NCHRP PROJECT 25-11 VEHICLE EMISSIONS DATABASE

INTRODUCTION

An extensive vehicle emissions testing program was conducted from April 1996 to September 1998 at the College of Engineering-Center for Environmental Research and Technology (CE-CERT) at the University of California Riverside. This program was carried out as part of a four-year project sponsored by the National Cooperative Highway Research Program (NCHRP, Project 25-11) to create and verify a comprehensive modal emission model. Details of the overall project can be found in the CMEM User's Guide and (forthcoming) NCHRP Project 25-11 Final Report.

In the first phase of the vehicle-testing program, a total of 327 vehicle tests were performed over 18 months. Of the 327 vehicle tests, 315 of the data sets are considered valid and are included on this CD. In the fourth phase of the test program an additional 31 vehicles were tested and are included in this database (test numbers 400 and above). Vehicles were typically tested over three test cycles: the 3-bag FTP (Federal Test Procedure), the US06 cycle (Bag 4 of the Supplemental FTP), and an in-house designed modal emission cycle, MEC. The FTP cycle is part of the standard certification test procedure and provides baseline information about a vehicle's emissions which can be used as a reference when comparing with existing vehicle tests. The FTP test data also provides cold and warm start information. The high speed US06 test cycle targets "off-cycle", non-FTP operation that is more characteristic of modern driving patterns. The modal emission cycle (MEC) was specially designed and included to provide emission data that can more easily be matched to specific driving modes: various steady-state cruise speeds, accelerations, decelerations, and idle.

Vehicle testing was performed by CE-CERT's Vehicle Emission Research Laboratory (VERL) and were processed and recorded by CE-CERT's Transportation Systems Research (TSR) group. Vehicle test data sets are referred to by their TSR assigned test number. The raw emission data were post-processed and validated. The raw emission data from VERL were received as concentration values and subsequently converted from gas concentrations in parts-per-million (ppm) to a mass emission rate in grams per second. This was done using algorithms for the dynamometer and gas analyzers which must account for parameters such as emission densities, exhaust flow rates, and differences in dry and wet gas measurements. The equations and procedure used to account for such factors are given in Appendix B of the NCHRP Project 25-11 Final Report. For both post-processing procedures, the post-processed modal data were appended to a log file which also includes the vehicle name, cumulative modal emission rates in grams per mile for CO_2, CO, HC, and NOx and comparable integrated emission results obtained by the bag analyses. The final step for all the test data is comparing the cumulative modal and integrated bag results as well as making visual checks to determine the need for any more post-processing of the data.

An important part of the post-processing sequence is the time alignment of the emission data. This is a necessary step since there is a time delay inherent in each of the gas analyzer response times. Time aligning is done as part of the processing step by simply shifting the pollutant concentrations at each second an appropriate time step. The proper time shift is determined through several steps. An initial time shift for each pollutant is provided by VERL as part of the validation and calibration of the emission benches. The second step is to determine time shifts for each pollution pair via a cross correlation analysis of the second-by-second emission data. The calculated time shifts are then compared to those expected. Since time shifts may be off by less than the one-second increment at which data are collected, time shifts of plus and minus one second are also evaluated. The shifted second-by-second results are integrated and compared with measured bag results for the various pollutants. The time shift with which the integrated second-by-second results agree most closely is compared with the expected time shifts. Since the time shift is a function of the analyzer system only, it should be consistent across all tests and vehicles. This procedure ensures the accuracy of the time alignment and helps detect any differences in the modal and bag emission values.

Valid vehicle parameter data were collected on 67 vehicles using a *Scan Gra-Fix*^{TM} datalogging tool connected to the vehicle ECU (engine control unit) during testing. Data were collected for all vehicles supported by the tool when used with a 1994 and later Domestic Combination Primary cartridge, a 1993 GM Primary cartridge, or a 1992 and later Asian Import Primary cartridge. With this it was possible to directly obtained measurements of vehicle parameters such as engine speed, throttle position, etc. The vehicle data variables change from model-to-model and year-to-year so the variables included in the files are not standardized.

CONTENTS:

Below is a list of files and a brief description of each.

DATA README.doc – This README.doc file.

project_vehicle_summary.xls - this is a quick vehicle summary sheet in a Microsoft Excel (97) format which contains various vehicle and test information. The format of this file is described below.

vehXXX.xls (example: veh052.xls) - There are 345 vehicle test data sets in Microsoft Excel (97) workbook format. These data set workbooks include vehicle, test, emission summary, second-by-second emission data, and where available the second-by-second vehicle parameter data as separate "sheets" in the workbook. Each filename consists of "veh" followed by the TSR vehicle number and the recognized Excel extension ".xls". The format of these files is described below.

FILE FORMATS

project_vehicle_summary.xls

This file is an 18-column Excel worksheet. The following is a description of each column:

> Column 1 (num) - The TSR assigned vehicle number. This is the number which corresponds to the individual vehicle test data files.
>
> Column 2 (Veh. Name) - An abbreviated vehicle name. This name usually consists of vehicle make, vehicle model, and vehicle model year.
>
> Column 3 (MY) - This is the vehicle model year.
>
> Column 4 (date) - This is the testing date.
>
> Column 5 (test n1) - This is the VERL cross reference test number for the FTP test.
>
> Column 6 (test n2) - This is the VERL cross reference test number for the MEC test and the US06 test (if it exists).
>
> Column 7 (Cat) - This is the assigned vehicle category that is used in the developed comprehensive modal emissions model (CMEM).
>
> Column 8 (FTP) - Refers to the FTP cycle. If "E" is present here than engine-out data exists. If "T" is present here then tailpipe data exists.
>
> Column 9 (US06) - Refers to the US06 cycle. If "E" is present here than engine-out data exists. If "T" is present here then tailpipe data exists.
>
> Column 10 (MEC) - Refers to the MEC cycle. If "E" is present here than engine-out data exists. If "T" is present here then tailpipe data exists.
>
> Column 11 (AC) - Refers to the air-conditioning data. If "E" is present here than engine-out data exists. If "T" is present here then tailpipe data exists.
>
> Column 12 (RPT) - Refers to repeat mode data. If "E" is present here than engine-out data exists. If "T" is present here then tailpipe data exists.
>
> Column 13 (Mass) - This is the mass of the vehicle in pounds.
>
> Column 14 (Tier) - This is the Tier emission standard classification of the vehicle.
>
> Column 15 (Veh Type) - This is the vehicle type, either car or truck.

Column 16 (State) - This indicates whether the vehicle is certified for California emission standards or for 49-state emission standards.

Column 17 (Odom) - This is the recorded odometer reading.

vehXXX.xls

This Microsoft Excel file is an Excel workbook containing as many as eight worksheets depending on the test data available. Each worksheet is described below.

Vehicle Summary Sheet

This 16 row worksheet contains various vehicle information. The following is a description of each row:

Row 1 (Make) - Vehicle make.
Row 2 (Model) - Vehicle model.
Row 3 (Year) - Vehicle model year.
Row 4 (Engine Size) - Engine size in liters.
Row 5 (Number of Cylinders) - Number of cylinders.
Row 6 (List Weight) - Listed vehicle weight in lbs.
Row 7 (Odometer) - Odometer reading in miles.
Row 8 (Rated Power) - Rated vehicle power in hp.
Row 9 (Catalyst) - Catalyst type.
Row 10 (Fuel System) - Fuel system type.
Row 11 (VIN Code) - Vehicle Identification Number.
Row 12 (License Number) - Vehicle license number.
Row 13 (Vehicle Category) - CMEM vehicle categorization (1-23).
Row 14 (Tier Type) - Vehicle tier emission standard level.
Row 15 (Vehicle Type) - Vehicle type (eg. car,truck).
Row 16 (State) - CA or 49-state certified vehicle.

Test Summary Sheet for FTP

This 32 row worksheet contains information about FTP testing conditions. The following is a description of the rows:

Row 1 (Test) - TSR test name.
Row 2 (Date) - Date the vehicle test was performed.
Row 3 (Time) - Time of day the vehicle test was performed.
Row 4 (Cycle) - The cycle which was used for the vehicle test.
Row 5 (Driver) - The driver during the vehicle test.
Row 6 (Operator) - The test operator during the test.
Row 7 (Dyno Inertia) - The vehicle weight in pounds which was used by the test computer for the vehicle test.

Row 8 (Dyno AHP) - The vehicle power in horsepower (hp) which was used by the test computer for the vehicle test.

Row 9 (A) - Tractive power coefficient A in hp/mph.

Row 10 (B) - Tractive power coefficient B in hp/mph^2.

Row 11 (C) - Tractive power coefficient C in hp/mph^3.

Row 12 (bag1Temp) - The temperature in degrees Fahrenheit at the start of the first bag test.

Row 13 (bag2Temp) - The temperature in degrees Fahrenheit at the start of the second bag test.

Row 14 (bag3Temp) - The temperature in degrees Fahrenheit at the start of the third bag test.

Row 15 (bag1Pressure) - The pressure in inches of mercury at the start of the first bag test.

Row 16 (bag2Pressure) - The pressure in inches of mercury at the start of the second bag test.

Row 17 (bag3Pressure) - The pressure in inches of mercury at the start of the third bag test.

Row 18 (bag1Humidity) - The humidity as a percent at the start of the first bag test.

Row 19 (bag2Humidity) - The humidity as a percent at the start of the second bag test.

Row 20 (bag3Humidity) - The humidity as a percent at the start of the third bag test.

Row 21 (bag1bkHC) - The background HC concentration in ppm at the start of bag1.

Row 22 (bag2bkHC) - The background HC concentration in ppm at the start of bag2.

Row 23 (bag3bkHC) - The background HC concentration in ppm at the start of bag3.

Row 24 (bag1bkCO) - The background CO concentration in ppm at the start of bag1.

Row 25 (bag2bkCO) - The background CO concentration in ppm at the start of bag2.

Row 26 (bag3bkCO) - The background CO concentration in ppm at the start of bag3.

Row 27 (bag1bkNOx) - The background NOx concentration in ppm at the start of bag1.

Row 28 (bag2bkNOx) - The background NOx concentration in ppm at the start of bag2.

Row 29 (bag3bkNOx) - The background NOx concentration in ppm at the start of bag3.

Row 30 (bag1bkCO2) - The background CO2 concentration in percent volume at the start of bag1.

Row 31 (bag2bkCO2) - The background CO2 concentration in percent volume at the start of bag2.

Row 32 (bag3bkCO2) - The background CO2 concentration in percent volume at the start of bag3.

Test Summary Sheet for MEC

This 18 row worksheet contains information about MEC testing conditions. The following is a description of the rows:

Row 1 (Test) - TSR test name.

Row 2 (Date) - Date the vehicle test was performed.

Row 3 (Time) - Time of day the vehicle test was performed.

Row 4 (Cycle) - The cycle which was used for the vehicle test.

Row 5 (Driver) - The driver during the vehicle test.
Row 6 (Operator) - The test operator during the test.
Row 7 (Dyno Inertia) - The vehicle weight in pounds which was used by the test computer for the vehicle test.
Row 8 (Dyno AHP) - The vehicle power in hp which was used by the test computer for the vehicle test.
Row 9 (A) - Tractive power coefficient A in hp/mph.
Row 10 (B) - Tractive power coefficient B in hp/ mph^2.
Row 11 (C) - Tractive power coefficient C in hp/ mph^3.
Row 12 (Temp) - The temperature in degrees F at the start of the MEC test.
Row 13 (Pressure) - The pressure in inches of mercury at the start of the MEC test.
Row 14 (Humidity) - The humidity as a percent at the start of the MEC test.
Row 15 (bkHC) - The background HC concentration in ppm at the start of the MEC test.
Row 16 (bkCO) - The background CO concentration in ppm at the start of the MEC test.
Row 17 (bkNOx) - The background NOx concentration in ppm at the start of the MEC test.
Row 18 (bkCO2) - The background CO2 concentration in percent volume at the start of the MEC test.

Test Summary Sheet for US06

This 18 row worksheet contains information about US06 testing conditions. The following is a description of the rows:

Row 1 (Test) - TSR test name.
Row 2 (Date) - Date the vehicle test was performed.
Row 3 (Time) - Time of day the vehicle test was performed.
Row 4 (Cycle) - The cycle which was used for the vehicle test.
Row 5 (Driver) - The driver during the vehicle test.
Row 6 (Operator) - The test operator during the test.
Row 7 (Dyno Inertia) - The vehicle weight in pounds which was used by the test computer for the vehicle test.
Row 8 (Dyno AHP) - The vehicle power in horsepower which was used by the test computer for the vehicle test.
Row 9 (A) - Tractive power coefficient A in hp/mph.
Row 10 (B) - Tractive power coefficient B in hp/ mph^2.
Row 11 (C) - Tractive power coefficient C in hp/ mph^3.
Row 12 (Temp) - The temperature in degrees F at the start of the US06 test.
Row 13 (Pressure) - The pressure in inches of mercury at the start of the US06 test.
Row 14 (Humidity) - The humidity as a percent at the start of the US06 test.
Row 15 (bkHC) - The background HC concentration in ppm at the start of the US06 test.
Row 16 (bkCO) - The background CO concentration in ppm at the start of the US06 test.
Row 17 (bkNOx) - The background NOx concentration in ppm at the start of the US06 test.
Row 18 (bkCO2) - The background CO2 concentration in percent volume at the start of the US06 test.

Emission Summary Table

This worksheet contains summary information for the second-by-second emission files and is split up into as many as four sections. The number of sections will depend on which cycles are included in the vehicle test data set. The sections in order are the FTP, MEC, US06, and a comment section. The following is a description of the sections:

FTP section - The first two fields of this section are data length in seconds and distance traveled in miles. These two fields refer to information about the entire FTP data set. The fields following refer to bag 1, bag 2, bag 3 and composite bag data as labeled. Data in these fields includes average speed in mph, the engine out emissions CO2, CO, HC and NOx, and the tailpipe out emissions CO2, CO, HC and NOx in grams per mile. Composite bag data is calculated base on the percentages 0.207 for bag 1, 0.518 for bag 2, and 0.275 for bag 3.

MEC section - The first two fields of this section are data length in seconds and distance traveled in miles. These two fields refer to information about the entire MEC data set.
The fields following refer to averages for seconds 1-400 and 1-900 of the MEC cycle. Data in these fields includes average speed in mph, the engine out emissions CO2, CO, HC and NOx, and the tailpipe out emissions CO2, CO, HC and NOx in grams per mile.

US06 section - All fields in this section refer to the entire data set. The first two fields are data length in seconds and distance traveled in miles. The following fields are average speed in mph, the engine-out emissions CO2, CO, HC and NOx, and the tailpipe out emissions CO2, CO, HC and NOx in grams per mile.

Comment section - This section contains any comments about the test vehicle, testing conditions, or test data.

Second-by-Second Data for FTP

This is an 11-column worksheet which contains second by second test data for the FTP. The following is a description of the columns:

> Row 1 (Time) - Time in increments of one second.
> Row 2 (V_TARGET) - Target velocity in mph which the test vehicle was trying to achieve.
> Row 3 (V_ACTUAL) - Actual velocity in mph which the test vehicle did achieve.
> Row 4 (ECO2) - Engine out CO2 in grams.
> Row 5 (ECO) - Engine out CO in grams.
> Row 6 (EHC) - Engine out HC in grams.
> Row 7 (ENOx) - Engine out NOx in grams.
> Row 8 (TCO2) - Tailpipe out CO2 in grams.
> Row 9 (TCO) - Tailpipe out CO in grams.
> Row 10 (THC) - Tailpipe out HC in grams.
> Row 11 (TNOx) - Tailpipe out NOx in grams.

Second-by-Second Data for US06

This is an 11-column worksheet which contains second by second test data for the US06. The following is a description of the columns:

Row 1 (Time) - Time in increments of one second.
Row 2 (V_TARGET) - Target velocity in mph which the test vehicle was trying to achieve.
Row 3 (V_ACTUAL) - Actual velocity in mph which the test vehicle did achieve.
Row 4 (ECO2) - Engine out CO2 in grams.
Row 5 (ECO) - Engine out CO in grams.
Row 6 (EHC) - Engine out HC in grams.
Row 7 (ENOx) - Engine out NOx in grams.
Row 8 (TCO2) - Tailpipe out CO2 in grams.
Row 9 (TCO) - Tailpipe out CO in grams.
Row 10 (THC) - Tailpipe out HC in grams.
Row 11 (TNOx) - Tailpipe out NOx in grams.

Second-by-Second Data for MEC

This is an 11 column worksheet which contains second by second test data for the MEC. The following is a description of the columns:

Row 1 (Time) - Time in increments of one second.
Row 2 (V_TARGET) - Target velocity in mph which the test vehicle was trying to achieve.
Row 3 (V_ACTUAL) - Actual velocity in mph which the test vehicle did achieve.
Row 4 (ECO2) - Engine out CO2 in grams.
Row 5 (ECO) - Engine out CO in grams.
Row 6 (EHC) - Engine out HC in grams.
Row 7 (ENOx) - Engine out NOx in grams.
Row 8 (TCO2) - Tailpipe out CO2 in grams.
Row 9 (TCO) - Tailpipe out CO in grams.
Row 10 (THC) - Tailpipe out HC in grams.
Row 11 (TNOx) - Tailpipe out NOx in grams.

Second-by-Second Vehicle Parameter Data for FTP

This is a worksheet which contains second by second vehicle parameter data for the FTP cycle. The engine data collected varies from vehicle to vehicle, depending on make and model year. As an example, the following is a description of the columns for a 1992 Ford Taurus.

Row 1 (TIME) - Time mark.
Row 2 (RPM) - Engine speed in revolutions per minute.

Row 3 (O2S1_mV) - Oxygen sensor 1 voltage in milliVolts.
Row 4 (O2S2_mV) - Oxygen sensor 2 voltage in milliVolts.
Row 5 (TP_TPS_V) - Throttle position.
Row 6 (TP_MODE) - Throttle position mode.
Row 7 (ECT_V) - Emission control temperature.
Row 8 (ECT_F) - Emission control temperature in degrees F.
Row 9 (IAT_ACT_V) - Idle air temperature.
Row 10 (MAF) - Mass air flow.
Row 11 (EPC_PSI) - Evaporative pressure control in pounds per square inch.
Row 12 (INJ_PW1_mS) - Injector pulse width 1.
Row 13 (INJ_PW2_mS) - Injector pulse width 2.
Row 14 (VPWR) - Vehicle power.
Row 15 (VREF_V) - Vehicle reference voltage.
Row 16 (SPARK_ADV) - Spark Advance in degrees.
Row 17 (WAC_WOT_A/C) - Wide open throttle air conditioning either on or off.
Row 18 (FP_FUEL_PUMP) - Fuel pump either on or off.
Row 19 (CANP_PURGE) - Canister purge either on or off.
Row 20 (VEH_SPEED_MPH) - Vehicle speed in miles per hour.
Row 21 (PARK/NEU_POS) - Park neutral position.
Row 22 (TR_GEAR) - Gear.
Row 23 (BOO_BRAKE_SW) - Brake signal.
Row 24 (OPEN/CLSD_LOOP) - Open loop.
Row 25 (LFC_LOW_FAN) - Low fan either on or off.
Row 26 (HFC_HIGH_FAN) - High fan either on or off.
Row 27 (ACCS_A_C) - Air conditioning either on or off.
Row 28 (OCTANE_ADJ) - Octane adjustment either on or off.

Second-by-Second Vehicle Parameter Data for MEC

This is a worksheet which contains second by second vehicle parameter data for the MEC cycle.
The engine data collected varies from vehicle to vehicle, depending on make and model year.

Second-by-Second Vehicle Parameter Data for US06

This is a worksheet which contains second by second vehicle parameter data for the US06 cycle.
The engine data collected varies from vehicle to vehicle, depending on make and model year.

For comments or questions regarding this database, please email: cmem@cert.ucr.edu.