Ethanol VW Report 11 – Gasoline Mileage Baseline Gary W. Johnson 12-10-06

Objective / Purpose

The overall objective of this experiment is to demonstrate that this type of equipment can successfully be operated on E-85 ethanol blend fuel instead of gasoline. The objective of this report is to document vehicle mechanical condition for the experiment, and its baseline fuel mileage on gasoline. The ultimate technical objective is to compare both power and fuel economy on ethanol with the gasoline baseline.

Equipment

The equipment was a 1973-vintage Volkswagen Type 1 standard "beetle" in more-or-less factory configuration, as described previously elsewhere. The vehicle is fitted with an intake manifold vacuum gage, and the trigger and power wires for a tachometer. The carburetor used for this baseline was a 30 PICT-2 with offset adapter plate. The air cleaner had a stock-type filter element during fall 2006, and no inlet air preheat hose for many years. However, the air cleaner had a home-made filter element during its use as a commuter car during spring 2006, and in many earlier years.

Theory

Overall, this type of conversion need only address three specific issues: (1) metering ratio of the fuel, (2) cold start capability, and (3) materials compatibility concerns.

However, this particular experiment was aimed at obtaining quantitative data for power and economy. Economy is determined from a straightforward fuel mileage log kept over a long period of time on a specific and repeatable driving cycle. Power performance can be obtained from carefully calibrated drag and intake vacuum measurements.

Procedure

Fuel mileage and mechanical condition data are collected simply by keeping a meticulous logbook record.

Data collected

This vehicle has a high-time engine and transmission, as indicated by the logbook records. In particular, the rings have well over 110,000 miles, and over 25 years, in-situ. This does include the elapsed time of over 8 years in deep mothball storage, accumulated in two storage episodes. The full set of data collected from the logbook is:

Vehicle condition
data -- from logbook 12/10/2006
current odometer 232135

item	date	odometer	years since	miles since
engine rebuild	Mar-81	118040	25.7	114095
cylinder head work *	Jan-86	166143	20.9	65992
30/31 PICT carburetor	Dec-84	154000	22	78135
30 PICT-2 carburetor	Sep-06	230535	0.3	1600

clutch work	Feb-88	189145	18.8	42990
brake rebuild	Feb-00	223905	6.8	8230
tie rod ends	Oct-99	220494	7.2	11641
ball joints	Jul-88	194514	18.4	37621
older tires	Dec-91	203066	15	29069
newer tires	Feb-94	210915	12.8	21220
wheel bearings	Mar-91	200097	9.7	32038
gear lube replacement	Feb-92	203337	14.8	28798
shocks	May-01	227989	5.6	4146
brake shoes	Nov-95	215119	11.1	17016
deep mothball	Dec-95	215660		
return to service	Apr-99	215660		
deep mothball	Apr-01	227990		
return to service	Mar-06	227990		

*** cyl hd work did not include pistons, cyls, or rings!!!!!**

first mothball interval	3 years	4 months
second mothball	4 years	11 months
total time mothballed	8 years	3 months

Rough-running and missing behaviors at idling conditions during these experiments prompted a compression check and an evaluation of the ignition high-voltage system. Those data showed an acceptable ignition, but significant wear damage to at least 3 of the 4 ring sets. Data were obtained with dry and oil-wet compression tests, with repeats as shown. This condition was determined about the time of the ethanol conversion, as indicated by dates and odometer readings.

compression test 11-06 231784

cyl no	dry	rep dry	wet
1	135	140	
2	87	85	135
3	68		100
4	79		105

spark plug wire/connector check 11-06 231784
spark gap ign test 9-06 230681

cyl no	KV OK	conn K
1	11	1.1
2	11	1.2
3	11	1.1
4	11	1.1

new plugs Bosch W8A's 9-06 230681
last valve adjust 8-06 231783 (nominal 232 K)

last oil (w/ screen) 11-06 231783 (nominal 232 K)

first underway on ethanol 10-29-06 231630

Calculations

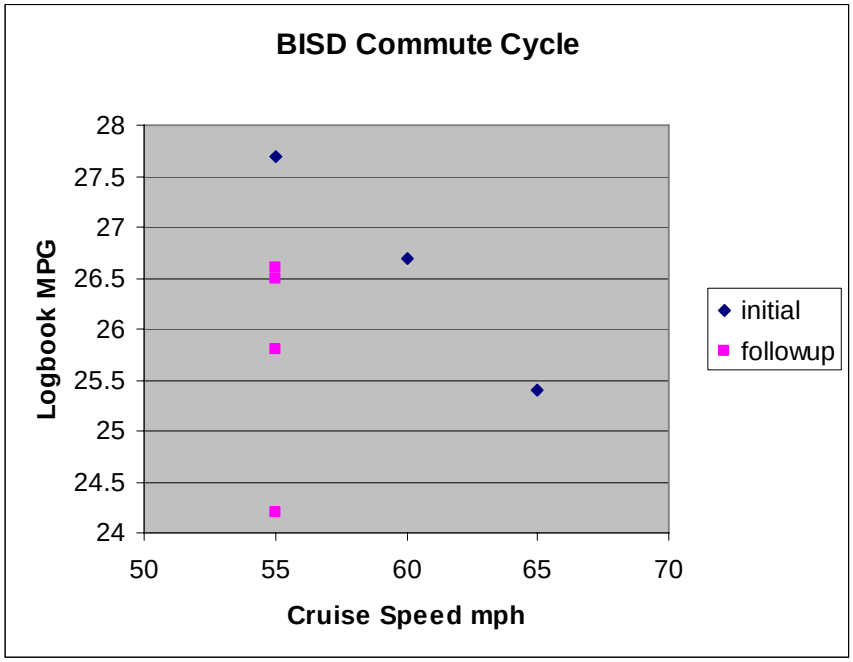
Data were keyed into an "Excel" spreadsheet, and processed for plotting in that software. There were no real calculations other than computations of elapsed time and miles. The elapsed times were for time-series plots to determine when mechanical condition changes actually occurred. Besides time, cruising speed was a variable of interest for plotting economy data.

Presentation of Results

During the spring of 2006, this car was used on a commuter driving cycle that included a 19-mile one-way trip to BISD 5 days per week, and a 27-mile one-way return trip from MCC twice a week. The initial three tankfuls of gasoline comprise a cruise speed effects study, and the following four tankfuls of gasoline comprise a time series study useful for detection of wear and random scatter effects.

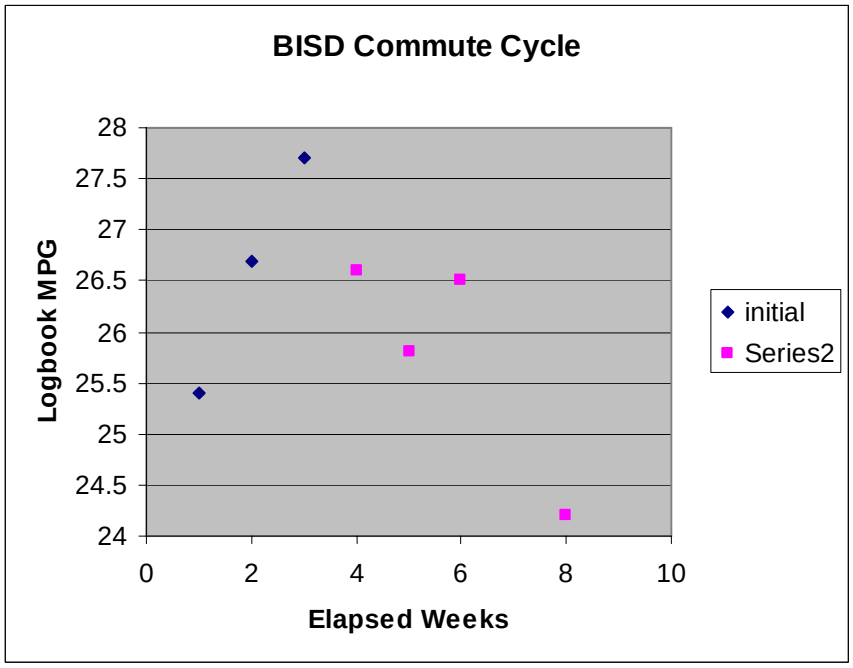
This driving cycle is not comparable to the actual gasoline baseline for this experiment because commute distances are long compared to the 10 miles required for full warmup of engine and tires, and because there are more highway cruise miles and fewer city stop-and-go miles.

Plotting miles/gallon vs cruise speed shows an initial trend with speed (blue data points) as expected, followed by a puzzlingly-large apparent scatter (purple data points) in the followup data accumulated at the selected 55 mph cruising speed.

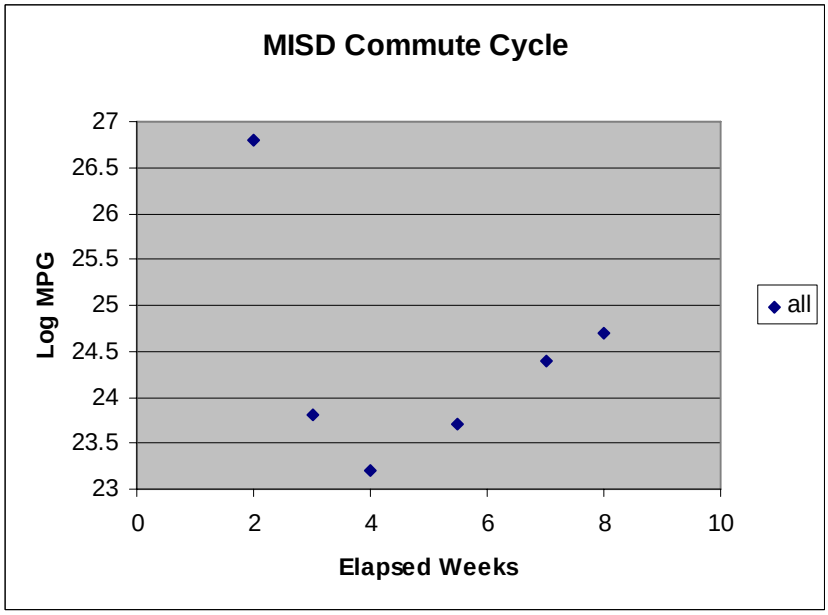


In time-series format, the nature of the 55 mph data becomes clear: a steady decline in performance over time, even with ongoing routine maintenance. Presumably, this is when the

rings wore to their current condition. These 55 mph data are the purple data points, plus the highest blue data point, in the following plot.



The driving cycle of the actual experimental gasoline baseline is the short-range (6 miles one-way) commute to MISD 5 days per week, with two complete round trips to MCC per week at 27 miles one-way. This 6 mile commute is shorter than the 10 mile warmup time, which tends to reduce fuel mileage further. The MCC trip is on a fully warmed car one way, but not the other. Ethanol performance is to be compared on this particular cycle. Data for the actual experimental gasoline baseline follow:



These data were collected during fall 2006, and show little trend with time, excepting one anomalously-high reading early in the time series. That point may contain extra highway trips to Waco, and is thus truly an outlier. The remaining data cluster tightly about 24.0 mpg average, within a scatter band of about +/- 0.8 mpg. The lack of a decreasing performance trend over time indicates a stable wear situation on the rings during fall 2006.

Conclusions / Recommendations

The MISD commute data set is usable for the gasoline fuel mileage, excepting the one outlier. Therefore, for the vehicle in its currently-indicated poor mechanical condition, a gasoline fuel economy on this cycle of 24.0 mpg at 55 mph cruise is representative.

The gasoline power performance baseline obtained recently and documented elsewhere also corresponds to this mechanical wear state.

Time-series data should be analyzed during the ethanol performance documentation, and allowances made accordingly, when analyzing the fuel mileage and power performance data.