



Performance Evaluation  
of a 2013 Chevrolet  
Malibu 2.5L GDI Ecotec  
Engine on Regular E10  
Fuel

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**NCAT – National Center for Advanced Technology**

*National Vehicle and Fuel Emissions Laboratory – Office of Transportation and Air Quality  
U.S. Environmental Protection Agency*

**TEST:** Performance Evaluation of a 2013 Chevrolet Malibu 2.5L GDI Ecotec Engine on Regular E10 Fuel  
**PROGRAM:** NCAT/ASD Light-Duty Greenhouse Gas Test Program  
**PROJECT:** MTE Engine Benchmarking  
**PROJECT ENGINEERS:** Mark Doorlag, Andrew Moskalik

## Table of Contents

PURPOSE OF TEST .....	3
SUPPORTING DOCUMENTATION .....	3
DEFINITIONS .....	3
TEST ARTICLE.....	4
TEST FUEL .....	4
TEST METHODOLOGY .....	4
DATA SET .....	5
RESULTS .....	6
DISCUSSION AND DATA USAGE .....	8

**PURPOSE OF TEST**

The purpose of this testing is to characterize the performance of a 2013 Chevrolet Malibu 2.5L GDI Ecotec engine, in particular to generate fuel map and peak torque data that may be used in the ALPHA (Advanced Light-Duty Powertrain & Hybrid Analysis) model.

**SUPPORTING DOCUMENTATION**

This data packet contains the following files:

<i>2013 Chevrolet Malibu 2.5L Engine Dynamometer Testing Final Presentation by FEV.pdf</i>	Final presentation prepared by FEV Engine Technology under EPA Contract EP-C-12-014, describing test procedures performed by FEV on the 2.5L engine.
<i>2013 Chevrolet Malibu 2.5L Engine Setup by FEV.pdf</i>	Photographs of the engine installation in the test cell.
<i>2013 Chevrolet Malibu 2.5L Engine Test Data.xlsx</i>	Data collected during engine testing for the points tested; including speed, load, fuel flow and calculated BMEP & BSFC & BTE values; additional temperature and pressure parameters are also included for reference
<i>SAE 2015-01-1140 Benchmarking and Modeling of a Conventional Mid-Size Car.pdf</i>	An SAE paper which describes the utilization of the Chevrolet Malibu engine data for modeling a conventional mid-size car using ALPHA

**DEFINITIONS**

Fuel map	Engine operating map that displays contours of brake specific fuel consumption (in g/kWh) on a grid of engine speeds (in RPM) and engine torques (in Nm)
WOT	Wide Open Throttle
LHV	Lower Heating Value

### **TEST ARTICLE**

The engine used in this project was a 2.5L Ecotec GDI engine from a 2013 Chevrolet Malibu 2.5L, VIN 1G11B5SA2DF147935. The engine was tethered to a vehicle located outside of the test cell to make use of the stock engine and vehicle controllers. Table 1 summarizes information that identifies the system used in this test program.

**Table 1: Summary of Vehicle and Engine Identification Information**

Vehicle (MY, Make, Model)	2013 Chevrolet Malibu
Vehicle Identification Number	1G11B5SA2DF147935
Engine (displacement, name)	Ecotec 2.5L DOHC I4 VVT DI
Rated Power	197 hp @ 6300 RPM
Rated Torque	191 lb-ft @ 4400 RPM
Recommended Fuel	Regular Unleaded
Engine Features of Interest for MTE	Continuously variable valve timing, high-pressure direct injection, electronic throttle control, coil-on-plug and 11.3:1 compression ratio

### **TEST FUEL**

This test program used regular E10 fuel consistent with the manufacturer's recommended fuel. The properties of the fuel used to test the engine are listed in Table 2.

**Table 2: Engine Test Fuel Properties**

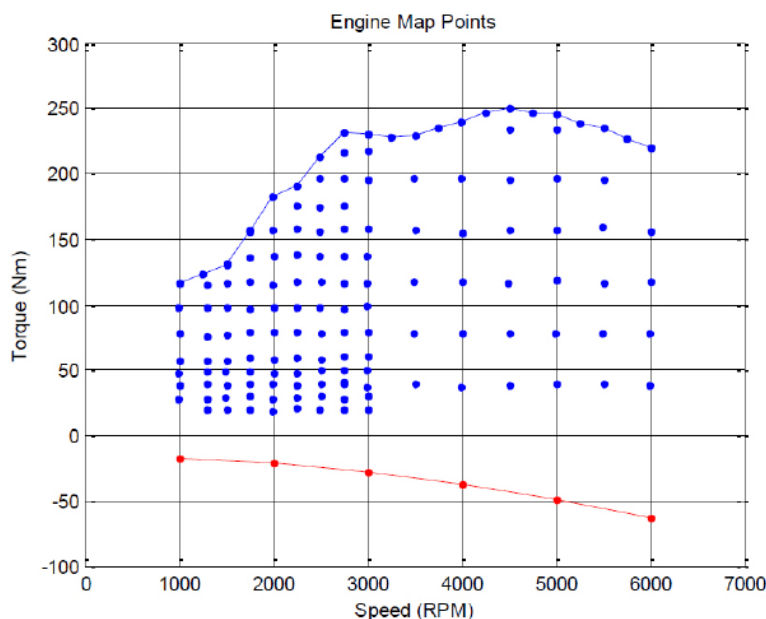
Fuel Type	Regular E10 Gasoline
Fuel Density	0.757 kg/L
Fuel Energy Density	41.047 MJ/kg
Carbon Weight Fraction	0.8272
RON	93.3

### **TEST METHODOLOGY**

The engine was installed in a test cell operated by FEV Engine Technologies. Photographs of the test cell setup including the complete engine installation, the overall test cell configuration, as well as several thermocouple locations, are provided in the attached file *2013 Chevrolet Malibu 2.5L Engine Setup by FEV.pdf*.

## DATA SET

After installation, data were collected at stable engine operation conditions over a range of steady state torque and speed operating points, as shown in Figure 1. These mapping points include a series of regularly spaced points, where the lower speed points (1000 to 3000 rpm) in the typical engine operating range were mapped at a higher density. In addition, points at maximum stable operation torque and motored friction points were included as indicated by the upper blue and lower red lines in Figure 1.



**Figure 1: Engine mapping points.**

The data obtained are given in the accompanying test data file, *2013 Chevrolet Malibu 2.5L Engine Test Data.xlsx*. Descriptions of each data tab in the file are provided below:

- *Variable List*: This sheet provides a description and unit of measure for the various test parameters collected during testing.
- *FEV – Steady State & WOT Data*: This sheet includes time-averaged data points collected at steady state conditions over a range of torques and speeds.
- *FEV – WOT Data*: This sheet contains the set of time-averaged data points representing the maximum steady-state torques achievable over a range of speeds.
- *EPA – WOT Data*: This sheet contains maximum torque points, modified by EPA using vehicle data as described below in the section “WOT Performance.”
- *Motored Friction*: This sheet includes time-averaged torque and speed points taken when the engine was not firing.

## RESULTS

The final results from the steady state testing are in a sheet entitled “FEV - Steady State & WOT Data” in the file: *2013 Chevrolet Malibu 2.5L Engine Test Data.xlsx*. The fuel map presenting these results is shown in Figure 2. Additional contour maps for engine test data measurements are provided in FEV’s final presentation, *2013 Chevrolet Malibu 2.5L Engine Dynamometer Testing Final Presentation by FEV.pdf*.

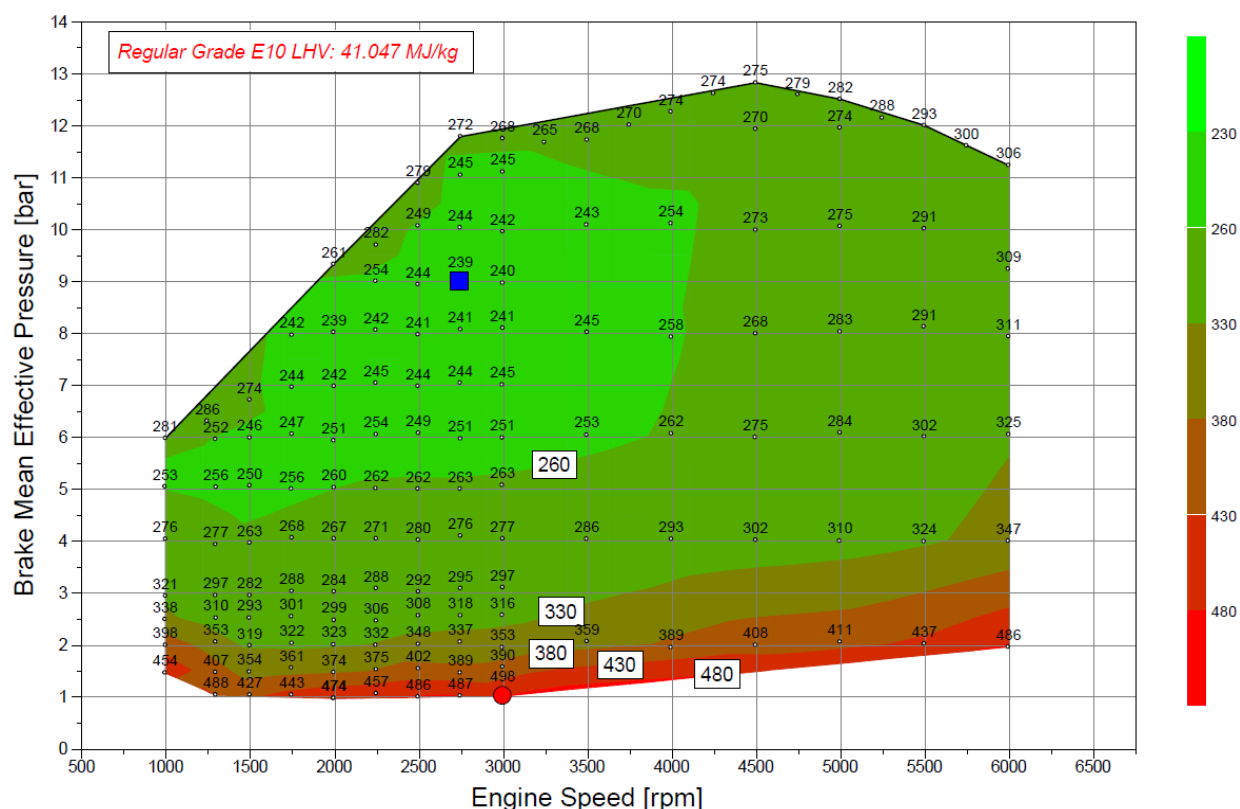
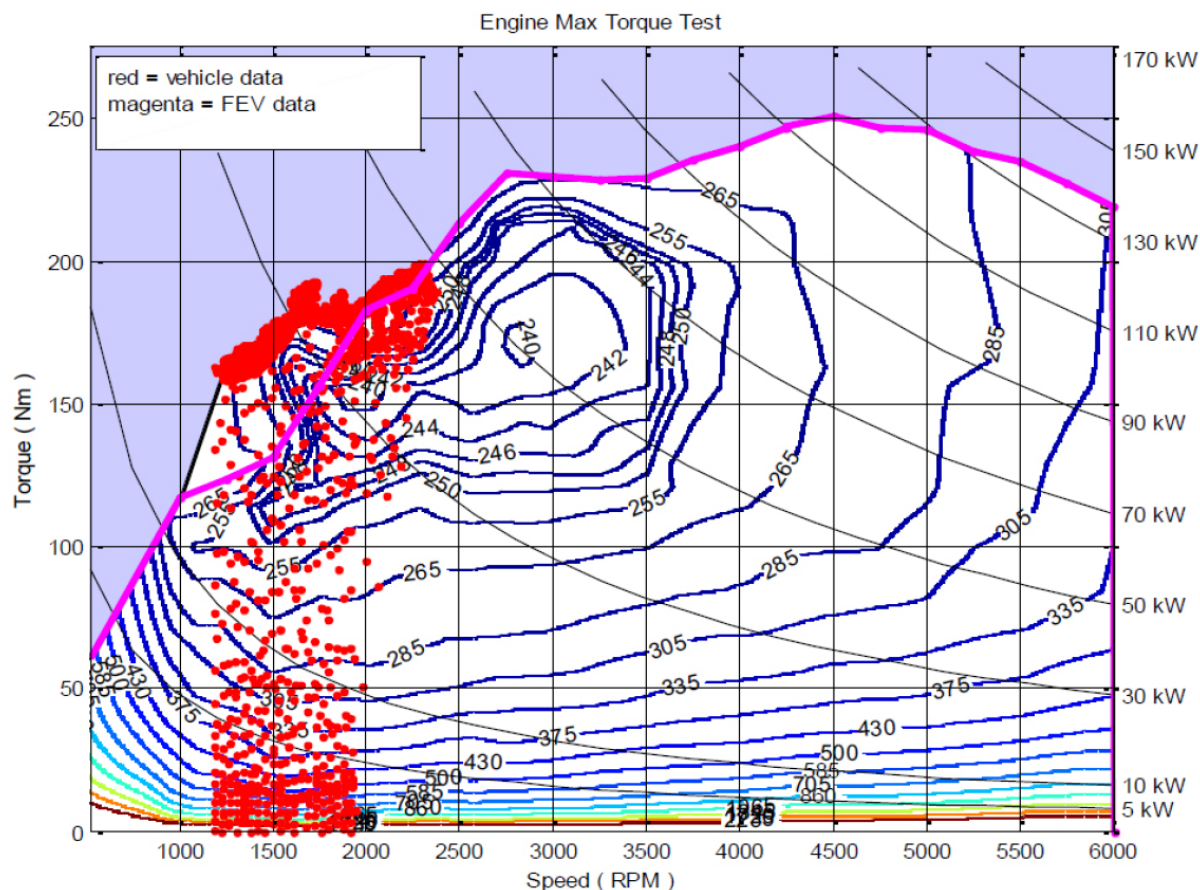


Figure 2: Ecotec BSFC (g/kWh)

## WOT Performance

During the modeling analysis, the acceleration performance of the vehicle appeared to exceed the performance of the simulated vehicle under certain conditions. After investigating the full torque data and performing some confirmation runs in the test vehicle, it was determined the throttle angle at some of the “maximum torque” data points was lower than the throttle angle observed in the vehicle under normal use.

To determine a more accurate max torque curve, a test was conducted with the vehicle on a dynamometer. The results of this additional testing are included in a sheet entitled “EPA - WOT Data” in the file *2013 Chevrolet Malibu 2.5L Engine Test Data.xlsx*. A representation of the re-evaluated WOT curve is presented in Figure 3. More detailed information on the testing conducted and results is given in a section entitled “Engine Max Torque” in the SAE paper *SAE 2015-01-1140 Benchmarking and Modeling a Conventional Mid-Size Car.pdf*.



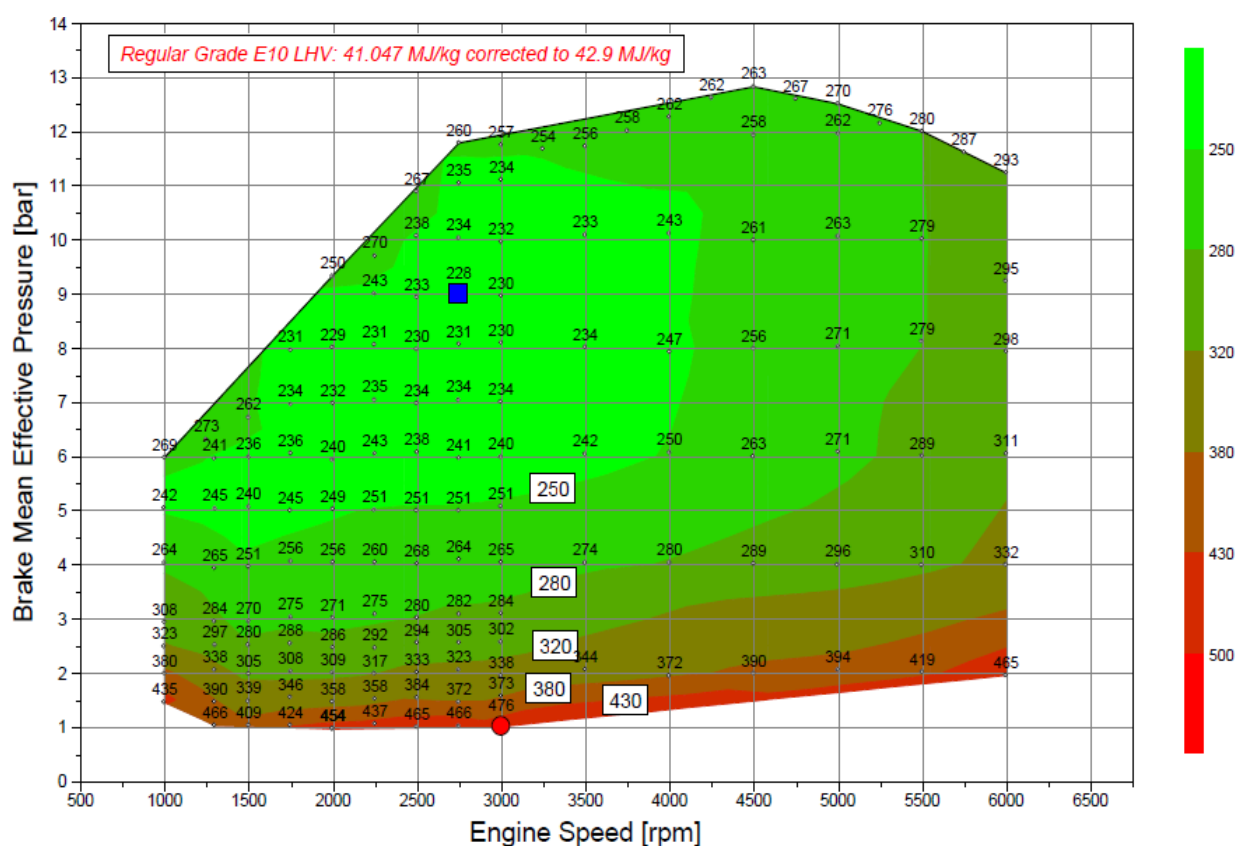
**Figure 3: Ecotec BSFC (g/kWh) and EPA Modified WOT Curve**



### DISCUSSION AND DATA USAGE

In general, the engine operation and fuel consumption data produced in this testing are robust and can be used for any purpose. The benchmarking results from this testing were provided to the ALPHA model to perform full vehicle simulations over several drive cycles and vehicle road loads. Additional details pertaining to this modeling and the results obtained are described in the attached SAE paper *SAE 2015-01-1140 Benchmarking and Modeling a Conventional Mid-Size Car.pdf*.

As an additional consideration, the BFSC map given in Figure 2 reflects the choice of E10 as a test fuel, with an LHV of 41.047 MJ/kg. The data could be corrected to produce a BSFC map for fuels with different LHVs. For example, FEV recalculated BSFC values using an E0 LHV of 42.9 MJ/kg; the results of this correction are shown in Figure 4 below.



**Figure 4: Ecotec BSFC (g/kWh) with 42.9 MJ/kg LHV**