

## Process for Generating Engine Fuel Consumption Map

(Ricardo Baseline Standard Car Engine Tier 2 Fuel)

Version: 06-20-2016

This document summarizes the process followed to utilize the fuel consumption map of a Ricardo modeled engine and vehicle fuel consumption data to generate a full engine fuel consumption map which can be used by EPA's ALPHA vehicle simulations. The original Ricardo engine modeling, based upon a 2007-era Toyota Camry engine, was completed as part of the final rulemaking for MY2017-2025 light duty greenhouse gas standards. The engine fuel consumption map generated defines the complete operating boundaries of the engine needed for ALPHA modeling, including idle, WOT, minimum torque, and maximum speed.

### Gather Engine Physical Characteristics

Source: GD118 simulation matrix V45-03222010.xls

```
engine.name = 'Ricardo Std Car ( 2007 Toyota Camry 2.4L )';  
engine.combustion_type = enum_engine_combustion_type.spark_ignition;  
engine.displacement_L = 2.4;  
engine.num_cylinders = 4;  
engine.inertia_kgm2 = 0.12;
```

### Load Simulation Data

Source: Baseline2007\_standard\_car.FTP.csv

Source: Baseline2007\_standard\_car.HWFET.csv

*Note: Load the output data from Ricardo's EASY5 simulation for FTP and HWFET.*

```
ftp_data = readtable( '..\data\raw\Baseline2007_standard_car.FTP.csv', 'Headerlines', 2 );  
  
hwfet_data = readtable( '..\data\raw\Baseline2007_standard_car.HWFET.csv', 'Headerlines', 2 );  
  
fuel_data.shaft_torque_Nm = [ftp_data.TA_ShaftS2R1_ME; hwfet_data.TA_ShaftS2R1_ME];  
fuel_data.speed_rpm = [ftp_data.OMG_ME; hwfet_data.OMG_ME];  
fuel_data.fuel_gps = [ftp_data.FR_ME; hwfet_data.FR_ME];  
fuel_data.accessory_power_W = [ftp_data.PowerAccessoryLoad_F010;  
hwfet_data.PowerAccessoryLoad_F010];  
  
fuel_data.torque_Nm = fuel_data.shaft_torque_Nm + fuel_data.accessory_power_W ./ (  
fuel_data.speed_rpm * convert.rpm2radps) ;
```

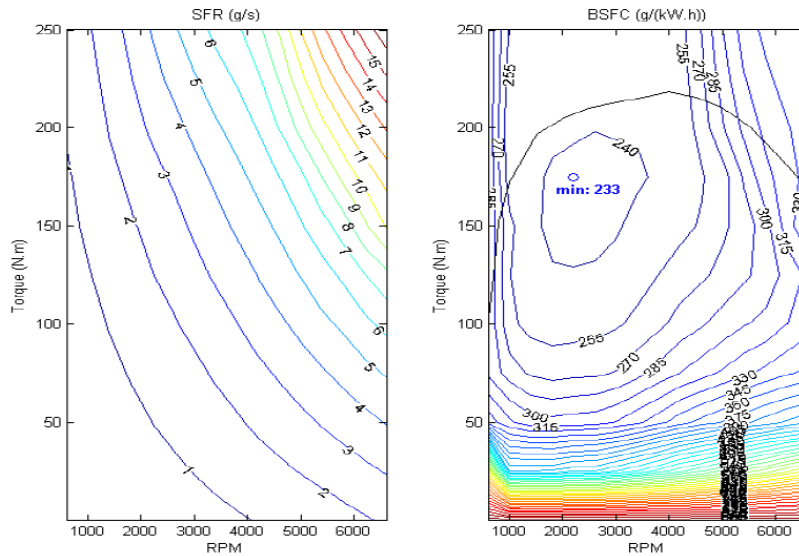
### Load Ricardo Map Images

Source: GE118\_Input\_Data\_Review\_v38\_-\_SI\_for\_EPA.pdf - Slide 8

## Baseline Engine: I-4 for Standard Car



- 2.4-L, 118 kW I-4 used in Standard Car (Toyota Camry) class



## Obtain Maximum Torque (WOT) Curve Data

Source: GE118\_Input\_Data\_Review\_v38\_-\_SI\_for\_EPA.pdf - Slide 8

```
load('..\data\map_image_points\standard_car_tc_pts.mat')
```

```
WOT_data.speed_rpm = tc(:, 1);
```

```
WOT_data.torque_Nm = tc(:, 2);
```

```
disp(struct2table(WOT_data))
```

speed_rpm	torque_Nm
615.38	105.16
942.83	169.05
1530.1	196.83
1868	202.38
2460.5	209.13
3999	218.25
5085.2	207.94
6296.3	178.97
6602.9	169.84

## Obtain Minimum Torque (Motoring) Curve Data

Source: Baseline2007\_standard\_car.FTP.csv

Source: Baseline2007\_standard\_car.HWFET.csv

*Note: These Ricardo simulations were completed as part of the final rulemaking for MY2017-2025 light duty greenhouse gas standards and provide a record of engine characteristics, including the motoring curve. The simulation included operation along the motoring curve that was analyzed to construct minimum torque curve.*

## Obtain Fuel Properties

Source: 2007 Camry baseline data – new TC calcs.xlsx

*Note: Fuel and associated fuel map data are normalized to a standard fuel when conducting technology assessments.*

```
%Load from fuel database
```

```
engine.fuel = class_REVS_fuel('RICARDO_GASOLINE');
```

```
disp(engine.fuel);
```

```
class_REVS_fuel with properties:
```

```
    id: 'RICARDO_GASOLINE'
```

```
  description: 'Estimated Ricardo Gasoline'
```

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```
density_kgpL_15C: 0.73829
energy_density_MJpkg: 44
carbon_weight_fraction: 0.88651
anti_knock_index: []
research_octane_number: []
motor_octane_number: []
cetane_number: []
alcohol_pct_vol: 0
gCO2pgal: 9087
energy_density_BTUplbm: 18917
specific_gravity: 0.739
```

### Calibrate Idle Fuel Consumption and Define Idle Speed

Source: GD118 simulation matrix V45-03222010.xls

*Note: The Ricardo simulation included idle operation that was analyzed to determine idle speed and fuel consumption.*

```
engine.idle_speed_radps = 680 * convert.rpm2radps ;
```

### Build Fuel Consumption Map

*Note: Generate fuel map and WOT curve using REVS\_build\_engine. This map defines the complete operating boundaries of the engine needed for ALPHA vehicle simulations, including idle, WOT, minimum torque, and maximum speed.*

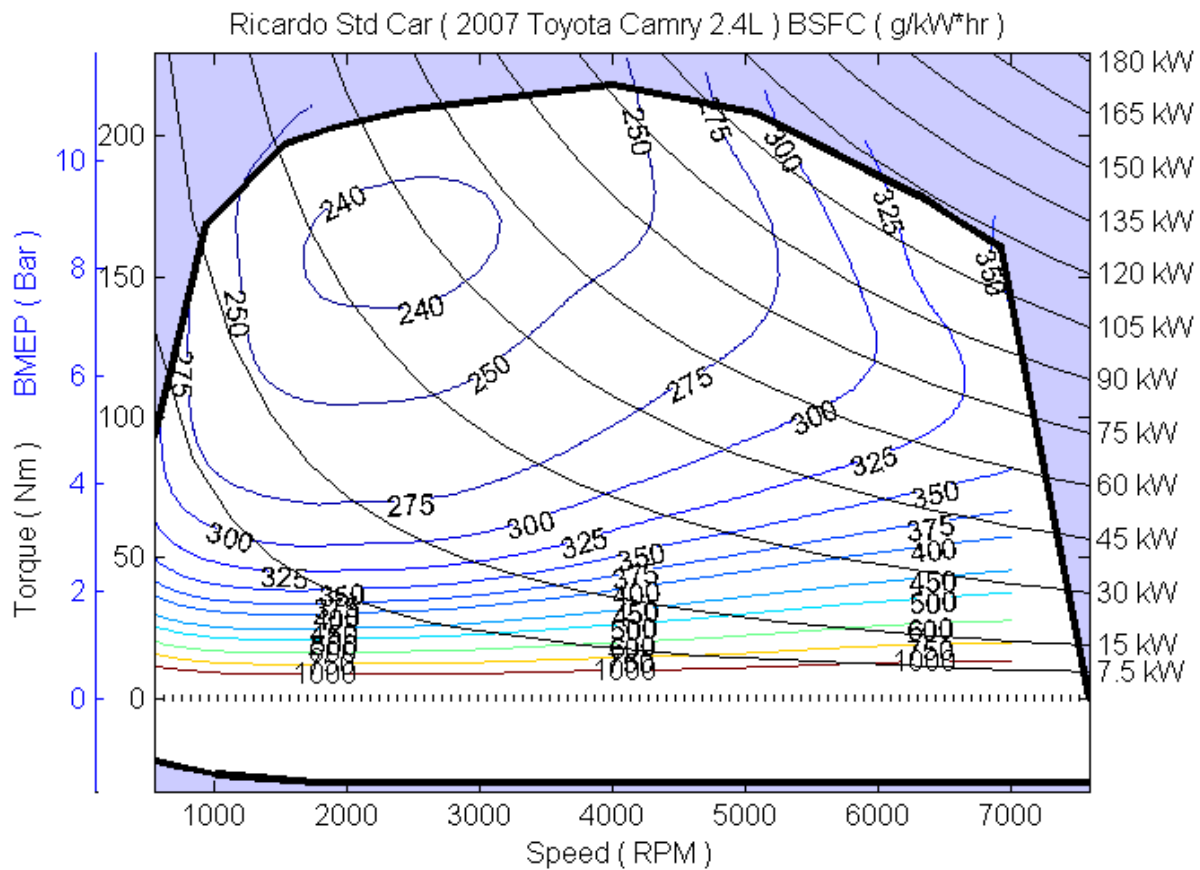
```
out_speed = (0:200:7000) * convert.rpm2radps;
out_torque = -50:10:230;

engine = REVS_build_engine(engine, fuel_data, WOT_data, [],
'out_speed', out_speed, 'out_torque', out_torque, 'no_point_labels');
```

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## Set Model Calibration Options

*Note: These parameters influence particular behaviors within the ALPHA model. They often do not have a corresponding value with test data, but are calibrated to match observed behavior.*

*Note: Accelerator pedal maps to engine power - standard for passenger cars.*

```
engine.pedal_map_type = enum_engine_pedal_map_type.max_engine_power;
```

*Note: Simulation data exhibited substantial reductions in fueling rate during upshifting.*

```
engine.fast_torque_fuel_adjust_norm = 1.0;
```

## Save Engine Fuel Consumption Map

```
write_REVS_engine( 'engine_std_car_camry_2L4.m', engine);
```

## Display Summary of Engine Fuel Consumption Map Information

*Note: The listing below shows only the engine's fuel consumption map related information contained in the ALPHA Engine Definition .m file for this engine. This information is a subset of the full engine definition .m file that adds vehicle level information related to dynamic fuel use, accessories, etc.*

```

% ALPHA ENGINE DEFINITION
% Generated 14-Jun-2016 14:22:43
% Ricardo Std Car ( 2007 Toyota Camry 2.4L )

% Constructor
engine = class_REVS_engine();
engine.name = 'Ricardo Std Car ( 2007 Toyota Camry 2.4L )';

% Physical Description
engine.displacement_L = 2.4000000;
engine.num_cylinders = 4.0000000;
engine.inertia_kgm2 = 0.12000000;

% Maximum Torque Curve
engine.full_throttle_speed_radps = [ 0.0000000, ; 64.442926, ; 98.732659,
; 160.23647, ; 195.61476, ; 257.66285, ; 418.77016,
; 532.52499, ; 659.34257, ; 691.45518, ; 726.02794,
; 795.17346, ];
engine.full_throttle_torque_Nm = [ 0.0000000, ; 105.15873, ; 169.04762,
; 196.82540, ; 202.38095, ; 209.12698, ; 218.25397,
; 207.93651, ; 178.96825, ; 169.84127, ; 160.01507,
; 0.0000000, ];

% Minimum Torque Curve
engine.closed_throttle_speed_radps = [ 0.0000000, ; 68.999951, ;
105.61325, ; 184.81257, ; 692.33815, ; 795.17346, ];
engine.closed_throttle_torque_Nm = [ -16.741051, ; -23.594488, ; -27.231113,
; -30.053430, ; -30.053430, ; -30.053430, ];

% Fuel Map
engine.fuel_map_speed_radps = [ 0.0000000, 20.943951, 41.887902, 62.831853,
83.775804, 104.71976, 125.66371, 146.60766, 167.55161, 188.49556,
209.43951, 230.38346, 251.32741, 272.27136, 293.21531, 314.15927,
335.10322, 356.04717, 376.99112, 397.93507, 418.87902, 439.82297,
460.76692, 481.71087, 502.65482, 523.59878, 544.54273, 565.48668,
586.43063, 607.37458, 628.31853, 649.26248, 670.20643, 691.15038,
712.09433, 733.03829, ];
engine.fuel_map_torque_Nm = [ -50.000000, -40.000000, -30.000000, -20.000000, -
10.000000, 0.0000000, 10.000000, 20.000000, 30.000000, 40.000000,
50.000000, 60.000000, 70.000000, 80.000000, 90.000000, 100.00000,
110.00000, 120.00000, 130.00000, 140.00000, 150.00000, 160.00000,
170.00000, 180.00000, 190.00000, 200.00000, 210.00000, 220.00000,

```

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```
230. 00000,    ];
engine.fuel_map_gps = [
  0. 18585401,  0. 17621594,  0. 16638521,  0. 15580172,  0. 14332324,  0. 12705605,  0. 10492618,
  0. 075681669,  0. 039373222,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,
  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,
  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,
  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,
  0. 00000000, ;
  0. 15969057,  0. 15944450,  0. 15877056,  0. 15706354,  0. 15392526,  0. 14885232,  0. 14069381,
  0. 12718533,  0. 10576341,  0. 076491824,  0. 042503805,  0. 0071131765,  0. 00000000,  0. 00000000,
  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,
  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,
  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,  0. 00000000,
  0. 00000000, ;
  0. 13412798,  0. 14381906,  0. 15297142,  0. 16066908,  0. 16508954,  0. 16808477,  0. 17239881,
  0. 17626601,  0. 17107569,  0. 15458910,  0. 13519353,  0. 11676796,  0. 10060242,  0. 087236712,
  0. 076821596,  0. 069232738,  0. 064145242,  0. 061114732,  0. 059688215,  0. 059529921,  0. 060492049,
  0. 062579430,  0. 065897325,  0. 070709281,  0. 077383269,  0. 086178713,  0. 097019499,  0. 10937859,
  0. 12232816,  0. 13475402,  0. 14566633,  0. 15445764,  0. 16095067,  0. 16528873,  0. 16796915,
  0. 16985421, ;
  0. 11110156,  0. 13103865,  0. 15056441,  0. 16807429,  0. 17918407,  0. 18688836,  0. 19774803,
  0. 21139904,  0. 22332850,  0. 22896060,  0. 23035950,  0. 23110996,  0. 23351852,  0. 23877405,
  0. 24736233,  0. 25932247,  0. 27433852,  0. 29177421,  0. 31076682,  0. 33047058,  0. 35041990,
  0. 37074210,  0. 39208816,  0. 41568190,  0. 44284062,  0. 47443921,  0. 51059697,  0. 55054541,
  0. 59262656,  0. 63447681,  0. 67349317,  0. 70755457,  0. 73570804,  0. 75821696,  0. 77660929,
  0. 79320594, ;
  0. 094858892,  0. 12439476,  0. 15314942,  0. 17874305,  0. 19556744,  0. 20794224,  0. 22674116,
  0. 25165079,  0. 27908162,  0. 30333658,  0. 32475047,  0. 34503595,  0. 36593837,  0. 38904044,
  0. 41545641,  0. 44577700,  0. 48002465,  0. 51761882,  0. 55734736,  0. 59746096,  0. 63627074,
  0. 67339447,  0. 71095555,  0. 75189584,  0. 79842494,  0. 85172735,  0. 91201411,  0. 97850832,
  1. 0493026,  1. 1211816,  1. 1897076,  1. 2498999,  1. 2983263,  1. 3359530,  1. 3675031,
  1. 3970874, ;
  0. 083214950,  0. 11906792,  0. 15415906,  0. 18657518,  0. 21185788,  0. 23389455,  0. 26204759,
  0. 29838258,  0. 33957419,  0. 37940240,  0. 41872575,  0. 45689004,  0. 49482568,  0. 53429859,
  0. 57706640,  0. 62428630,  0. 67634539,  0. 73283949,  0. 79256602,  0. 85328811,  0. 91106335,
  0. 96262685,  1. 0153219,  1. 0734874,  1. 1389483,  1. 2125916,  1. 2945975,  1. 3843717,
  1. 4803547,  1. 5795321,  1. 6766184,  1. 7636872,  1. 8298786,  1. 8796309,  1. 9257286,
  1. 9713988, ;
  0. 072691107,  0. 11364341,  0. 15398340,  0. 19297540,  0. 22976711,  0. 26729355,  0. 30996501,
  0. 35752909,  0. 40839411,  0. 45898097,  0. 51254947,  0. 56570764,  0. 61839219,  0. 67241069,
  0. 72993227,  0. 79242093,  0. 86041346,  0. 93332854,  1. 0091238,  1. 0846456,  1. 1573813,
  1. 2279166,  1. 3003197,  1. 3777900,  1. 4622587,  1. 5546616,  1. 6551995,  1. 7633188,
  1. 8776623,  1. 9953883,  2. 1090035,  2. 2108462,  2. 2972333,  2. 3725638,  2. 4430524,
  2. 5121717, ;
  0. 062685386,  0. 11054431,  0. 15798800,  0. 20512942,  0. 25441615,  0. 30666715,  0. 36202633,
  0. 41927084,  0. 47921837,  0. 54071306,  0. 60647632,  0. 67164306,  0. 73641225,  0. 80329848,
  0. 87416048,  0. 95022270,  1. 0317664,  1. 1177882,  1. 2061666,  1. 2953111,  1. 3846556,
  1. 4749275,  1. 5677362,  1. 6650617,  1. 7684096,  1. 8779901,  1. 9936041,  2. 1149449,
  2. 2399017,  2. 3658856,  2. 4890175,  2. 6063693,  2. 7170927,  2. 8212335,  2. 9199732,
  3. 0167709, ;
  0. 054505497,  0. 11257843,  0. 17084186,  0. 22994473,  0. 29103254,  0. 35443013,  0. 42012503,
  0. 48650412,  0. 55568978,  0. 62755462,  0. 70342912,  0. 77820071,  0. 85252596,  0. 92993702,
```

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1. 0126570,	1. 1012957,	1. 1947995,	1. 2925328,	1. 3936971,	1. 4975290,	1. 6036028,
1. 7119727,	1. 8232181,	1. 9386993,	2. 0594415,	2. 1845767,	2. 3128950,	2. 4442348,
2. 5775307,	2. 7114750,	2. 8449651,	2. 9777145,	3. 1097903,	3. 2386589,	3. 3635832,
3. 4868332, ;						
0. 050754190,	0. 12090617,	0. 19146943,	0. 26296607,	0. 33569470,	0. 40970335,	0. 48487719,
0. 56039730,	0. 63800945,	0. 71899485,	0. 80490139,	0. 88762848,	0. 97021335,	1. 0578862,
1. 1516689,	1. 2506699,	1. 3546313,	1. 4637545,	1. 5782692,	1. 6975206,	1. 8204076,
1. 9461757,	2. 0744733,	2. 2063856,	2. 3415034,	2. 4791851,	2. 6190120,	2. 7605749,
2. 9037320,	3. 0488896,	3. 1963443,	3. 3446024,	3. 4928449,	3. 6398657,	3. 7853807,
3. 9300349, ;						
0. 053440090,	0. 13525817,	0. 21745295,	0. 30034411,	0. 38378471,	0. 46723094,	0. 55071804,
0. 63435072,	0. 72034566,	0. 81043953,	0. 90650132,	0. 99834684,	1. 0910389,	1. 1889551,
1. 2922287,	1. 4012723,	1. 5165249,	1. 6376042,	1. 7653786,	1. 8999937,	2. 0398324,
2. 1825051,	2. 3263914,	2. 4714130,	2. 6181802,	2. 7672983,	2. 9192662,	3. 0743193,
3. 2320041,	3. 3917379,	3. 5525924,	3. 7138445,	3. 8754300,	4. 0372937,	4. 1984342,
4. 3592660, ;						
0. 063289106,	0. 15501951,	0. 24701349,	0. 33953536,	0. 43244429,	0. 52521015,	0. 61810564,
0. 71204865,	0. 80808911,	0. 90668851,	1. 0123100,	1. 1139887,	1. 2164301,	1. 3235700,
1. 4369417,	1. 5577197,	1. 6862914,	1. 8215629,	1. 9623173,	2. 1100999,	2. 2642877,
2. 4210661,	2. 5776983,	2. 7339867,	2. 8919879,	3. 0542741,	3. 2211858,	3. 3920528,
3. 5653771,	3. 7399860,	3. 9148787,	4. 0897039,	4. 2646788,	4. 4400312,	4. 6151622,
4. 7901006, ;						
0. 079852273,	0. 17975320,	0. 27972805,	0. 37994953,	0. 48085390,	0. 58258273,	0. 68535711,
0. 78992037,	0. 89592346,	1. 0028113,	1. 1194610,	1. 2327487,	1. 3456522,	1. 4622995,
1. 5854142,	1. 7178604,	1. 8596201,	2. 0081096,	2. 1621229,	2. 3223222,	2. 4871216,
2. 6549010,	2. 8241130,	2. 9937224,	3. 1664261,	3. 3446347,	3. 5278948,	3. 7144829,
3. 9027101,	4. 0926824,	4. 2835345,	4. 4748708,	4. 6661577,	4. 8571957,	5. 0481477,
5. 2390698, ;						
0. 10185860,	0. 20901987,	0. 31622536,	0. 42365744,	0. 53176767,	0. 64123250,	0. 75329332,
0. 86841759,	0. 98553211,	1. 1046316,	1. 2316659,	1. 3565315,	1. 4807538,	1. 6084959,
1. 7420578,	1. 8845742,	2. 0358257,	2. 1946494,	2. 3613153,	2. 5346262,	2. 7124845,
2. 8927032,	3. 0739473,	3. 2586601,	3. 4478166,	3. 6417817,	3. 8404872,	4. 0411450,
4. 2432602,	4. 4489559,	4. 6585946,	4. 8707169,	5. 0829075,	5. 2959284,	5. 5095175,
5. 7233050, ;						
0. 12780655,	0. 24207214,	0. 35643948,	0. 47114458,	0. 58641688,	0. 70316973,	0. 82420298,
0. 94969298,	1. 0787918,	1. 2107432,	1. 3468233,	1. 4829479,	1. 6199742,	1. 7598975,
1. 9040695,	2. 0550534,	2. 2149373,	2. 3844797,	2. 5631774,	2. 7499493,	2. 9425499,
3. 1370979,	3. 3329470,	3. 5335236,	3. 7396499,	3. 9488859,	4. 1587500,	4. 3707538,
4. 5871880,	4. 8093829,	5. 0391585,	5. 2762795,	5. 5183211,	5. 7637187,	6. 0112704,
6. 2600394, ;						
0. 15605666,	0. 27773169,	0. 39950649,	0. 52152546,	0. 64381099,	0. 76801961,	0. 89819366,
1. 0351574,	1. 1751407,	1. 3183007,	1. 4650431,	1. 6127145,	1. 7618936,	1. 9139970,
2. 0693142,	2. 2295931,	2. 3993952,	2. 5812446,	2. 7725622,	2. 9700955,	3. 1728253,
3. 3821419,	3. 5956557,	3. 8120993,	4. 0313918,	4. 2534145,	4. 4786342,	4. 7074093,
4. 9391444,	5. 1788210,	5. 4325183,	5. 7003808,	5. 9798353,	6. 2681488,	6. 5647534,
6. 8658927, ;						
0. 18465215,	0. 31440146,	0. 44425124,	0. 57438655,	0. 70477231,	0. 83707768,	0. 97669818,
1. 1235803,	1. 2751709,	1. 4299966,	1. 5874741,	1. 7467767,	1. 9075331,	2. 0715084,
2. 2404731,	2. 4151269,	2. 5969273,	2. 7879063,	2. 9886230,	3. 1961373,	3. 4109605,
3. 6335455,	3. 8613792,	4. 0900155,	4. 3205096,	4. 5577024,	4. 8024169,	5. 0495604,
5. 2986696,	5. 5619939,	5. 8481573,	6. 1525314,	6. 4742680,	6. 8187200,	7. 1821372,
7. 5536833, ;						



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0. 21132506,	0. 35034526,	0. 48936570,	0. 62845783,	0. 76751738,	0. 90867886,	1. 0578444,
1. 2135621,	1. 3750960,	1. 5410454,	1. 7104064,	1. 8826447,	2. 0549655,	2. 2305716,
2. 4130736,	2. 6038124,	2. 8018610,	3. 0036709,	3. 2083577,	3. 4242957,	3. 6527678,
3. 8881911,	4. 1228368,	4. 3605260,	4. 6085058,	4. 8654432,	5. 1257684,	5. 3914960,
5. 6723840,	5. 9731631,	6. 2954623,	6. 6479930,	7. 0261314,	7. 4387682,	7. 8777856,
8. 3220820, ;						
0. 23349405,	0. 38356311,	0. 53345301,	0. 68300672,	0. 83215258,	0. 98259222,	1. 1400810,
1. 3041243,	1. 4742192,	1. 6498266,	1. 8312191,	2. 0154809,	2. 1980727,	2. 3846624,
2. 5810973,	2. 7878539,	3. 0009190,	3. 2156464,	3. 4339687,	3. 6589572,	3. 8930796,
4. 1335825,	4. 3790618,	4. 6335557,	4. 8994635,	5. 1764140,	5. 4624539,	5. 7613299,
6. 0797556,	6. 4304547,	6. 8144152,	7. 2426181,	7. 6924670,	8. 1686804,	8. 6573363,
9. 1444295, ;						
0. 24857708,	0. 41183282,	0. 57478917,	0. 73708273,	0. 89869860,	1. 0594684,	1. 2242131,
1. 3959154,	1. 5748057,	1. 7614636,	1. 9543737,	2. 1484214,	2. 3430370,	2. 5411484,
2. 7475121,	2. 9648859,	3. 1909989,	3. 4235815,	3. 6604944,	3. 8986548,	4. 1349059,
4. 3766920,	4. 6340358,	4. 9080046,	5. 1954426,	5. 4987421,	5. 8211987,	6. 1600526,
6. 5294227,	6. 9512607,	7. 4270667,	7. 9518610,	8. 4789768,	8. 9915905,	9. 4870095,
9. 9776252, ;						
0. 25455087,	0. 43286314,	0. 61086981,	0. 78795175,	0. 96272562,	1. 1332174,	1. 3077961,
1. 4898687,	1. 6801140,	1. 8788030,	2. 0813789,	2. 2858188,	2. 4926889,	2. 7039344,
2. 9210779,	3. 1448314,	3. 3808162,	3. 6302194,	3. 8837801,	4. 1317674,	4. 3774300,
4. 6302367,	4. 8972242,	5. 1855283,	5. 5002046,	5. 8387047,	6. 1984642,	6. 5914064,
7. 0304812,	7. 5376877,	8. 0980555,	8. 6880270,	9. 2629457,	9. 7974320,	10. 293868,
10. 783455, ;						
0. 25032592,	0. 44456239,	0. 63828634,	0. 83018055,	1. 0175886,	1. 1997748,	1. 3900494,
1. 5873980,	1. 7916522,	2. 0023699,	2. 2152329,	2. 4308864,	2. 6497318,	2. 8726585,
3. 1019152,	3. 3383865,	3. 5828316,	3. 8392126,	4. 0997015,	4. 3588694,	4. 6221991,
4. 8930922,	5. 1747173,	5. 4789306,	5. 8212789,	6. 1948448,	6. 6102486,	7. 0799898,
7. 6030733,	8. 1803765,	8. 7811275,	9. 3814996,	9. 9617440,	10. 505245,	11. 025072,
11. 538502, ;						
0. 23576579,	0. 44581679,	0. 65540023,	0. 86317629,	1. 0658901,	1. 2666870,	1. 4764871,
1. 6914330,	1. 9100617,	2. 1326685,	2. 3585178,	2. 5873146,	2. 8190055,	3. 0548041,
3. 2983111,	3. 5476894,	3. 8010924,	4. 0556797,	4. 3170664,	4. 5920656,	4. 8750582,
5. 1652355,	5. 4693399,	5. 7995055,	6. 1716488,	6. 5910091,	7. 0768276,	7. 6344466,
8. 2400090,	8. 8564880,	9. 4570542,	10. 036065,	10. 595695,	11. 145065,	11. 694297,
12. 240300, ;						
0. 21233247,	0. 43802225,	0. 66352333,	0. 88835843,	1. 1108923,	1. 3357087,	1. 5694217,
1. 8053746,	2. 0393959,	2. 2736932,	2. 5143139,	2. 7585835,	3. 0043326,	3. 2533341,
3. 5087579,	3. 7691727,	4. 0291350,	4. 2871481,	4. 5570212,	4. 8448793,	5. 1419775,
5. 4533064,	5. 7891896,	6. 1592109,	6. 5835904,	7. 0705585,	7. 6372568,	8. 2621086,
8. 9073811,	9. 5331381,	10. 124121,	10. 683936,	11. 230335,	11. 781973,	12. 343025,
12. 906365, ;						
0. 18294622,	0. 42529502,	0. 66766282,	0. 91058970,	1. 1558971,	1. 4077883,	1. 6668387,
1. 9266962,	2. 1797557,	2. 4311645,	2. 6859191,	2. 9433424,	3. 1989686,	3. 4594978,
3. 7272119,	3. 9988654,	4. 2691514,	4. 5428339,	4. 8255418,	5. 1167841,	5. 4230806,
5. 7580122,	6. 1340190,	6. 5670727,	7. 0703071,	7. 6444814,	8. 2760783,	8. 9343791,
9. 5821162,	10. 202418,	10. 786999,	11. 341921,	11. 884457,	12. 434759,	12. 997703,
13. 564376, ;						
0. 15111574,	0. 41265144,	0. 67459828,	0. 93817366,	1. 2056439,	1. 4806302,	1. 7618021,
2. 0427449,	2. 3183600,	2. 5927958,	2. 8671875,	3. 1371721,	3. 4048109,	3. 6783680,
3. 9599663,	4. 2453729,	4. 5320731,	4. 8193822,	5. 1039701,	5. 3965013,	5. 7156979,
6. 0782965,	6. 5032692,	7. 0103023,	7. 5943713,	8. 2406771,	8. 9233086,	9. 6028938,

## Process for Generating Engine Fuel Consumption Map

(Ricardo Baseline Standard Car Engine Tier 2 Fuel)

Version: 06-20-2016

```
10. 252314,    10. 869262,    11. 453970,    12. 014172,    12. 562513,    13. 112944,    13. 672289,
14. 234919, ;
    0. 12029052,  0. 40348273,  0. 68721018,  0. 97254130,  1. 2610374,  1. 5551091,  1. 8537372,
2. 1521650,    2. 4491267,    2. 7447386,    3. 0386259,    3. 3302071,    3. 6215131,    3. 9146364,
4. 2108483,    4. 5085937,    4. 8051907,    5. 0951020,    5. 3813418,    5. 6831614,    6. 0181884,
6. 4070002,    6. 8736490,    7. 4404538,    8. 0934989,    8. 8036809,    9. 5363840,    10. 246670,
10. 912041,    11. 538012,    12. 131024,    12. 701212,    13. 257529,    13. 810756,    14. 368253,
14. 926997, ;
    0. 092637821,  0. 39866540,  0. 70511574,  1. 0125715,  1. 3215611,  1. 6328157,  1. 9459968,
2. 2592650,    2. 5740071,    2. 8891641,    3. 2042901,    3. 5220434,    3. 8396510,    4. 1537768,
4. 4665976,    4. 7762924,    5. 0768402,    5. 3678392,    5. 6642856,    5. 9774182,    6. 3272344,
6. 7404531,    7. 2483735,    7. 8763650,    8. 5933422,    9. 3595226,    10. 131135,    10. 871264,
11. 568613,    12. 213525,    12. 819935,    13. 398693,    13. 963601,    14. 523130,    15. 081086,
15. 639446, ;
    0. 068655572,  0. 39741314,  0. 72639495,  1. 0558032,  1. 3855560,  1. 7149149,  2. 0415732,
2. 3662359,    2. 6922391,    3. 0242974,    3. 3659650,    3. 7098706,    4. 0520786,    4. 3890089,
4. 7192052,    5. 0414561,    5. 3560375,    5. 6639236,    5. 9629425,    6. 2745959,    6. 6349618,
7. 0793403,    7. 6348348,    8. 3117388,    9. 0896147,    9. 9119602,    10. 722548,    11. 504351,
12. 216684,    12. 878513,    13. 499113,    14. 094560,    14. 671244,    15. 236618,    15. 802157,
16. 367275, ];
```

### % Fuel Properties

```
engine.fuel = class_REVS_fuel('RICARDO_GASOLINE');
```

### % Idle Speed

```
engine.idle_speed_radps = 71.209433;
```

### % Pedal Calibration

```
engine.pedal_map_type = enum_engine_pedal_map_type.max_engine_power;
```

### % Fuel response associated with rapid torque reduction

```
engine.fast_torque_fuel_adjust_norm = 1.0000000;
```

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