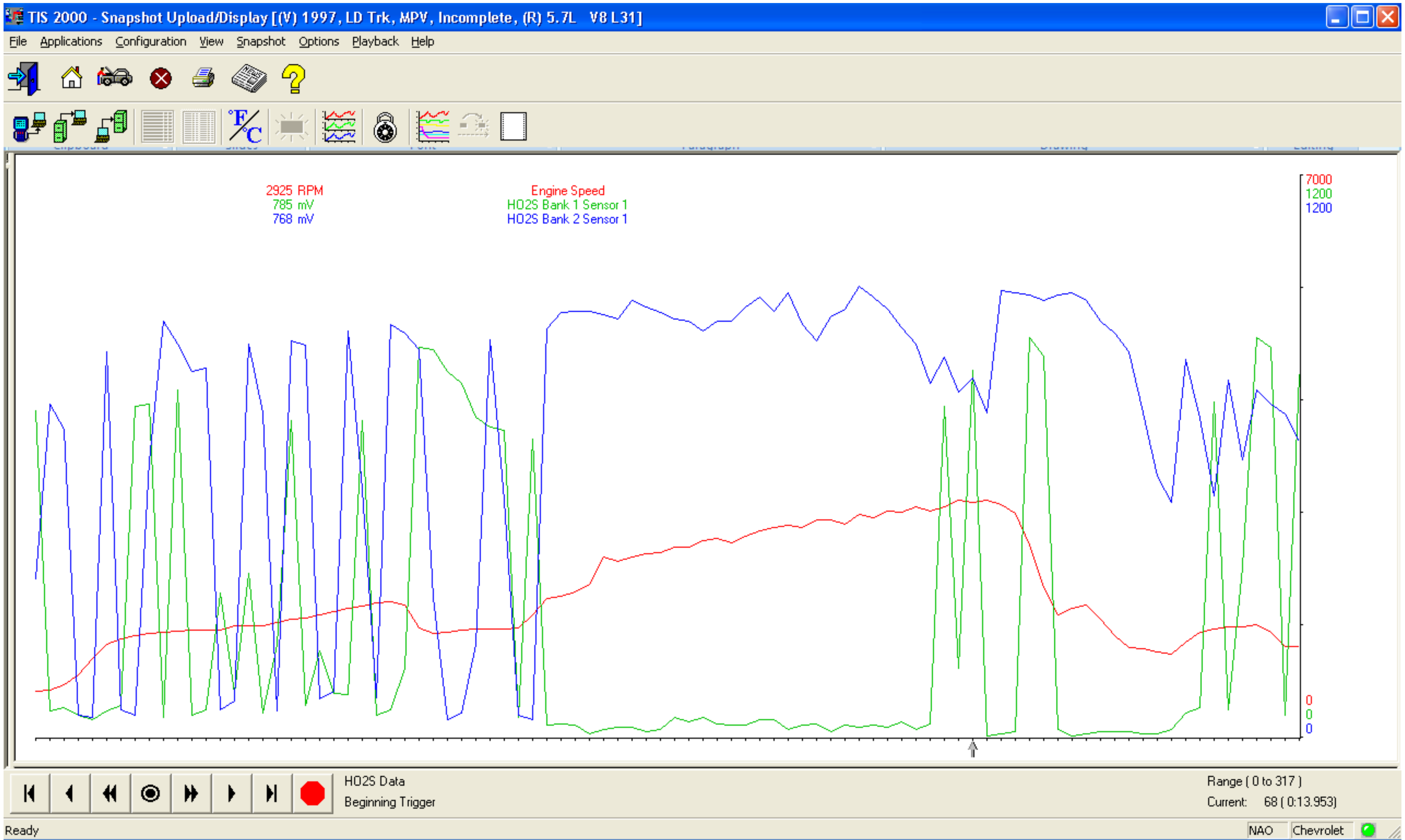
PicoScope 6 Automotive - [1 screen.psdata]
File Edit Views Measurements Tools Automotive Help
x 4
1 of 1
211.5 A
200.0
188.5
177.0
165.5
154.0
142.5
131.0
119.5
108.0
96.5
15.8 V
13.88
11.97
10.05
8.134
6.217
4.3
2.384
0.467
-1.45
-3.366
1.875
2.0
2.125
2.25
2.375
2.5
2.625
2.75
2.875
3.0
3.125
s
x2.0
Zoom Overview
Notes
2002 mustang 3.8 NS barely runs cha RC Ch b sync 1 Ch c FLS vac cranking F0142536
Trigger

1997 Chevy Suburban 5.7 L

Low Power


TIS 2000 - Snapshot Upload/Display [(V) 1997, LD Trk, MPV, Incomplete, (R) 5.7L V8 L31]
File Applications Configuration View Snapshot Options Playback Help
2925 RPM
66.32 g/s
50 %
Engine Speed
MAF
Engine Load
7000
500.00
100
0
0.00
0
HO2S Data
Beginning Trigger
Range (0 to 317)
Current: 68 (0:13.953)
Ready
NAO
Chevrolet


VOLUMETRIC EFFICIENCY / FUEL REQUIREMENT CALCULATION
Displacement 5.7 Liters
RPM 2925
MAF 66.32 GPS
Fuel type Gasoline (14.7 : 1)
Calculate
Volumetric Efficiency 40%
Max. Air Flow 166 GPS 22 Lb/M 287 CFM
Fuel Vol. Req. @ Stoich 0.24 Gal/M 0.92 L/M
Fuel Vol. Req. @ Stoich + 20% 0.29 Gal/M 1.11 L/M
Atmospheric Factors
Temp 70 F
BARO 0 Ft above sea level
BPCC
Humidity 30 %



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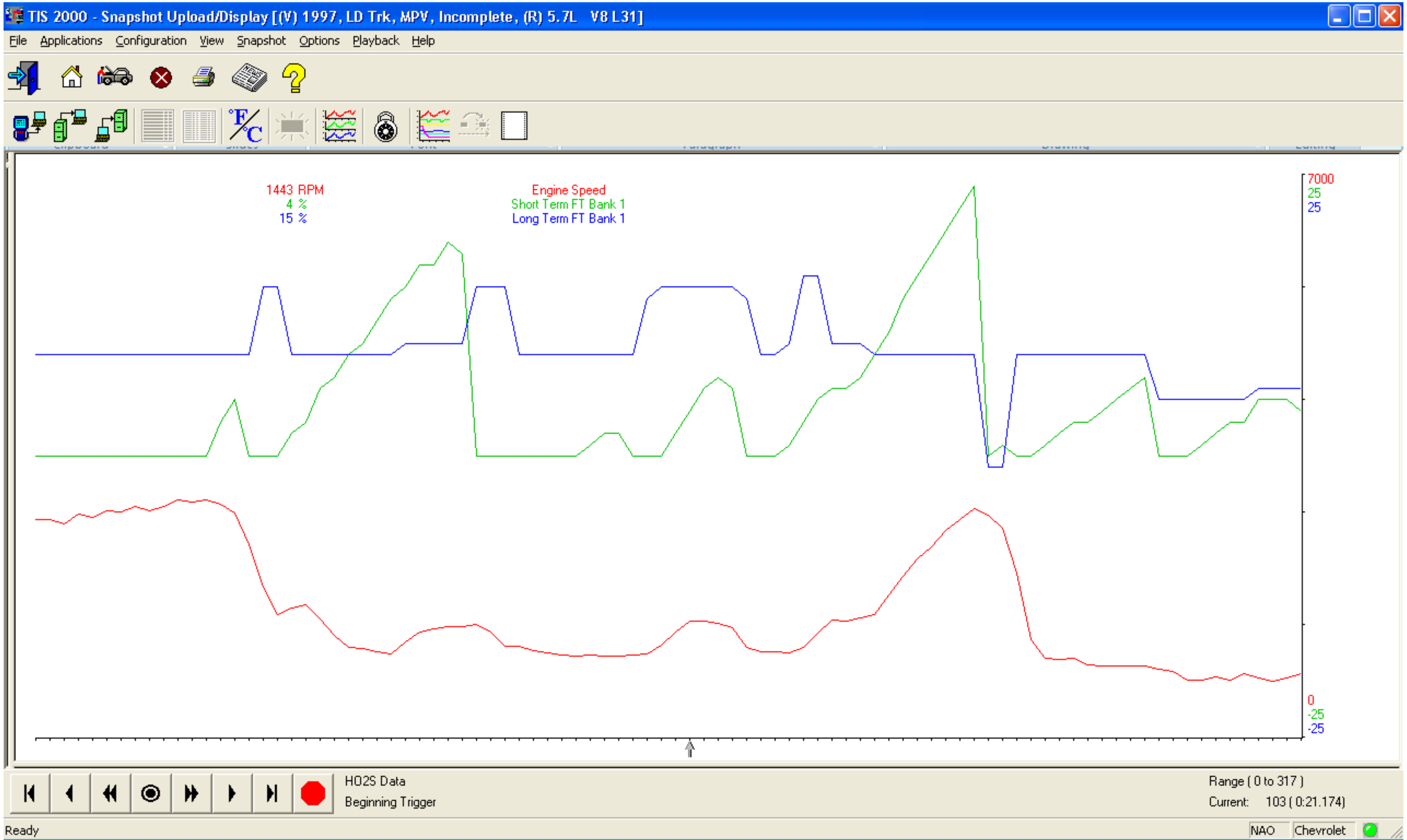
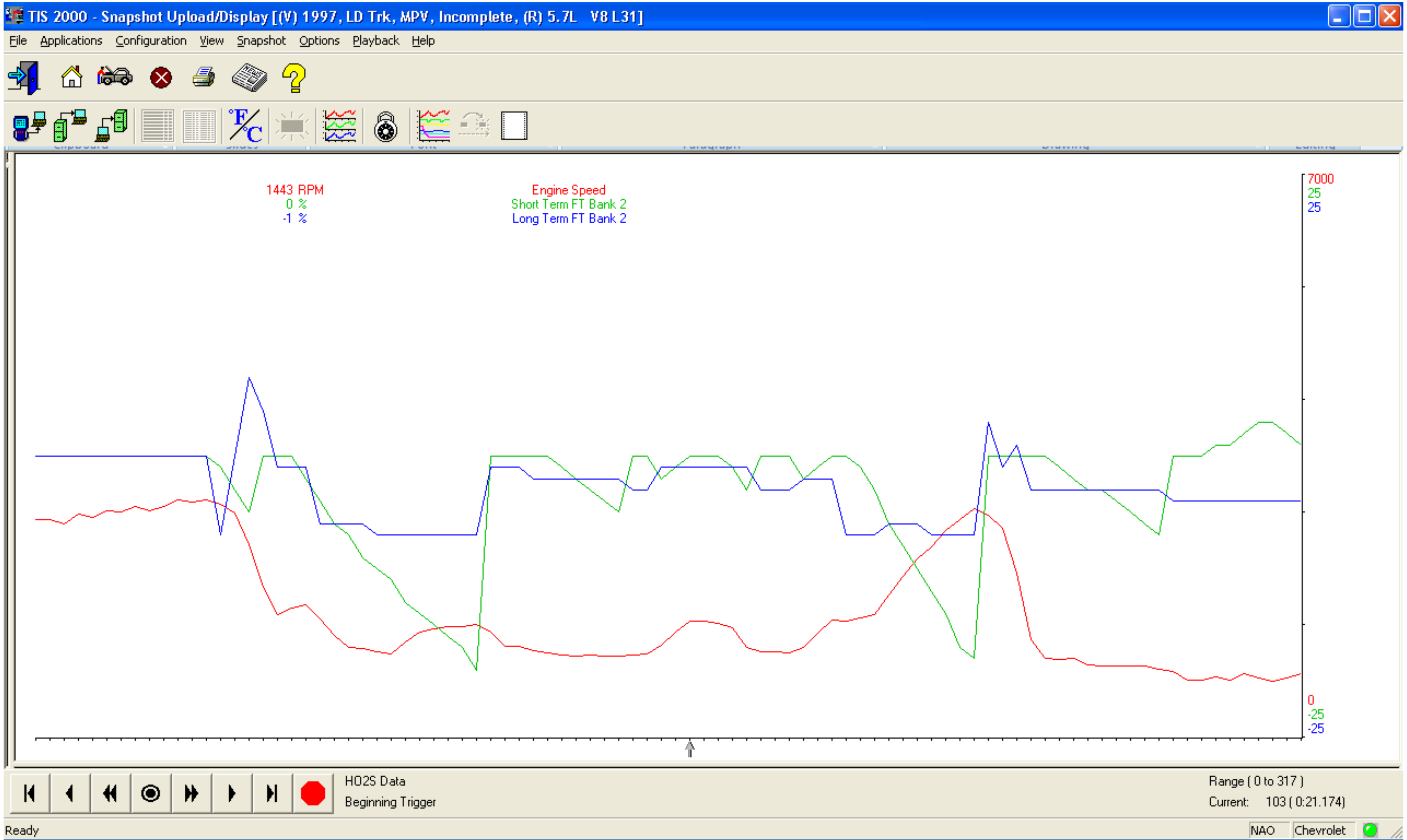


TIS 2000 - Snapshot Upload/Display [(V) 1997, LD Trk, MPV, Incomplete, (R) 5.7L V8 L31]
File Applications Configuration View Snapshot Options Playback Help
1443 RPM
4 %
15 %
Engine Speed
Short Term FT Bank 1
Long Term FT Bank 1
7000
25
25
0
-25
-25
H02S Data
Beginning Trigger
Range (0 to 317)
Current: 103 (0:21.174)
Ready
NAO
Chevrolet



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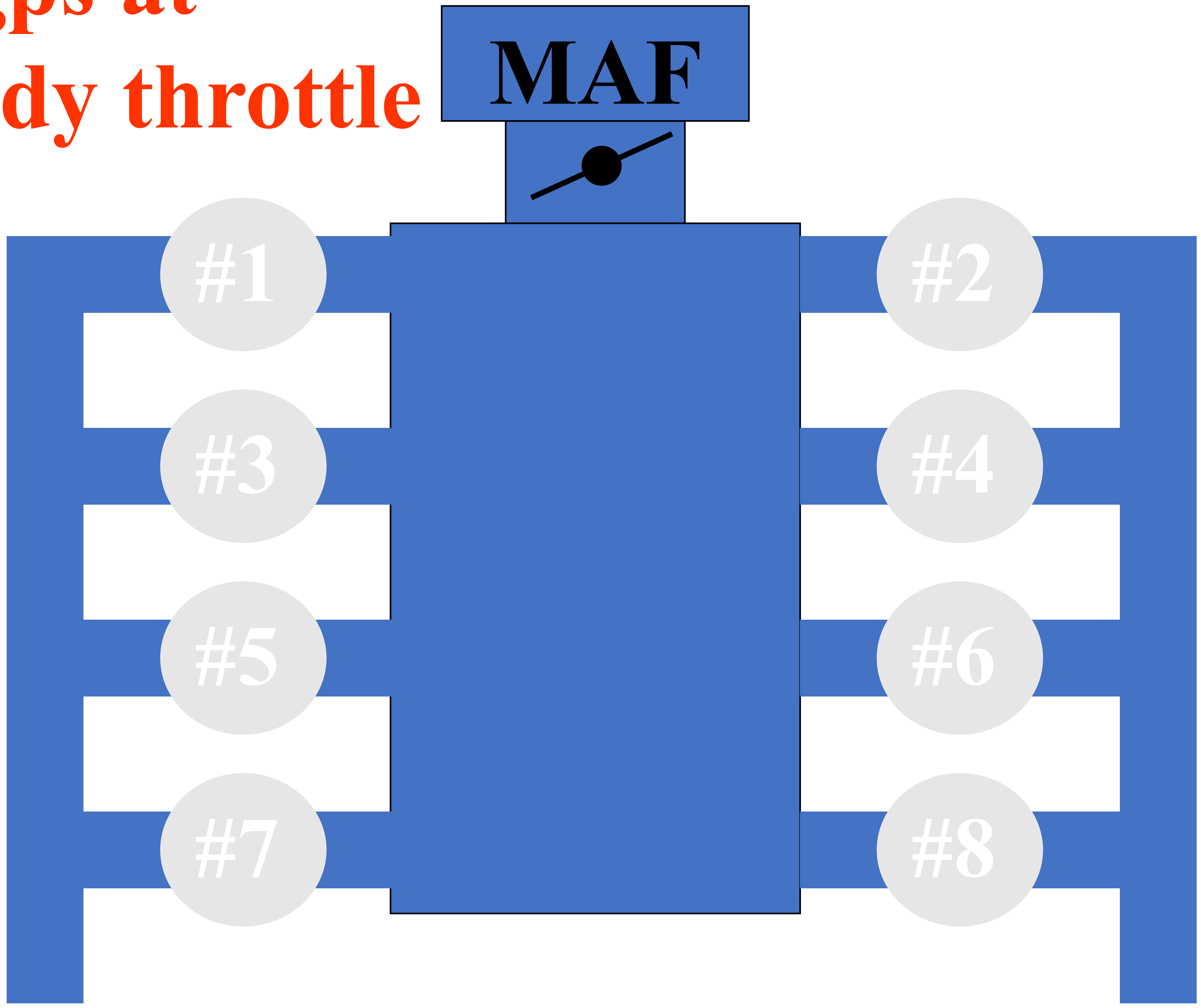
Trim Skew Bank to Bank

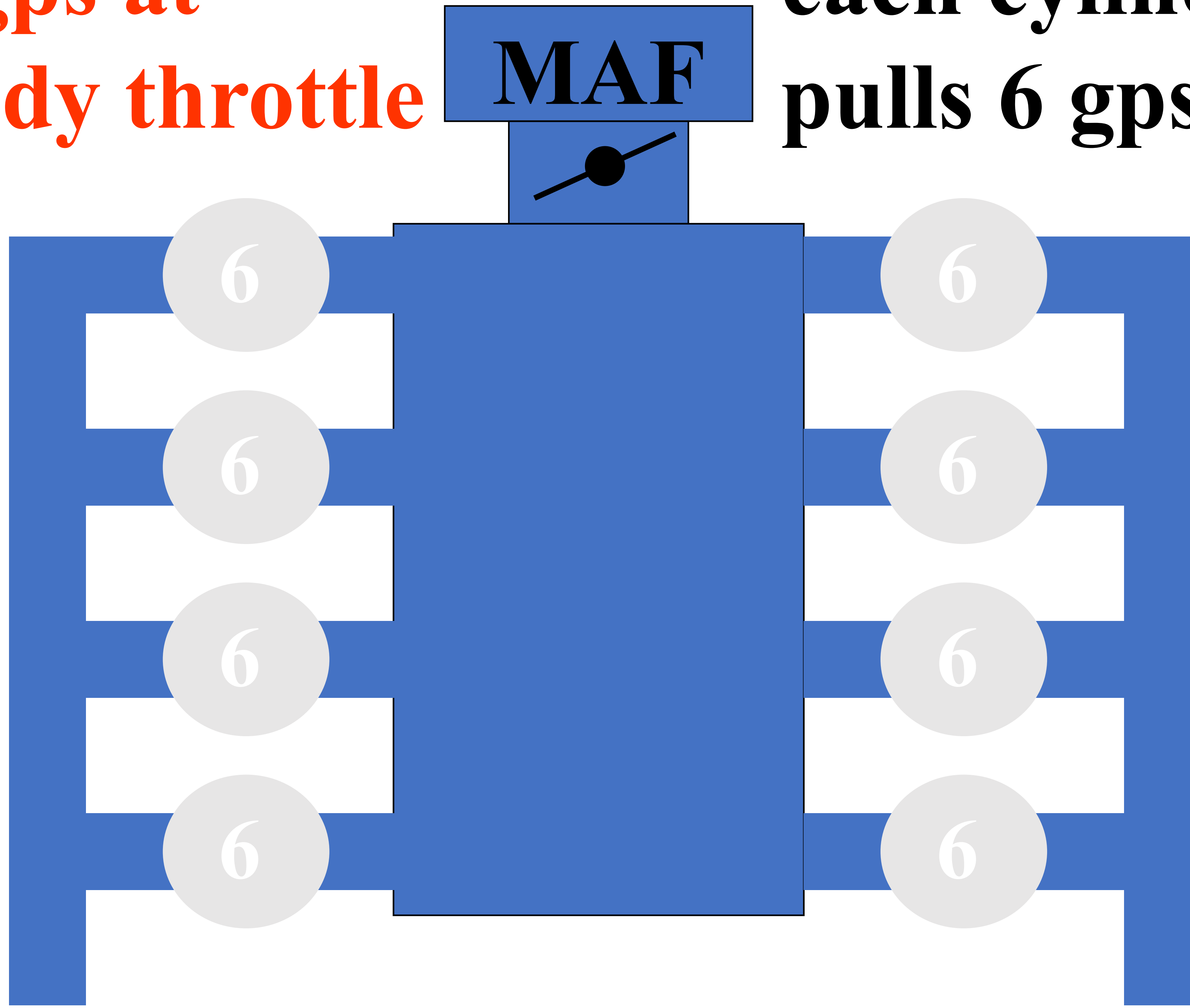
- What could cause this?

48 gps at steady throttle



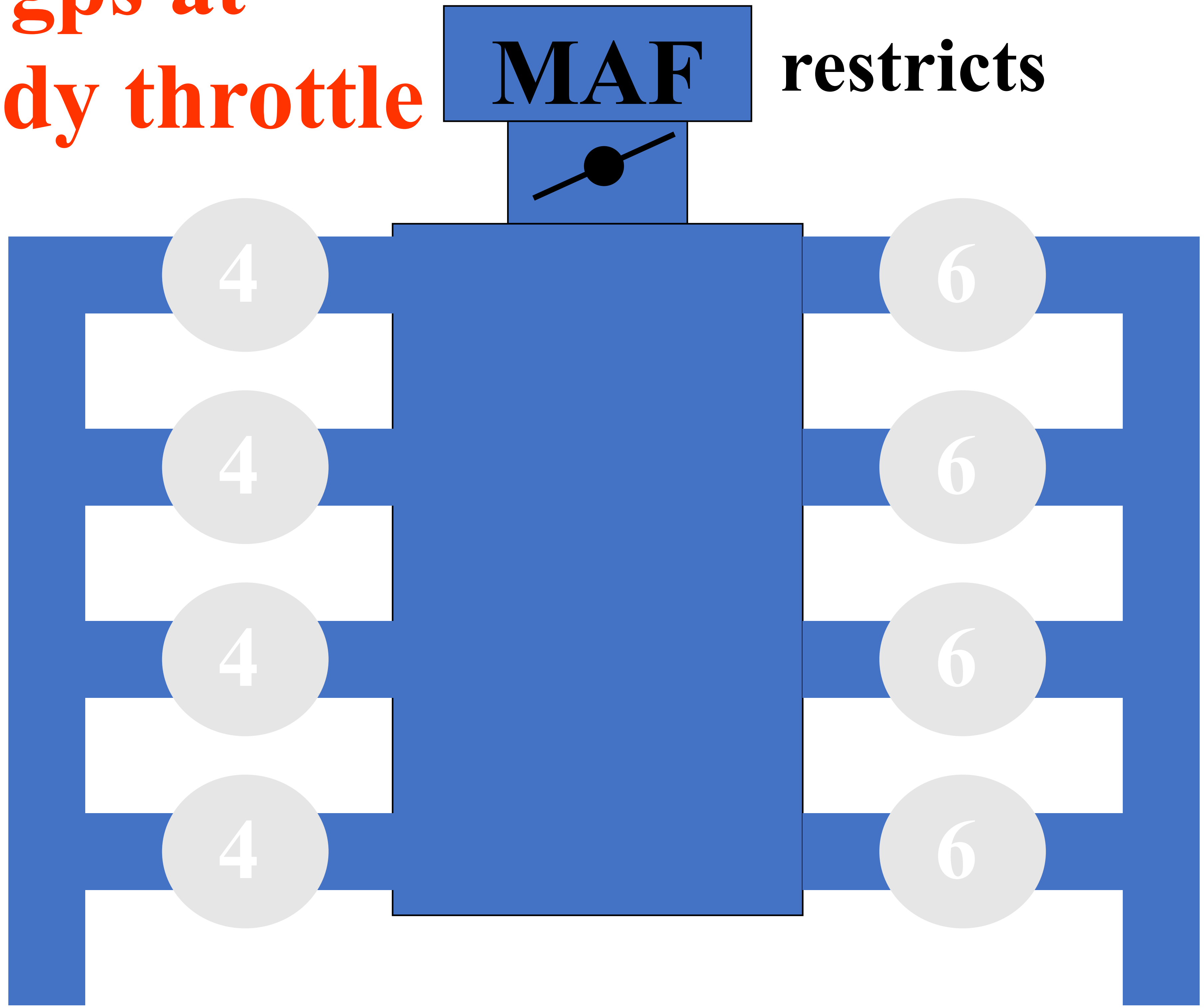
48 gps at steady throttle

each cylinder pulls 6 gps



??? gps at steady throttle

Bank #1 exhaust restricts



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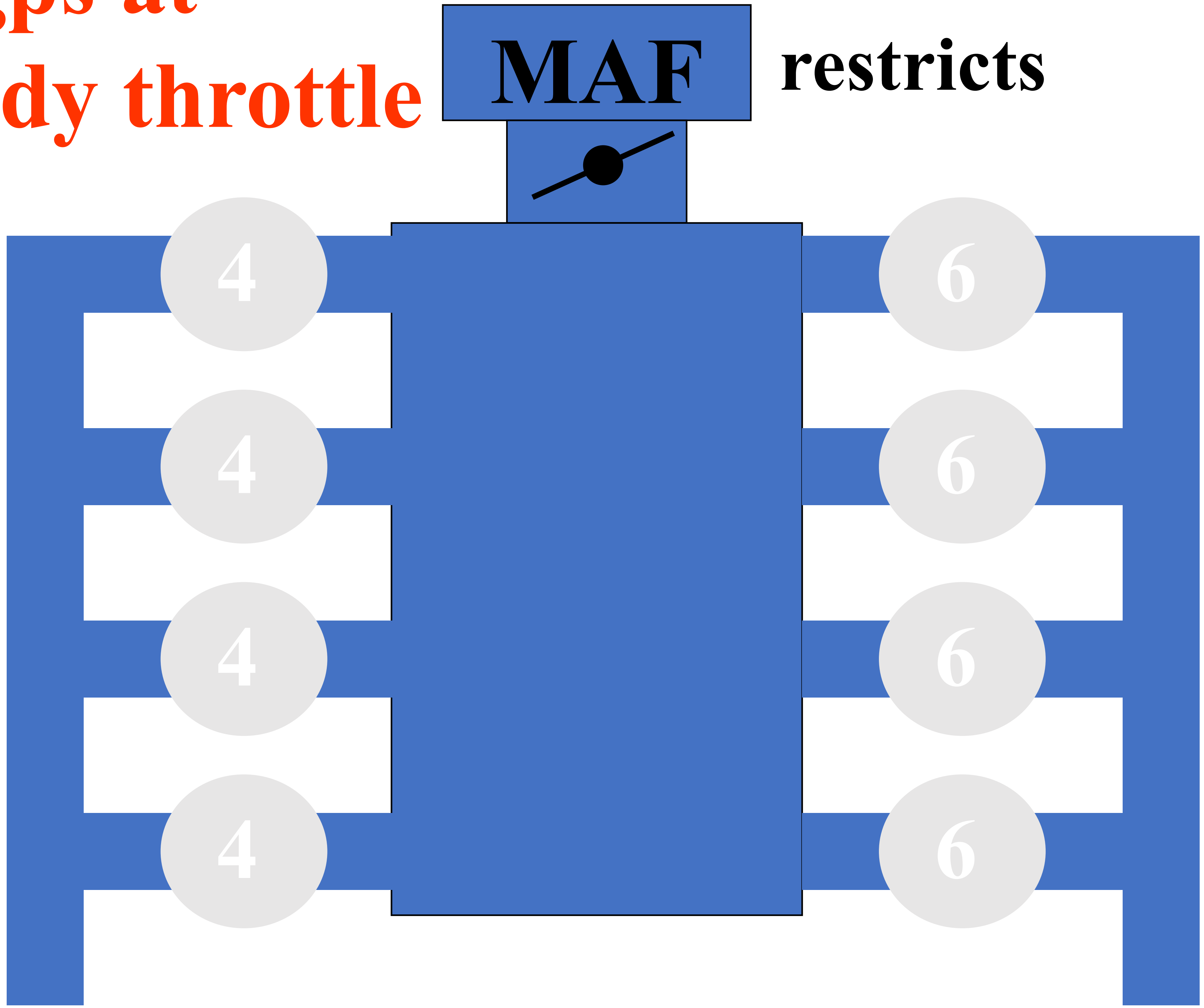
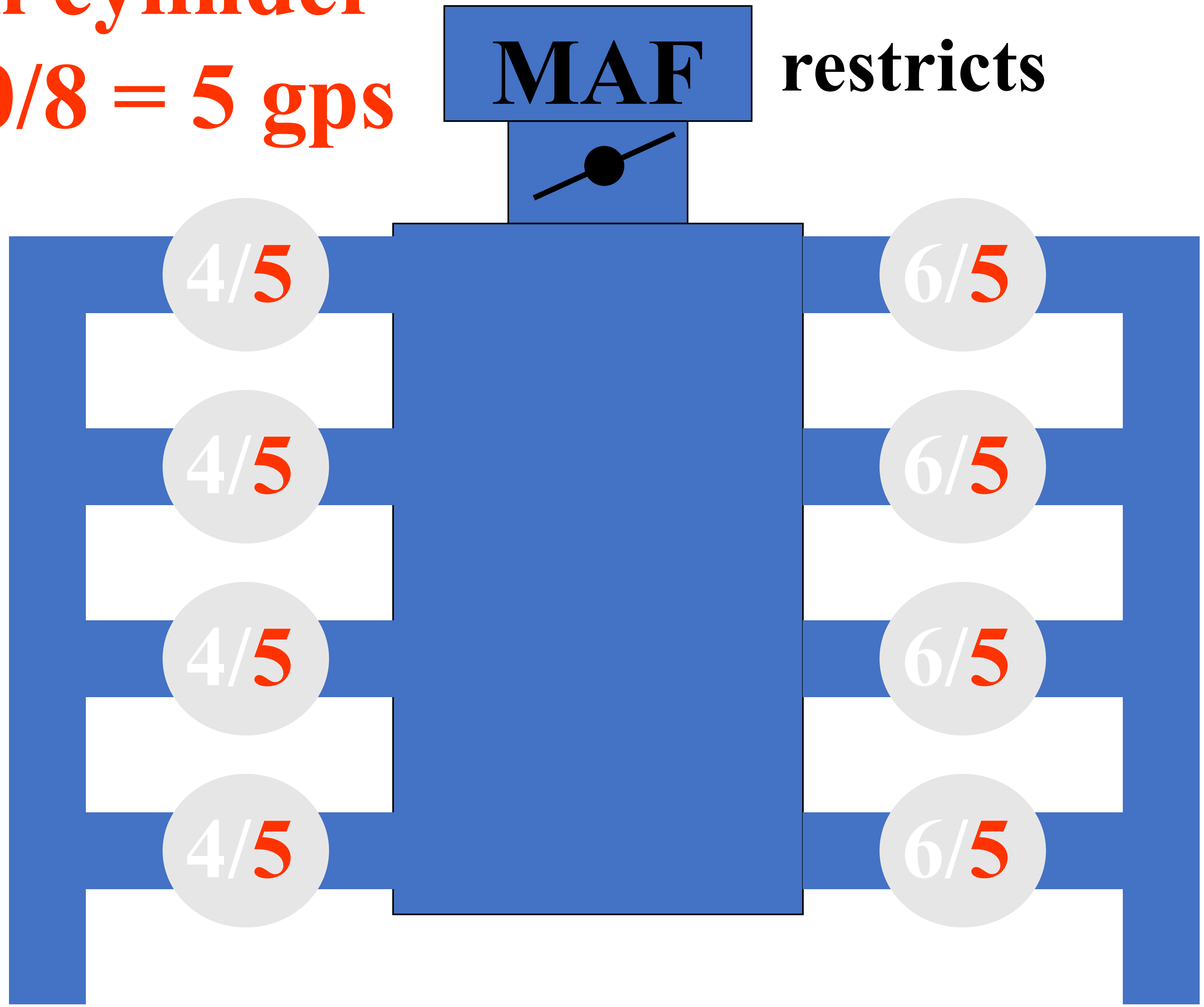
40 gps at steady throttle

Bank #1 exhaust restricts



each cylinder
= 40/8 = 5 gps

Bank #1 exhaust
restricts



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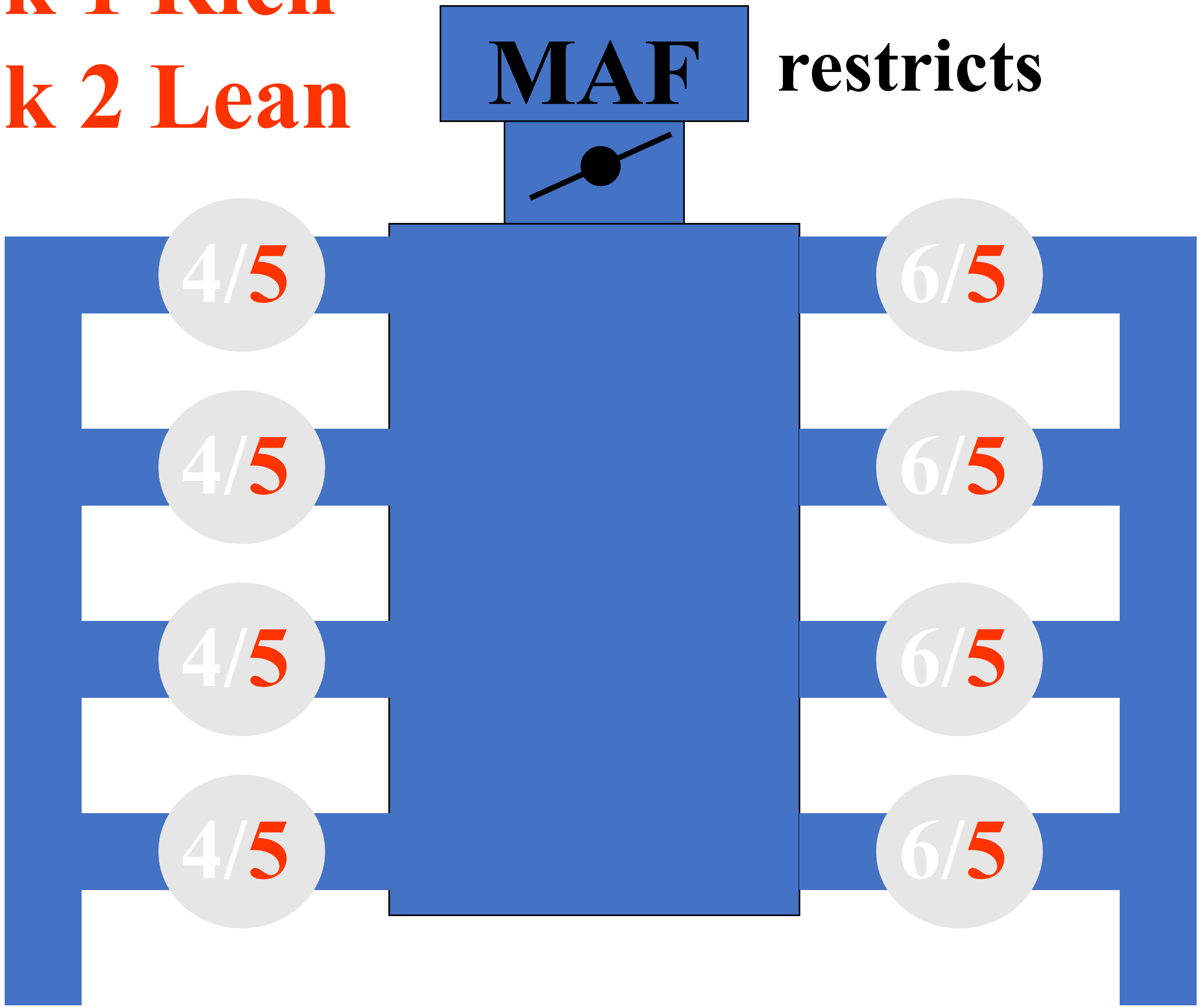
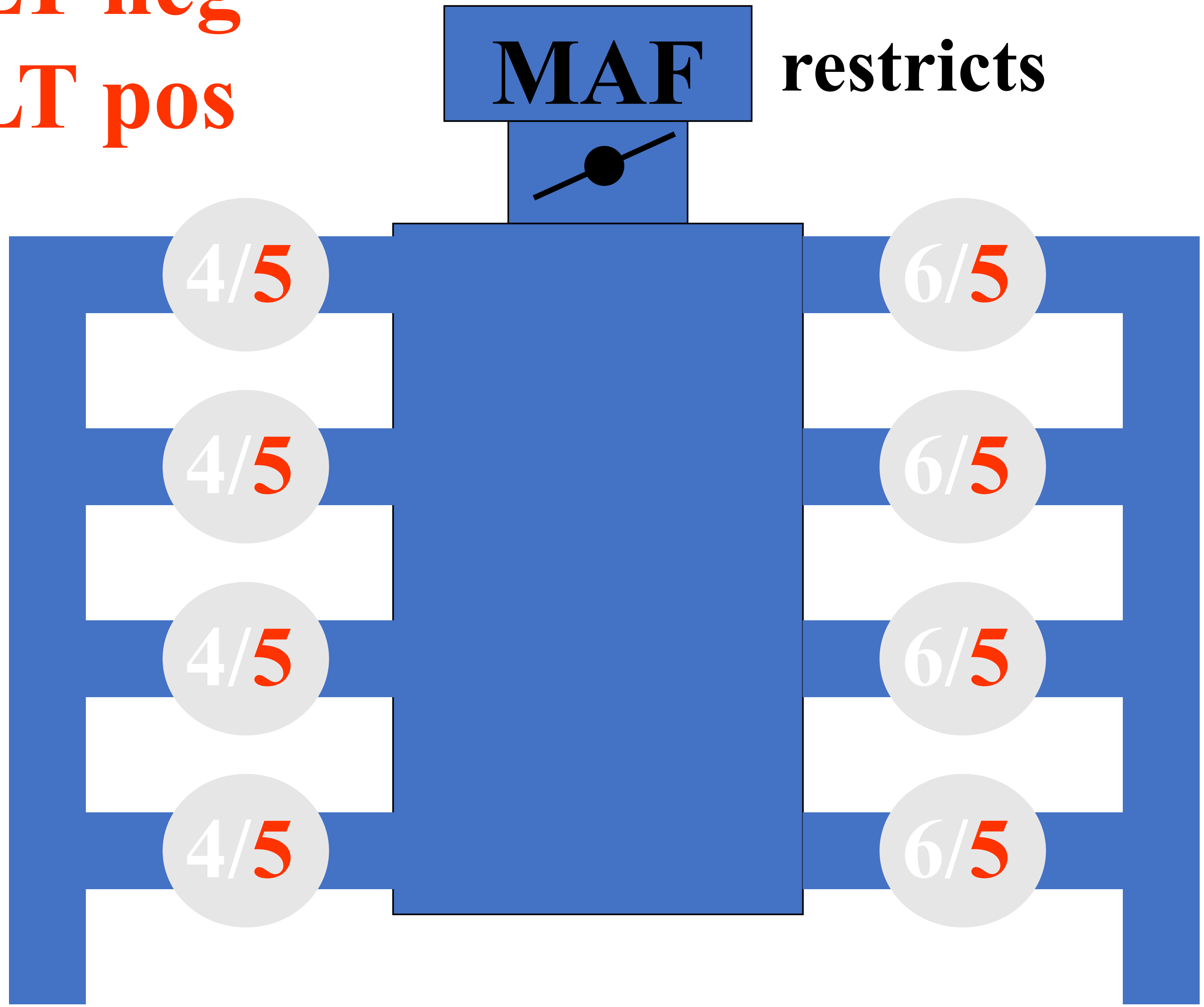
Bank 1 Rich
Bank 2 Lean

Bank #1 exhaust restricts



#1 LT neg
#2 LT pos

Bank #1 exhaust restricts



Opposing Fuel Trims Bank to Bank

Generally caused by bank to bank imbalance in airflow.

Causes:

- Restricted exhaust
- Incorrect cam timing
- One side of the engine wore out

Opposing Fuel Trim Tips

- The side with the most negative fuel trims is the side that has the issue with air flow
- Restricted exhaust FT are usually good @ idle and opposed at higher RPM
- Incorrect cam timing (bank to bank) FT's are usually opposed at idle and better at higher RPM
- Incorrect cam timing (bank to bank) and restricted exhaust are usually opposite

FT Diagnostics Summary

- Using FTs for diagnostics is quick and fairly simple way to get diagnostic direction
- System must be a Closed Loop
- Check FTs @ Idle, 1500 no load and 2500 loaded.
- Use the snapshot function and record a movie with a flatrater test drive
- Calculate VE
- Graphing FTs help to see the bigger “picture”

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Special Thanks

- I would like to thank the following:
- Scott Shotton and John Thornton for their contributions
- WorldPac/WTI and TST for the opportunity to present here at The Big Event!